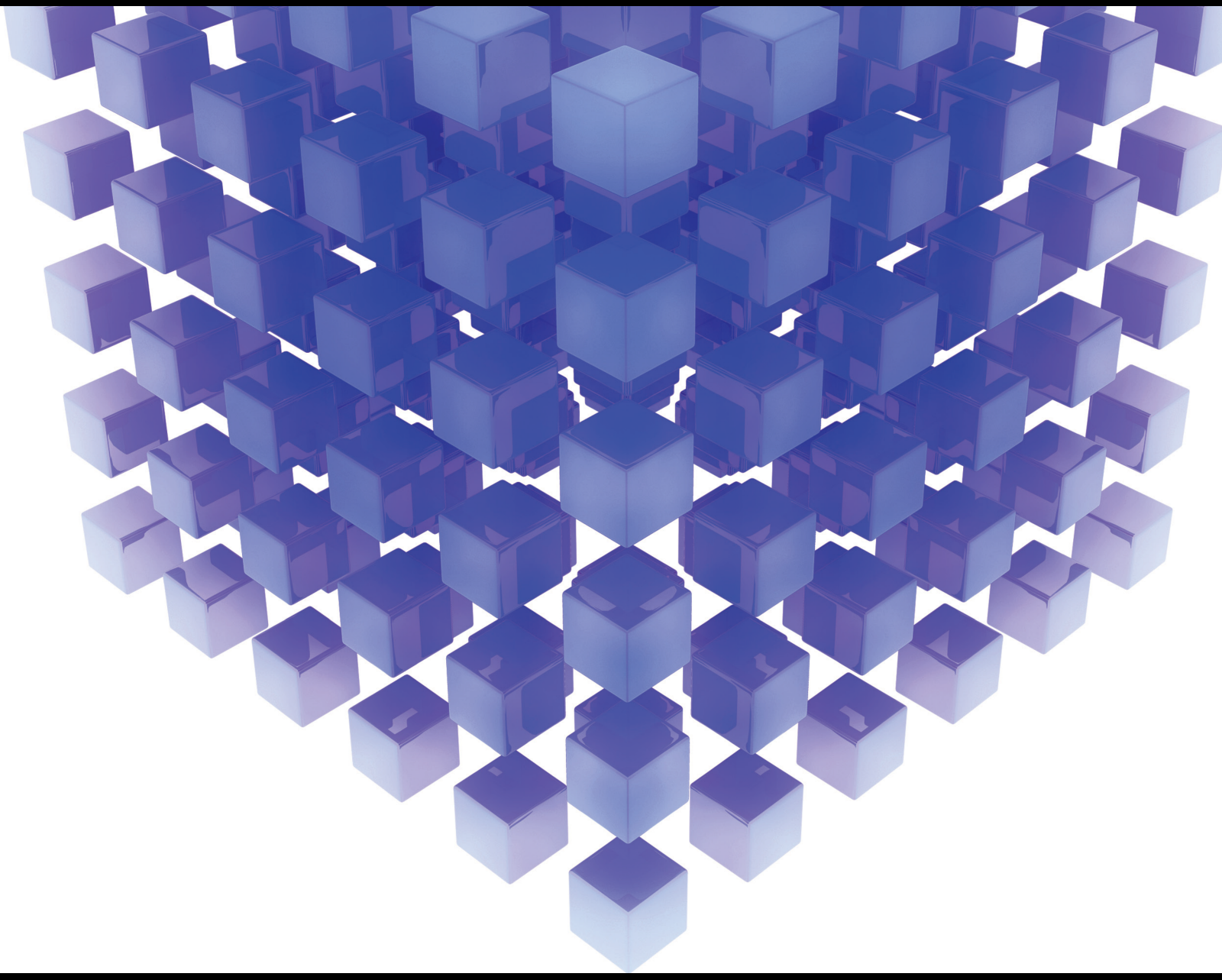
Mathematical Problems in Engineering

Recent Advances in Industrial Mathematics and Applications 2022

Lead Guest Editor: Gengxin Sun
Guest Editors: Jiafu Su and Xiaoning Zhu



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Retraction

Retracted: Path Optimization Model of Rural Red Tourist Attractions Based on Ant Colony 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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1].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] L. Chen and J. Chen, "Path Optimization Model of Rural Red Tourist Attractions Based on Ant Colony Algorithm," *Mathematical Problems in Engineering*, vol. 2022, Article ID 9403207, 12 pages, 2022.

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Retracted: An Evaluation Model of Urban-Rural Exchange Teachers in Elementary School Based on Optimal Control Neural Network

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

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[1] K. Chen, "An Evaluation Model of Urban-Rural Exchange Teachers in Elementary School Based on Optimal Control Neural Network," *Mathematical Problems in Engineering*, vol. 2022, Article ID 7808127, 13 pages, 2022.

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Mathematical Problems in Engineering
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Retraction

Retracted: Interactive Teaching Based on Artificial Intelligence and Its Application in Improving National Music Appreciation Ability

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[1] Z. Zhang, "Interactive Teaching Based on Artificial Intelligence and Its Application in Improving National Music Appreciation Ability," *Mathematical Problems in Engineering*, vol. 2022, Article ID 5363782, 10 pages, 2022.

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Retraction

Retracted: Evaluation Method of Vocal Music Teaching Quality for Music Majors Based on the Theory of Multiple Intelligences

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[1] D. Li, "Evaluation Method of Vocal Music Teaching Quality for Music Majors Based on the Theory of Multiple Intelligences," *Mathematical Problems in Engineering*, vol. 2022, Article ID 3353776, 11 pages, 2022.

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Research Article

Evaluation and Prediction Model of Intelligent Manufacturing Capability Based on Applied Mathematical Modelling

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With the exponential enhancement of manufacturing effectivity and the structural transformation of the software of manufacturing elements induced by using the new spherical of scientific and technological revolution, the sample of comparative gain of manufacturing elements in the worldwide manufacturing enterprise has passed through profound changes, progressively forming a transformation from the industrial chain to the price chain, therefore promoting the transformation of manufacturing mode and aid utilization mode. Based on the applicable theories of wise manufacturing, this paper proposes an clever manufacturing functionality assessment and prediction mannequin primarily based on utilized mathematical modelling, which integrates the contrast facts of agencies into a database, establishes the corresponding time sequence relationship of the comparison data, and establishes a relationship with the corresponding organization attributes, fashions the assessment data, and combines them into a total prediction mannequin through built-in learning. By functionality of migration learning, the prediction model applicable to large statistics is migrated to small information to recognize the distinction of the equal type alternatively special entities. Input the comparison facts of the organization to be evaluated into the prediction mannequin to reap the shrewd manufacturing functionality maturity fee of the enterprise. It realizes the automated comparison of shrewd manufacturing capability, saves human cost, and improves the accuracy of evaluation. It solves the troubles that manufacturing companies have no longer deep hold close and understanding of smart manufacturing, inaccurate identification of their very personal smart manufacturing enhancement stage, and unscientific self-evaluation and diagnosis.

1. Introduction

Manufacturing enterprise is a vital section of the country wide economy, the basis for hold competitiveness, healthful financial operation, and social stability, and the fundamental battlefield for scientific and technological innovation. It has been connected with remarkable significance through the governments of all countries, especially after the worldwide financial crisis, the usual manufacturing has regularly uncovered many troubles such as susceptible innovation capability and low scientific and technological content, and it is in pressing want of transformation and upgrading. Under this background, developed nations such as Europe and America have launched the approach of reindustrialization in an strive to catch the commanding peak of worldwide competition [1]. The most consultant international locations are Germany, the United States and Japan with developed manufacturing industries. Germany's manufacturing enterprise is very aggressive in the world. In phrases of data technology, the applied sciences represented by way of embedded structures and automation are at the world's main level. The core of its industrial four is to digitize and sensible the supply, manufacturing and income data in the manufacturing manner through the cyber bodily system, so as to gain speedy product furnish and enhance Germany's industrial competitiveness. Relying on its sturdy web capability, the United States has put ahead a country wide strategic sketch for superior manufacturing primarily based on "Internet +" manufacturing, hoping to beef up the manufacturing enterprise via the cooperation of the government, universities and enterprises [2]. The motive is to decorate the competitiveness of American manufacturing,

promote the transformation of revolutionary technological know-how into a standardized, low-budget and environment friendly neighbourhood manufacturing capacity, and realise a sustainable improvement commercial enterprise model [3]. In the early years, Japan proposed a manufacturing administration system with the renovation of the entire manufacturing machine as the core. Later, it chosen lean manufacturing as the transformation direction, and adjusted the focal factor of manufacturing employer enhancement in authentic time in accordance to the dynamics of Germany and the United States [4].

Intelligent manufacturing is primarily based on synthetic genius technology, which integrates and runs through the total manufacturing process, so that it has clever behaviour and hastens industrial transformation. Intelligent manufacturing no longer solely brings a lot of advantages to enterprises, such as decreasing costs, enhancing exceptional and standardizing work processes, however additionally promotes multidimensional integration and improvement of firms and realizes transformation and upgrading of enterprises [5]. In the modern technology of speedy improvement of records technology, vigorously and continually growing shrewd manufacturing is the great way to assist companies enhances their competitiveness. However, for a long time, the merchandise is broadly speaking focused in the centre and low-end fields and the low brought fee of merchandise are the fundamental traits and long-standing hazards of the usual manufacturing industry. It is pressing to promote the transformation and upgrading of the manufacturing enterprise from the low-end to the high-end. The improvement of wise manufacturing is most likely an essential and tremendous way to acquire the transformation and upgrading [6]. It is fundamental to give a boost to the help of shrewd manufacturing, so as to promote the growth of data science and wise technology. In addition, the improvement of clever manufacturing enterprise can practice extra energy-saving and environment-friendly superior gear and wise optimization technology, which will assist basically clear up the energy-saving and emission discount troubles in China's manufacturing process [7]. Some firms cannot completely apprehend and apprehend clever manufacturing, lack of systematic and scientific enhancement positioning and path planning, in unique the dubious definition of the enhancement stage of smart manufacturing in which the corporations are located, and lack of achievable prognosis in the constructing of smart manufacturing. Therefore, a scientific comparison technique is urgently needed [8]. Therefore, it is fundamental to find out about the contrast of sensible manufacturing functionality maturity of manufacturing enterprises.

Based on the above lookup background, this paper proposes a wise manufacturing functionality assessment and prediction mannequin based totally on utilized mathematical modelling from the applicable theories of clever manufacturing. With the assist of the prediction model after built-in studying training, the importance of every comparison parameter can be ranked, and the qualitative influence of every parameter on the last comparison conclusion can be achieved. The quantitative influence of every parameter on the closing assessment conclusion can be located via multibatch coaching and real-time monitoring based totally on it. It realizes the computerized assessment of sensible manufacturing functionality maturity, saves labour value, and improves the accuracy of evaluation.

The organization of this paper is as follows: Section 1 mainly describes the background, content framework, and main significance of the study. The related work is discussed in Section 2. Section 3 introduces relevant theories and technologies. The experimental analysis is carried out in Section 4. Section 5 summarizes the full text.

2. Related Work

As the core of the new spherical of the industrial revolution, sensible manufacturing has been surprisingly worried through the enterprise and tutorial circles. Most students basically learn about clever manufacturing from the components of development, science, and application. However, with the improvement and implementation of shrewd manufacturing, its functionality degree displays the improvement popularity of smart manufacturing and the core competitiveness of enterprises. Therefore, how to consider the wise manufacturing functionality has grown to be a new lookup hotspot. The fundamental lookup contents are summarized as follows:

Foreign scholars' lookup on the assessment of manufacturing ability basically focuses on the enhancement of the competitiveness and manufacturing potential of manufacturing enterprises. Relevant pupils trust that the improvement of shrewd manufacturing enterprise cannot be separated from the assist and improvement of records technology [9]. Intelligent manufacturing additionally promotes the enhancement of manufacturing efficiency to a sure extent. In the assessment of manufacturing capacity, the contrast index gadget is mounted in a qualitative way. In order to enhance the competitiveness of the manufacturing industry, enhancing the manufacturing and manufacturing capability of businesses and enhancing the business enterprise device are two key factors that cannot be ignored [10]. Based on these two lookup emphases, a contrast gadget of manufacturing functionality is proposed. In the surroundings of fast improvement of sensible manufacturing, the upgrading and adjustment of manufacturing technological know-how and industrial shape will have an effect on the manufacturing potential of the manufacturing enterprise to a positive extent [11]. In order to make the business enterprise higher adapt to the necessities of a shrewd manufacturing environment, the multiagent gadget is delivered to the simulation of the manufacturing system to enhance the manufacturing ability of the enterprise. Finally, the benefits of the simulation approach are demonstrated via the real data, and the manufacturing potential of the manufacturing device after the simulation is evaluated by way of the fuzzy complete assessment method [12].

Different from the lookup course of overseas scholars, some home pupils have carried out a lot of assessment and research on the processing and manufacturing capabilities of manufacturing systems. A reference gadget for evaluating

the manufacturing ability of desktop equipment and tools based totally on inexperienced manufacturing is established [13]. On this basis, a multiobjective optimization selection mannequin is established. The mixture of grey relational evaluation and the analytic hierarchy method is utilized in the ability evaluation, and the mannequin is solved [14]. The trouble of deciding on the manufacturing capability of laptop equipment and tools is correctly solved. Through summarizing the complete contrast strategies of manufacturing capacity, it is determined that there are nevertheless some deficiencies in the comparison strategies of the total manufacturing process. On this basis, a complete assessment is carried out through the usage of the proposed assessment mannequin via analytic hierarchy process. According to the improvement of manufacturing enterprise and the informatization degree of manufacturing enterprise in our country, the functionality contrast index gadget for the implementation of manufacturing informatization is constructed. When evaluating the informatization capability of manufacturing industry, AHP is used to weight the contrast indexes of every level, and a fuzzy complete contrast approach is used to analyse the informatization maturity of manufacturing enterprises [15]. Through the proper investigation and lookup of a precise consultant enterprise, the comparison index machine is used to consider the manufacturing informatization capacity of the enterprise. On the foundation of reading the improvement of manufacturing capacity, a hierarchical decision-making approach of manufacturing laptop device primarily based on fuzzy complete contrast technique is proposed, and an entire assessment mannequin of computer device manufacturing capability is established [16].

To sum up, it can be considered from the above overseas literature on manufacturing capability contrast that the lookup of overseas students on intelligent manufacturing focuses on how to enhance the manufacturing potential and typical competitiveness of manufacturing enterprises. There are few literatures on the distinction of manufacturing capacity, and the contrast penalties of manufacturing capability are essentially used to think about the trendy competitiveness of manufacturing firms [17]. Most scholars' lookup on intelligent manufacturing tends to be qualitative lookup on standards and modes, whilst quantitative lookup is less. However, this paper focuses on quantitative research, proposes a clever manufacturing functionality contrast and prediction mannequin based totally on utilized mathematical modelling, establishes a shrewd manufacturing complete functionality assessment system, realizes the automated assessment of clever manufacturing functionality maturity, saves labour costs, and improves the accuracy of evaluation [18].

3. Intelligent Manufacturing System Based on Mathematical Modelling

3.1. Structure of Intelligent Manufacturing System. The digital format machine of clever manufacturing tools is special from the regular product sketch system. With the improvement of community and verbal exchange technology, in order to minimize the set up and upkeep prices of shrewd manufacturing equipment, the faraway analysis and preservation of clever manufacturing gear is the well-known trend. This requires that the digital layout and verification device of smart manufacturing tools is an open-structure gadget-based totally on the Internet. Intelligent manufacturing gear is a subsystem of a manufacturing system [19]. Therefore, it is imperative to think about the layout and verification of clever manufacturing tools below the basic framework of the manufacturing system. The format and verification machine of shrewd manufacturing tools integrates applicable manufacturing device information, and can layout merchandise that higher meet the necessities of customers [20]. In addition, when clever manufacturing gear is used, it will devour electricity and produce elements that have an effect on the environment. Therefore, shrewd manufacturing gear needs to adopt environment-oriented design [21]. Of course, modelling the environmental influence is a tremendously complicated work. The structure of the sensible manufacturing gear digital format and verification device described right here is proven in Figure 1.

3.2. Construction of Evaluation Model. Digital technological know-how refers to the technical skill of laptop hardware, software, data storage, conversation protocol, peripheral tools, and Internet. Technology is primarily based on statistics science. Digital science consists of the series of science and technological know-how in the fields of facts discrete expression, scanning, processing, storage, transmission, sensing, execution, materialization, support, integration, and networking. The extensive software of digital technological know-how in the format area has modified the regular graph technique and plan method, and fashioned the digital sketch technology. The core of digital layout is the discretization of a number fact in the graph process [22]. All facts are expressed digitally, and the design, premeeting, and simulation check are all carried out on the computer [23]. It discretizes the continuous bodily phenomena, fuzzy and not sure phenomena in nature, and human trip, and skills to understand digitization. Discrete mathematics, computational geometry, computational mechanics, and different disciplines grant theoretical help for digital design [24]. In addition to assembly the necessities of universal product design, the digital layout of wise manufacturing tools must additionally reflect on consideration on the traits of manufacturing equipment as given in the following:

(1) Because clever manufacturing tools are generally a complicated electromechanical gadget or mechanical, electrical, hydraulic, and pneumatic systems, the digital layout of smart manufacturing gear has a massive quantity of sketch statistics and complicated relationship between information. This brings positive troubles to the storage and transmission of information.

(2) The digital preassembly of sensible manufacturing equipment, mechanism action simulation, and

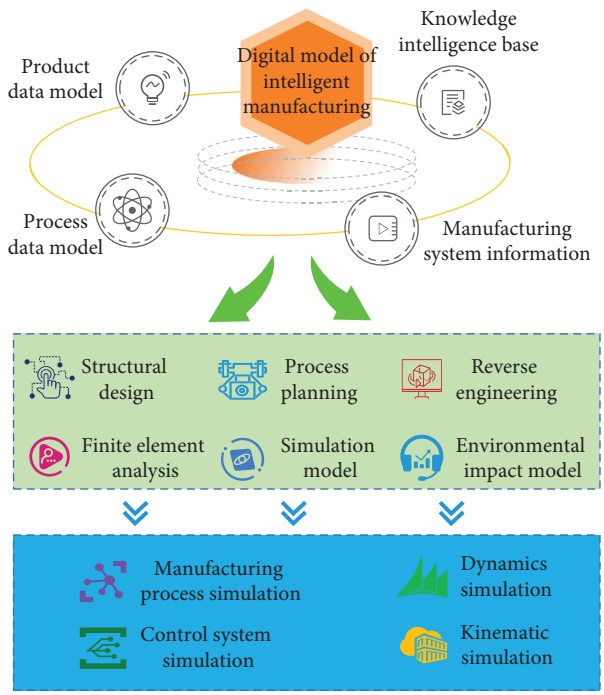


Figure 1: Architecture of digital design for intelligent manufacturing equipment.

manufacturing method simulation all require the corresponding main know-how of manufacturing, such as the modelling of bodily portions such as force, heat, sound, vibration, and error in the manufacturing process.

(3) The future sensible manufacturing machine additionally places ahead new necessities for the plan of sensible manufacturing equipment, such as the smart manufacturing gear have to be convenient to be reconfigurable.

Virtual truth technology, object-oriented technology, sensing technology, and hardware and software program science with more and more effective processing capability are the digital laboratory of sensible manufacturing tools [25]. The bodily prototype of wise manufacturing gear has a lengthy building time and excessive cost. The digital verification technique can no longer solely affirm the shape and technique parameters of smart manufacturing gear in the digital space; however, additionally visualize a variety of bodily and geometric phenomena when the tools are used [26]. Taking the sensible assembly robotic as an example, the digital verification science can be used to affirm the workspace, motion trajectory, whether or not there is interference in the assembly process, and the size of assembly stress of the designed clever assembly robotic in the computer, and even to verify the coordination between greater than one wise meeting machines and the integration of facts [27]. People immersed in the digital area will have a profound grasp of the composition and meeting manner of wise meeting robots. In addition, digital verification technological know-how based totally on digital surroundings is conducive to people's innovative thinking, similarly enhancing the brain of manufacturing tools and growing a pleasant human-machine interface. Module of intelligent closed-loop processing is shown in Figure 2.

3.3. Calculation of Prediction Model. When optimizing the community parameters, the returned propagation algorithm is used to acquire the Jacobian matrix corresponding to the batch normalization of the enter vector and the typical education pattern values. The batch normalization technique requires a massive quantity of computation for the entry of all layers, and the time taken to achieve the covariance matrix is long. The following two simplified enhancement strategies are proposed as follows:

(1) The impartial batch normalization processing is used to exchange the joint normalization processing of every dimension data, and the components are as follows:

$$X^{(k)} = \frac{x_i^{(k)} - E\left(x^{(k)}\right)}{x^2 - u^2} + \frac{\sqrt{\mathrm{var}\left(x^{(k)}\right)}}{\lambda}. \quad (1)$$

Among them, the k-th dimension of the enter pattern is represented through $x^{(k)}$, the expectation is represented with the aid of $E(x^{(k)})$, and the variance is represented by means of $\mathrm{var}(x^{(k)})$. The unbiased batch normalization processing can efficiently velocity up the community education speed, however, it can't make sure the steadiness of the preliminary description of every degree of the network. In order to preserve the trade of the brought batch normalization constant, add parameters in the k-th dimension of every enter pattern $\lambda^{(k)}$ and $\beta^{(k)}$, the following components are obtained as follows:

$$y^{(k)} = \frac{\lambda^{(k)}\left[x_i^{(k)} - E\left(x^{(k)}\right)\right]}{\beta^{(k)}\left(x_i^{(k)} - x_{i-1}^{(k)}\right)}. \quad (2)$$

Among them, $\lambda^{(k)}$ equal to $\mathrm{var}(x^{(k)})$, they are all variance, which more often than not refers to the k-th dimension of the enter pattern after scale transformation; $\beta^{(k)}$ equal to $E(x^{(k)})$, they are the expectations of the input, usually referring to the dimension of the enter pattern after translation transformation.

(2) The random gradient education of convolutional neural community is carried out through microbatch samples, and the common and variance of every degree of every pattern are calculated. The gradient propagation in the contrary course can be realized through the above operation.

On the groundwork of the above mode theoretical analysis, mixed with the statistical evaluation method, the independent estimation mannequin of sensible manufacturing functionality prediction is mounted with the aid of the usage of the ordinary

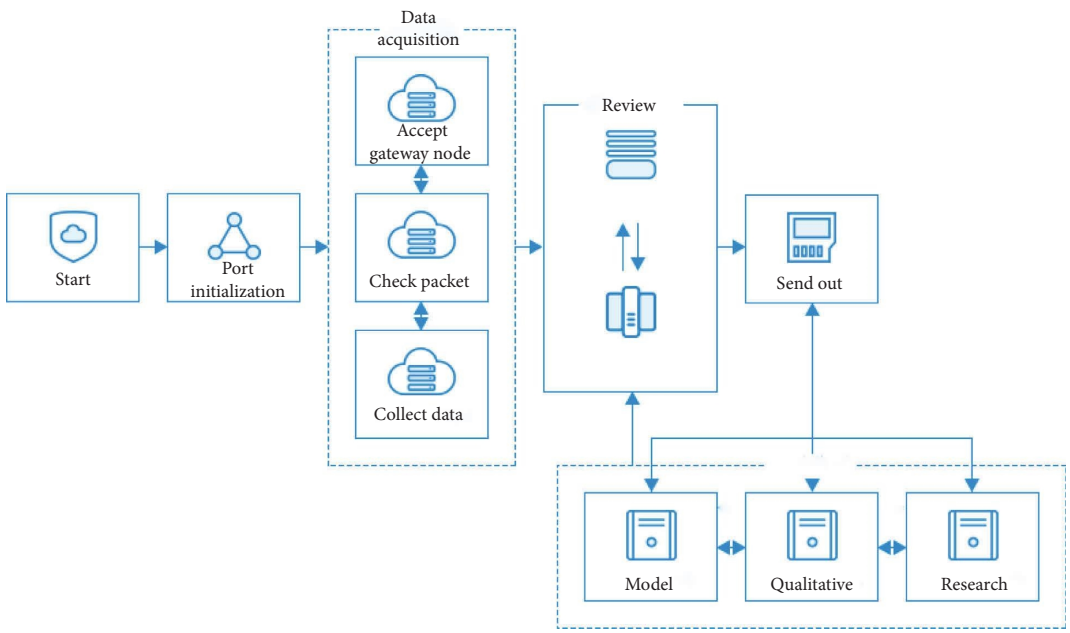


Figure 2: Module of intelligent closed-loop processing.

distribution model. The regular distribution feature is described as follows:

$$F(x) = \frac{\int_{-\infty}^{x} \exp(x-\mu)^2 \mathrm{d}x}{\sqrt{2\pi\delta}} + \frac{x^2-\mu^2}{2\delta^2} \int_{\infty}^{x} \exp\left(\frac{x}{k}\right) \mathrm{d}x. \tag{3}$$

In method

(3) μ is the self-assurance parameter of the wise manufacturing functionality comparison model; δ is a scale parameter; and k is the studying parameter of smart manufacturing functionality evaluation. According to the statistical characteristic quantity, popular ordinary evaluation is carried out to reap the self-belief distribution chance distribution characteristic of clever manufacturing functionality contrast as follows:

$$F(x) = \frac{\left(\int_0^x (x-\mu)^2/\sqrt{2\pi\delta}\right) + \int_{\infty}^{x} \exp\{\ln(x/K)-\mu\}\mathrm{d}x}{\left(x^2-\mu^2/2\delta^2\right)}. \tag{4}$$

According to the poor bias of smart manufacturing functionality evaluation, the chance distribution characteristic of reliability distribution of wise manufacturing functionality is obtained via the usage of the technique of binary parameter evaluation as follows:

$$F_L(x) = \frac{\int_0^x (\delta/k)(x/k)^{\delta-1} \exp\{\ln(x/k)-\mu\}\mathrm{d}x}{x^2-\mu^2} + \int_{-\infty}^{x} \exp\left(-\frac{x}{k}\right)\mathrm{d}x. \tag{5}$$

Combined with statistical decision and fuzzy decision method, the generalized extreme value distribution function of intelligent manufacturing capability evaluation is obtained as follows:

$$F_G(x) = \frac{\int_0^x \exp\left\{[1+(k/\delta)(x-\mu)]^{(1/k)}\right\}\mathrm{d}x}{\left(x^2-\mu^2\right)\int_{-\infty}^{x} \exp(-(x/k))\mathrm{d}x}. \tag{6}$$

The gamma probability distribution function is as follows:

$$F_G(x) = \frac{\int_{-\infty}^{x} (x-\mu)^{k-1} \exp[\mu - x/\mu]\mathrm{d}x}{\Gamma(k)} + \frac{\int_0^x \exp\left\{[1+(k/\delta)(x-\mu)]^{(1/k)}\right\}\mathrm{d}x}{x^2-\mu^2}. \tag{7}$$

According to the above distribution feature shape for the contrast of wise manufacturing capability, the following complete inspection components for clever manufacturing functionality is fashioned by way of the usage of the traits of goodness of in shape take a look at method:

$$H = \frac{(F_T(x,y)/\partial\theta)(\partial F_T(x_{t-1},y)/\partial\theta)(\partial F_T(x_{t-2},y)/\partial\theta)\cdots(\partial F_T(x_1,y)/\partial\theta)}{\alpha_{jy}\left(\chi^2\right)+\beta(ks)+\gamma(\delta)} + \frac{P_{tj}(PP)-R_{tj}(RM)}{P_{av}(PP)-R_{av}(RM)}. \tag{8}$$

4. Experiment and Analysis

4.1. Analysis of Digital Maturity Score. The pattern facts and the anticipated output cost of the pattern statistics transformed from the assessment indexes have been determined. It is solely critical to divide the information in accordance to the coaching set and the take a look at set, carry them into the community assessment mannequin for education and testing, and then evaluate and analyse the accuracy of the take a look at consequences of one-of-a-kind community comparison models, so as to decide that the assessment mannequin proposed in this paper is extra appropriate for this research. Finally, the mannequin after the education is used to consider the ultimate assessment index records of the subsidiaries, and the smart manufacturing functionality maturity degree is bought to pick out its sensible manufacturing level.

Take the four-dimension symptoms as an example, as proven in Figure 3 the case corporation has a notably excessive diploma of digital maturity at the strategic and ecosphere levels and a surprisingly low diploma of operational science and cultural enterprise ability. In particular, the diploma of digitization at the operational science degree is nearly equal to the authentic state. It can be inferred that the employer management has realized the significance of digitization and formulated applicable strategies; however, great measures nonetheless want to be implemented. From the standpoint of operation technology, the very best rating of order administration digitization maturity is solely 0.792, whilst the ratings of manufacturing fine management, actual logistics, and grant chain collaboration are low, which are 0.070, 0.261, and 0.284, respectively. This suggests that the digitization of the case organization in the fields of production, manufacturing, and provide chain has no longer but commenced or has simply started, which is the weak spot of organization digitization.

According to the classification approach and blended with the precise data of the surveyed enterprises, character businesses are categorised and adjusted, and the digital maturity rankings of manufacturing organizations of exceptional industrial kinds are calculated, respectively, as proven in Figure 4.

It can be viewed from Figure 4 that capital-intensive manufacturing organizations have the easiest digital maturity of 2.343 points, accompanied by way of technological know-how-intensive companies with 2.255 points, and labour-intensive companies have the lowest digital maturity of 2.003 points. This end result additionally essentially conforms to the digital maturity popularity of manufacturing enterprises, that is, the labour-intensive companies with the lowest dependence on technological know-how and gear regularly lack the riding pressure for digital construction, and the digital stage is low, whilst the technological know-how-intensive organizations with the very best dependence on technological know-how and gear regularly make investments solely a small quantity of money in key science lookup and improvement due to the lack of authentic accumulation of funds. The funding in the digitalization has been correspondingly reduced, and the digitalization maturity is barely decreasing than that of capital-intensive enterprises. However, capital-intensive corporations with enough capital accumulation and

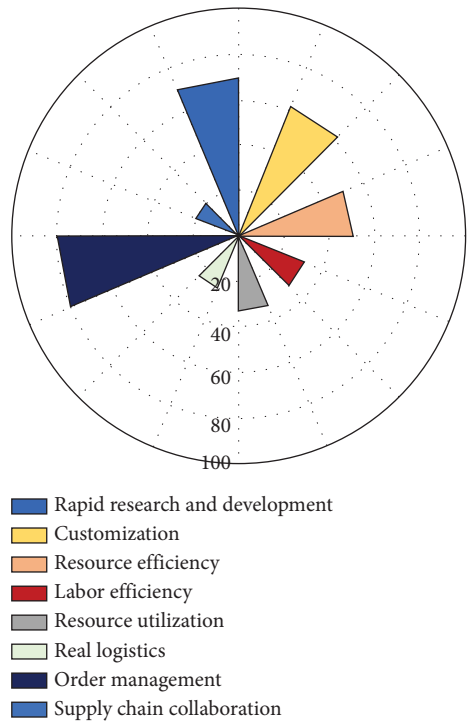


Figure 3: Comparison of digital maturity evaluation index scores of operation technology dimension.

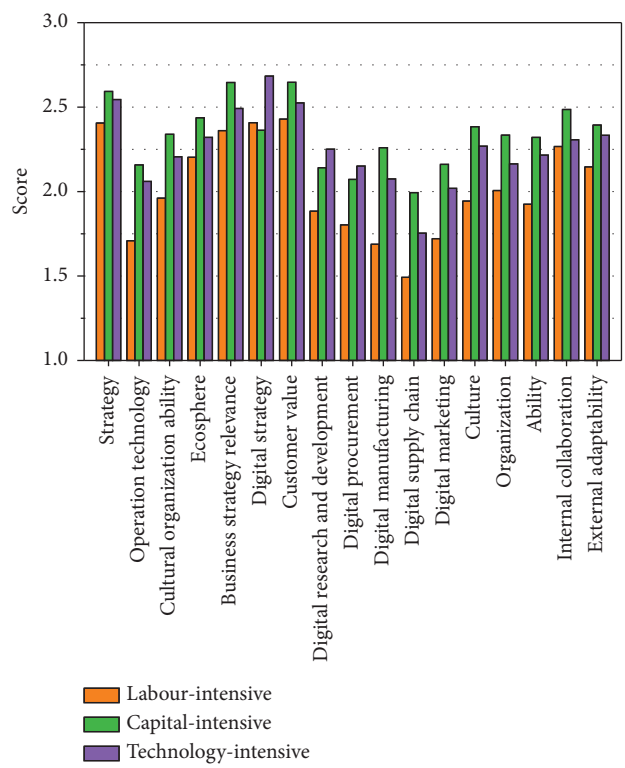


Figure 4: Digital maturity scores of manufacturing enterprises of different industrial types.

mature science accumulation normally have higher functionality and motivation to put into impact digital initiatives. That is, although the modern utilized sciences of these corporations are very mature, it is these mature utilized sciences that make these organizations regularly face technological understanding dependence inertia. Therefore, companies are eager to make structural adjustment via digital upgrading, break the historical science lock, and gather new leapfrog development.

As proven in Figure 5, the digital maturity of the four-dimension segmentation warning signs of specific kinds of manufacturing firms can be plotted. It can be considered from the parent that capital-intensive companies have benefits in phrases of relevance to commercial enterprise strategy, focusing on purchaser value, digital manufacturing, digital provide chain, digital marketing, culture, organization, ability, inside cooperation, and exterior adaptability. Technology-intensive agencies have blessings in long-term digital approach oriented, and digital procurement. Labour-intensive organizations have no indications with apparent advantages. Manufacturing corporations of distinctive industrial kinds have specific emphasis on digital upgrading. For example, capital-intensive businesses have increased benefits in the area of digital manufacturing, while science-intensive companies have apparent benefits in the subject. When one-of-a-kind kinds of businesses behaviour digital upgrading, they have to absolutely think about their very own attributes and characteristics, hold the first mover gain in their fields, and research from the incredible digital ride of different sorts of enterprises, so as to comprehend the complete digital upgrading of enterprises.

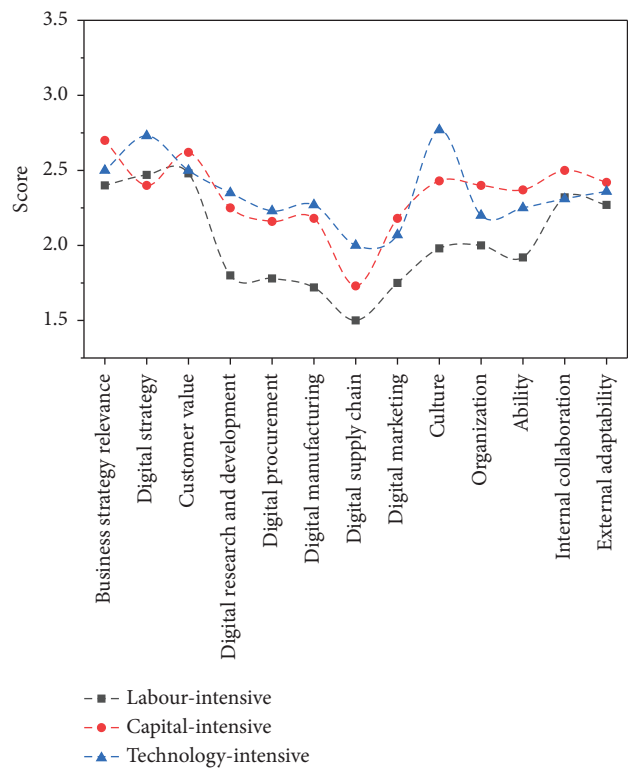


Figure 5: Digital maturity score of four-dimension segmentation indicators of different types of manufacturing enterprises.

4.2. Comparative Analysis of Evaluation Model Training and Testing. Through theoretical research, it is located that the populace measurement and the wide variety of iterations have an excellent have an impact on the optimization impact of the optimization algorithm. When the populace is too small, the algorithm converges quickly; however, the opportunity of nearby extremum is high, which makes it tough to iterate to the most fulfilling fitness. If the variety of populations is too large, the complexity of optimization will be extensively increased, and the search time of the algorithm will be prolonged. In addition, too much iterations will limit the variety of the population. Therefore, excellent populace dimension and generation instances are useful for the algorithm to discover the fantastic solution. Therefore, this paper compares the overall performance of the BP model, the PSO-BP model, the SSA-BP mannequin, and the FASSA-BP mannequin proposed in this paper from the same, most useful populace dimension and generation times.

After placing the parameters of every model, the preprocessed pattern information is entered into the FASSA-BP model, the SSA-BP model, the PSO-BP mannequin and BP mannequin, respectively, for education and testing. First, the education samples are entered into the 4 fashions for training. After the education is completed, the take a look at stage is entered. After countless iterations, the assessment consequences between the contrast values and the actual values of the samples of the mannequin check set are obtained, as proven in Figure 6.

In consideration of the exceptional outcomes of every run of the neural community algorithm and the smart optimization algorithm, the 4 algorithm fashions are run for 30 instances, respectively, and the common price of the experimental effects of the overall performance comparison indexes of the special fashions is compared, as proven in Figure 7.

In order to in addition take a look at the superiority of the FASSA-BP algorithm, the top-of-the-line parameters of the FASSA-BP algorithm, the SSA-BP algorithm, and the PSO-BP algorithm underneath the ultimate health are chosen and their algorithm overall performance is analysed through experiments. Similarly, the preprocessed pattern facts are entered into the FASSA-BP model, the SSA-BP mannequin, the PSO-BP mannequin, and the BP model, after various iterations, the comparison values of every mannequin are obtained and in contrast with the actual values, as proven in Figure 8.

The FASSA-BP model, the SSA-BP mannequin, and the PSO-BP mannequin are respectively set with the finest populace dimension and the quantity of iterations. Since the strolling time of the three algorithm fashions is too lengthy below the situation of the top-of-the-line populace dimension and the wide variety of iterations, the FASSA-BP model, the SSA-BP mannequin, and the PSO-BP mannequin are run for 20 instances, respectively, and the common cost of the experimental end result facts of every mannequin in

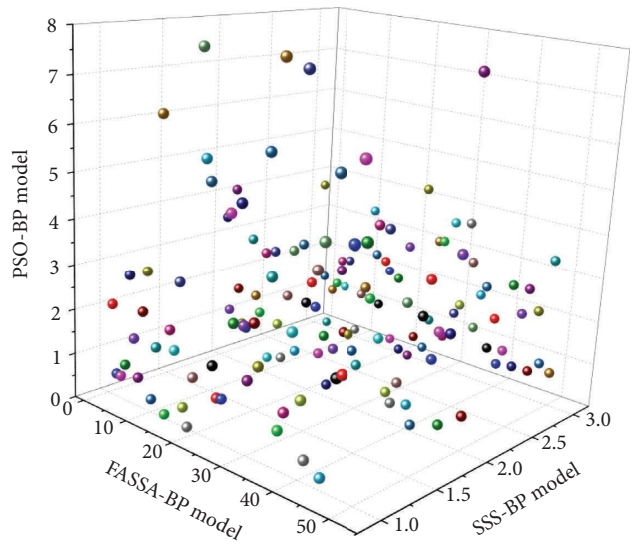


Figure 6: Expected output value and actual output value of different model test sets.

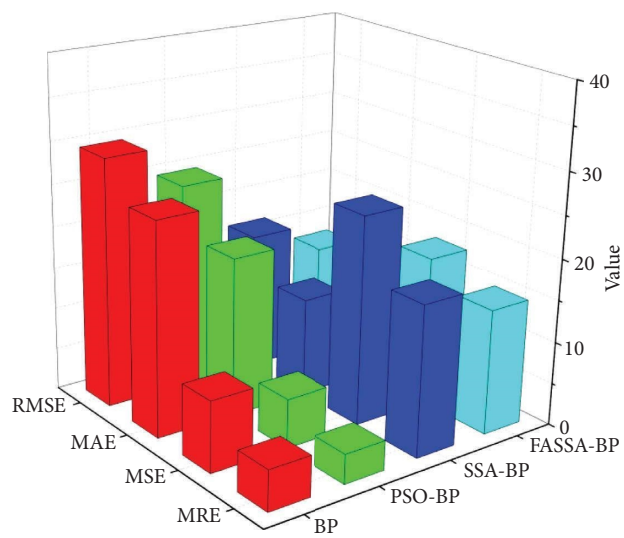
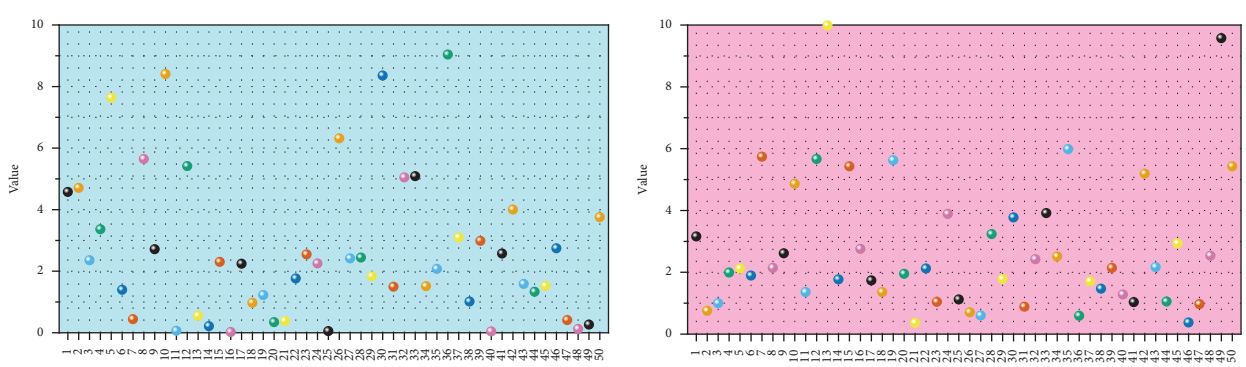
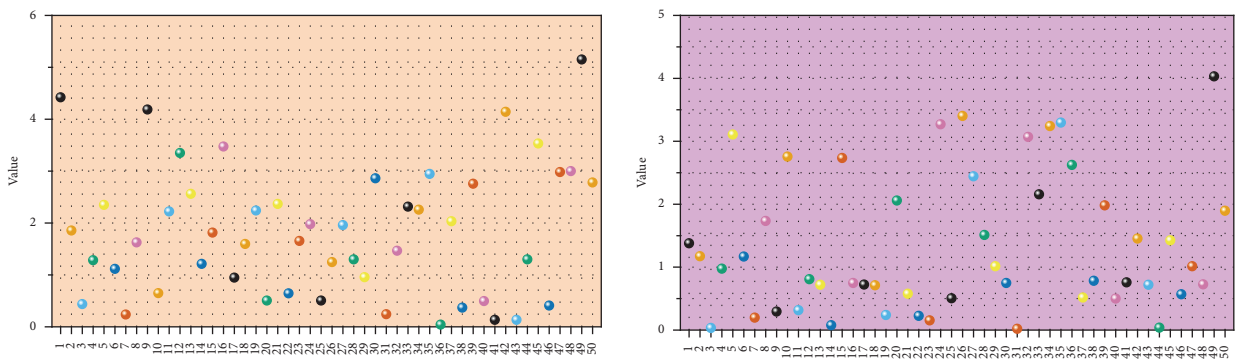


Figure 7: Performance evaluations of four models based on the same population size and iteration times.



(a) (b)

Figure 8: Continued.



(c) (d)

Figure 8: Test sets of each model based on the optimal population size and iteration times. (a) BP. (b) PSO-BP. (c) SSA-BP. (d) FASSA-BP.

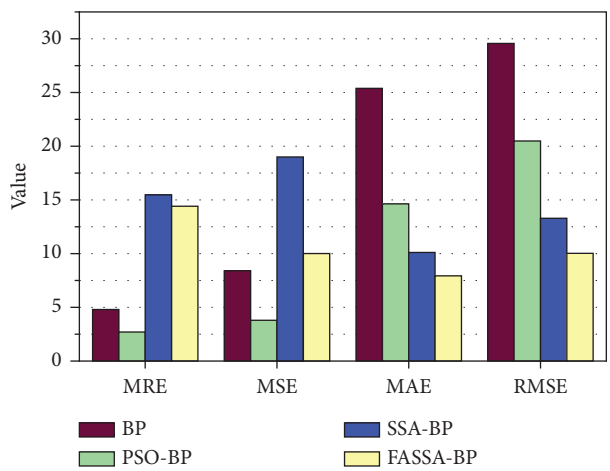


Figure 9: Data results of four model performance evaluation indexes based on optimal population size and iteration times.

the overall performance contrast index is calculated to analyse and evaluate the overall performance of these models, as proven in Figure 9.

5. Conclusion

Aiming at the issues that companies cannot completely apprehend and recognize the wise manufacturing capability, lack of systematic and scientific improvement positioning and course planning, especially the doubtful definition of the improvement stage of intelligent manufacturing in which firms are located, and lack of capability analysis in the development of shrewd manufacturing, this paper constructs an shrewd manufacturing functionality comparison and prediction mannequin-based totally on utilized mathematical modelling. Design a preliminary evaluation index computing device to apprehend the distinction of the equal sort then again one-of-a-kind entities. Input the comparison facts of the business enterprise to be evaluated into the prediction mannequin to gain the sensible manufacturing functionality maturity fee of the enterprise. It realizes the computerized comparison of clever manufacturing capability, saves human cost, and improves the accuracy of evaluation. It solves the troubles of manufacturing agencies such as lack of deep grasp and appreciation of smart manufacturing, inaccurate identification of their personal sensible manufacturing improvement stage, unscientific self-evaluation and diagnosis, and can assist businesses analyse the troubles in clever manufacturing construction, Formulate measures to enhance the maturity degree of business enterprise-shrewd manufacturing abilities and promote the transformation and upgrading of agency sensible manufacturing. There are moreover some troubles to be improved in this study. In the study, the constructing of the evaluation index computer of smart manufacturing performance maturity wants to be increased scientifically. How to think about the dynamic have an impact on elements at unique tiers in the improvement of shrewd manufacturing and optimize the mannequin through the use of smart optimization algorithms.

Data Availability

All data, models, and code generated or used during the study appear in the submitted article.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Acknowledgments

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Research Article

Evaluating the Quality of Engineering Translator Training Based on the DEA Model

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This paper adopts the DEA model to conduct in-depth research and analysis on the evaluation of the quality training of engineering English translation talents. The BIM application performance of nine engineering projects is empirically analyzed, including slack value analysis, correlation validity analysis, and BIM application performance path optimization. The nine cases have an unreasonable allocation of resources invested in BIM application in the early stage so that the performance path optimization is carried out to find out the key paths for the reallocation of resources. Further analysis of BIM application performance improvement strategies, including strengthening the training of BIM application professionals. The fuzzy two-stage DEA model with adjustable fuzzy opportunity constraint constructed for the situation where both intermediate and final processes have non-desired outputs. First, the additive efficiency decomposition model in the exact number environment is extended to the non-desired output situation. Second, the generalized fuzzy measure and opportunity constraint planning are applied to further extend the model to a non-expected output fuzzy DEA model, and a two-stage DEA model with adjustable fuzzy opportunity constraints is constructed. There are still some differences between the two. Strengthening practice is the general trend of current curriculum reform in our country. Finally, the proposed model is applied to the evaluation problem of quality training of engineering English translators. The adjustable fuzzy opportunity-constrained DEA model proposed in this paper can effectively evaluate the efficiency of real production and operation activities. The research results of this paper not only enrich the existing DEA model theoretical system but also have broad application prospects and values in practical problems. We provide a reasonable guarantee in terms of system and funding and pay attention to the follow-up communication with employers to strengthen the implementation of the influence of social forces on the quality evaluation of English teaching in higher education. To a certain extent, this study enriches the theoretical research on the quality evaluation of English translation talents' quality training and can play a role in strengthening and improving the quality evaluation of translation talents' quality training at the present stage.

1. Introduction

The progress of science and technology has simultaneously promoted the development of English for Special Purposes. Special-purpose English refers to English about a field, such as legal English, technical English, agricultural English, business English, etc. Engineering English is one of the special-purpose English (ESP), and its main function is to disseminate and promote scientific and technological knowledge in this field worldwide. Engineering English is analyzed and studied from the perspective of the interpretive school theory. Although the theory of the interpretive school mostly used to guide the practice of interpretation, its translation idea of attaching importance to the communication of meaning in translation without adhering to the form of language is also a great guide in the practice of translation [1]. The theory of this school helps the author to be able to put aside the bondage of words and phrases in the translation process and pursue accurate translation based on understanding words and phrases. Engineering English translation is professional, straightforward, simple in language, and logical and requires clear and specific meanings of statements and strong operability; therefore, it is not a new idea to use the theory of the interpretation school to

guide engineering English translation. In terms of theory, the research on this topic can enrich the connotation of talent evaluation to a certain extent. At the same time, the education evaluation dimension can also be broadened to a relevant extent [2]. Due to the limitations of the observations themselves, our statistics are not yet able to demonstrate that translators have conducted translation quality assessments during the meaning assumption stage, the unformed translation stage, and the post-delivery stage of the translation process. At present, scholars in our country are devoted to introducing the results of the existing research experience in western countries and the application of these results to the evaluation of university education. In those research studies, the problem that the research objects are not clear enough also revealed; especially, the evaluation of talents of specific majors is very little. Through combing, we can easily find that the research subjects of these studies are also talent training units, education supervisory departments, teaching practice, etc. There is no research on quality evaluation systems in terms of necessary social demand, school-enterprise collaborative education, enterprise participation, student satisfaction, etc. Therefore, based on the research results of previous scholars, this topic enriches and improves its theoretical basis, expands the evaluation subjects from training units and management departments to a multi-perspective talent training quality evaluation system for schools, enterprises, students, and social needs, and provides new ideas for education evaluation [3].

Due to the scarcity of educational resources, the evaluation of educational performance can improve the efficiency of resource allocation under the existing educational resources. It reduces the waste of educational resources, i.e., same output, lower consumption, or high output, low consumption. In contrast, the current situation of higher education in China focuses more on quantity increase than quality improvement. Therefore, it is important and urgent to study the efficiency of higher education. Only through such efficiency assessment can we timely identify unreasonable problems in resource allocation, make timely adjustments and adjustments, and thus improve efficiency. In the process of establishing the BIM application performance index evaluation system, the balanced scorecard is used as the theoretical framework to expand the research field of the balanced scorecard method and further improve the performance evaluation theory. In addition, the data envelopment analysis method is used in the three-stage network DEA model for BIM application performance evaluation, which has been rapidly used and developed in the fields of banking, medical, environment, and supply chain since its introduction, but is relatively lacking in the construction field, is conducive to the further improvement of BIM evaluation theory [4]. The establishment of a performance evaluation system is conducive to the structure of the BIM application management body and capital investment allocation of construction enterprises, the training of BIM professionals, and the establishment of BIM-related standards. The conclusion of the study can provide reference and reference for construction enterprises to improve the performance of BIM application and help promote the promotion and application of BIM in the construction industry, which will enhance the core competitiveness of construction enterprises and accelerate the speed of construction industry reform and realize the construction enterprise information construction. This part of the cost investment is mainly to stimulate the enthusiasm of the staff and avoid the loss of professional talents, and at the same time, it can attract other outstanding professionals to introduce into the project management, thereby improving the management level.

However, with the smooth development of the whole economy, the supply and demand relationship in the talent market has undergone significant changes, coupled with the increasing adjustment, and upgrading of the industrial structure, resulting in increasingly serious structural contradictions in the field of education, and there is a significant tendency of homogenization. Although China has been creating more employment opportunities, it still cannot alleviate the problem of difficult employment and low employment level of graduates, which fully demonstrates that the talent cultivation mechanism constructed by the current higher education is obviously out of line with the development needs of society. In particular, the shortage of innovative, application-oriented, and practical talents is due to the unsound cultivation mechanism of such talents, which leads to the low quality of cultivated and delivered talents and cannot meet the real demand for industrial restructuring and upgrading. In addition, despite the serious talent shortage problem faced by major enterprises, they have always been stagnant and have fully realized the importance of participating in school-enterprise cooperation, resulting in very limited cooperation targets that can be screened by major universities.

2. Related Works

Data Envelopment Analysis (DEA) has been applied and developed in many fields around the world and has become an effective method for the same type of inputs and for generating relative efficiencies in multiple production or non-production sectors. This method is based on single-objective linear programming, which maximizes the output within a defined set of production possibilities or fixed inputs, or fixes the output while minimizing the inputs [5]. The inverse of the maximum expansion ratio of its outputs or the minimum reduction rate of its inputs is defined as the relative efficiency of the decision unit. While the former is called output DEA, the latter is called in DEA. In terms of the selection of data envelope indicators, Moorkens et al. selected faculty salaries, fixed asset expenditures, and recurrent expenditures as input indicators, and the number of university graduates, graduate graduates, and government research grants as output indicators to inquire into the overall teaching efficiency of higher education [6]. At this stage, the average technical efficiency was 0.467, which did not reach the level where the effective value of technical efficiency was 1.00. In contrast, Correia et al. examined the overall operational efficiency of higher education with the percentage of faculty with doctoral degrees among all faculty, the student-

teacher ratio, the cost of education per student, the average student enrolment score, and the average tuition per student as five input indicators, and the student graduation rate and the first-year enrolment rate, which can indicate student satisfaction, as output indicators [7]. Papadimitriou used the DEA model to analyse the productivity of schools and concluded that the lack of competition crisis in schools is a possible reason for their lack of efficiency, and it pointed out that increasing the level of competition among schools is the top priority for the reform of the education management system. In terms of school efficiency, Papadimitriou et al. used a DEA model based on public goods and human capital theories [8]. The basic theories of cost investment and education effectiveness assessment in universities are discussed and analyzed.

The practical communicative purpose of engineering English translation determines that the translator should focus on the readers of the translated text and aim at achieving the reproduction of the meaning of the original text so that the translation can produce the same effect as the original text in the readers; thus, in the choice of strategy, the translator should try to present the readers with the language that conforms to the way of thinking and expression habits of the translated language readers [9]. In this paper, when analysing the translations, we take the target language receivers as the guide and focus on the complete expression of the meaning of the original text. The author believes that the translation of engineering English should follow three principles of accuracy, conciseness, and standardization [10]. First, language innovation is a difficult point faced by translators in translation, and translators should reasonably handle the balance between innovation and fidelity [11]. The theory of the interpretive school attaches great importance to the study of the translation process, focusing on the intermediate process of detaching from the language shell, believing that people in communication want to understand the information that the other party tries to express, which is the fundamental purpose of communication [12]. The translation is not a simple conversion of linguistic codes, but the transmission of meaning through interpretation.

The phenomenon of lexical shift is very common in English. In translation, lexical conversion is the method of switching from one lexical function to another. We all know that translation is never a mere conversion of word to word. According to the theory of interpretation, translation means "interpretation," and translators should not only pursue the equivalence of language units. The application of BIM in engineering projects was basically recognized by the project participants, but it did not reach a level that satisfies them. To translate conform to the norms of the translated language in the context of the translation, and to fully convey the original language information needed to achieve the intended function of the translation, it is usually necessary to make word-to-word conversions according to the linguistic characteristics of English. Translation quality self-assessment in this study, unless otherwise specified, includes not only the translator's quality assessment of the finished translation but also the translator's quality assessment behaviour during the translation production process. In this study, translation quality self-assessment refers to the translator's judgment of the finished translation, the formed translation fragments, and the unformed translation in terms of rightness, goodness, and conformity to standards.

3. DEA Model Design for Quality Evaluation

Addressing the most important objectives and functions of the DEA model, the input-output efficiency can reflect the overall efficiency when the DMU is in a state of constant revenue. Technical efficiency can reflect the input-output efficiency of the assumed DMU in the state of optimal scale gain, while scale efficiency is a relative measure of the current state of DMU scale gain and optimal scale by analysing the comprehensive efficiency, the combination of technical efficiency and scale efficiency, the relative efficiency of DMUs of different scales can be identified to provide targeted suggestions for management decisions [13]. These values can reflect the degree of input-output deficiency or redundancy, and their role is mainly to help propose management strategies and guide decision-makers to make more accurate input-output corrections.

As the evaluation object of DEA, a decision-making unit (DMU) refers to an entity that converts certain inputs into certain outputs, which can be an organization such as a bank, hospital, or supermarket, or a separate individual such as an airplane, computer, or athlete. Therefore, the application of BIM there needs to be some innovation in the presentation of the effect. In addition, the DEA model requires that the DMUs are homogeneous, i.e., each DMU has the same objective, the same external environment, and the same input-output metrics. If the decision units do not satisfy the above conditions, some processing is required before the DEA model can be used for efficiency evaluation.

If the set of production possibilities satisfies the above four assumptions, then T can be expressed as

$$T = \left\{ (X, Y) | \sum_{i=1}^{n} \lambda_i X_i \geq X, \sum_{i=1}^{n} \lambda_i \leq Y, \lambda_i \leq 0 \right\}. \quad (1)$$

The CCR model is a DEA calculation model proposed by Charnels with the concept of engineering efficiency, which assumes constant payoffs of scale to measure the relative efficiency of decision units, and the efficiency value calculated by this model is called technical efficiency,

$$h_j = \frac{u_{ic}^2 Y_{ic}^2}{v_{ic}^2 X_{ic}^2}. \quad (2)$$

The above equation shows that the output value determines the production efficiency of the decision unit under the assumption of constant inputs. In addition, to evaluate the effectiveness of the decision unit using the above model, it is necessary to calculate the maximum efficiency index in the decision unit and use this value as the target, which constitutes a model expressed in fractional form as in equation (3),

$$(\mathrm{CCR}) = \begin{cases} \min \dfrac{u_{ic}^2 Y_{ic}^2}{v_{ic}^2 X_{ic}^2} = h_i, \\ \dfrac{u_{ic}^2 Y_{ic}^2}{v_{ic}^2 X_{ic}^2} \geq 1, \quad i \in N, \\ u \leq 0, \qquad v = -1, \\ u > 0, \qquad v \neq -1. \end{cases} \tag{3}$$

The above model shows that the technical efficiency of DEA is determined by the output-to-input ratio, so the technical efficiency range is between 0 and 1, which means that the larger the technical efficiency value of a decision unit, the closer it is to the technical production level of the industry. In particular, the technical terminology mentioned above has always been a headache for many technical translators but cannot be avoided, all of which require translators to have a certain breadth and depth of professional knowledge. Since the performance evaluation is set by multiple factors and multiple aspects of performance, it needs to be weighted in the process of calculation, and there are two main ways to weight the data: The first one is to conduct a weighting process on the data through subjective ways such as communication and consultation with experts or literature review; the second one is to use data envelopment analysis to obtain input and output weights through the data itself [14]. The second one, which is to use data envelopment analysis to obtain input and output weights through the data itself, eliminates the influence of human factors on the data and makes the data more accurate.

The technical efficiency calculated by the DEA model is called "relative efficiency" because the evaluated object is obtained by comparing it with other evaluated objects through the mathematical planning method. Therefore, mathematical planning can be used to obtain an external effective production envelope consisting of each decision unit, and the frontier surface can include the observation points of the input/output values of the evaluated object, which is the reason that the DEA model is called data envelopment analysis. The decision unit corresponding to the point in the frontier surface is called a technically effective unit (or weak DEA effective unit) with an efficiency value of 1. Conversely, the decision unit corresponding to the point outside the frontier surface is called technically ineffective with an efficiency value less than 1. The frontier surface is used to find the location of the corresponding technically effective point, as shown in Figure 1.

The first stage refers to the learning and growth dimension as an input item and the internal operation process dimension as an output item [15]. In this stage, it mainly measures the technical personnel to use BIM to innovate and develop new management mode or apply practical techniques such as mode to help or assist the management activities of engineering projects and improve the efficiency of engineering management, that is, this stage is called the transformation stage of BIM application results.

The second stage refers to the use of a new management model and technology, i.e., internal operation process dimension as input items, and whether it can improve the recognition of the owner or other participants, i.e., customer dimension as output items. The translation thought that does not stick to the form of language also has a great guiding role in the practice of translation. In this stage, the main measurement is whether BIM, as a new building information management model, has achieved the expected expectations for the participants. As BIM is promoted and used mainly by owners and other participants to promote the application and development of BIM in China's construction industry, that is, this stage is called the BIM application effect demonstration stage.

The third stage refers to the customer dimension as the input item and the financial dimension as the output item. This stage mainly refers to the overall performance effect of BIM application in the economic dimension under getting the owner's affirmation of BIM application in engineering projects, whether it can help engineering projects to reduce economic input, that is, this stage is called the BIM application economic benefit transformation stage.

Using the network DEA model to study the performance of BIM applications is of great significance. First, the network DEA model can identify the key index factors that affect BIM application in the evaluation system. Second, the network DEA model analyzes each index and finally optimizes the performance evaluation system. Third, the results of the efficiency value of each stage to find out the key indicators at that stage are significant for promoting the development of BIM application and the overall level of performance improvement,

$$\%P = \begin{cases} \max u_{ic}^2 Y_{ic}^2 = Vh_i \\ W^T x_i + u^T y_{yj} \geq 1, i \in N \\ u^T y_{yj} \leq 0, v = -1 \\ W^T x_i > 0, v \neq -1 \end{cases} \tag{4}$$

First, the efficiency values of each system cannot be calculated separately if it will lead to high-efficiency values and prompt distortion of data [16]. This school theory helps the author to put aside the constraints of words and sentences in the translation process and pursue accurate translation based on understanding words and sentences. Second, the research in this paper uses a tandem network DEA model, so it is not possible to add input terms or output terms to the system in the external environment, which will also lead to distortion of the data.

The design of any assessment index system has a corresponding direction to serve the social and economic needs. Before developing a reasonable assessment indicator system, we must have a clear assessment direction. On the other hand, if the basis of the research is different, the proposed assessment index system will also be different. Therefore, the direction of higher education performance assessment is to understand the performance of the higher education system and to clarify the causes of the differences in higher

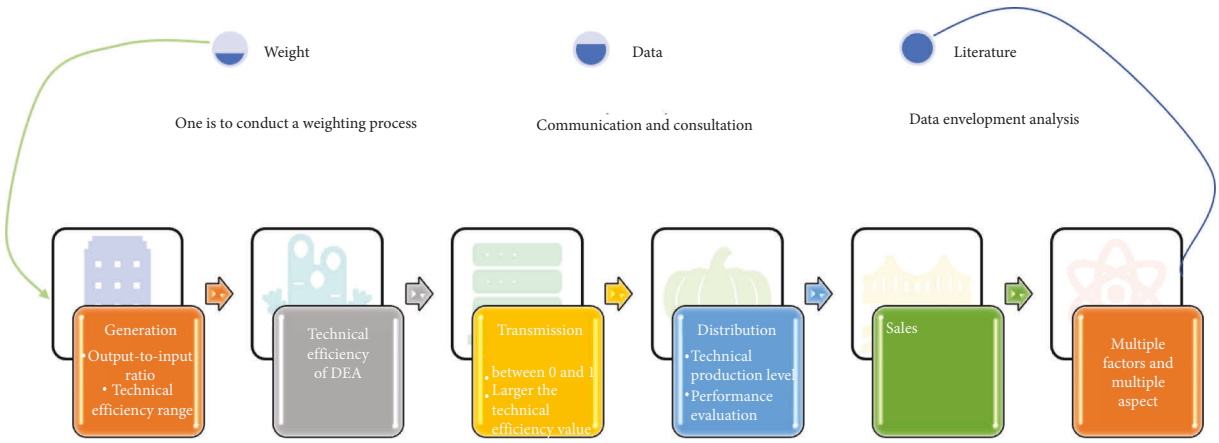

Figure 1: DEA model.

education performance in different places. The key is to improve the higher education system in regions with low supporting performance and to move in the right direction. Therefore, in the process of developing higher education performance assessment indicators, it is necessary to collect data with an eye to the direction of higher education performance assessment. The established system of performance evaluation indicators can fully reflect the purpose of higher education performance evaluation, as shown in Figure 2. There is no research on the quality evaluation system in terms of social necessary needs, school-enterprise collaborative education, corporate participation, and student satisfaction.

The design of the evaluation index system should be based on scientific research theories and combined with practical experience. First, an objective and scientific evaluation method should be found, and the evaluation index system constructed under the guidance of this method should reflect the real situation of the evaluated objects. The evaluation indexes in this evaluation index system should have clear and definite meanings and fully reflect the connotation and essence of higher education performance,

$$\lambda^2 = \frac{k \times \sum_{i=1}^{k} R_i^2 + \left(\sum_{i=1}^{k} R_i\right)^2}{n}. \tag{5}$$

The development of evaluation indicators should form a hierarchy of all selected indicators and an intrinsic evaluation indicator system [17]. The education system is a special whole with several components, which are independent of each component, but inextricably linked with these subsystems. First, it is necessary to establish the goal of the evaluation, i.e., the ultimate purpose of the evaluation, what problems are to be reflected, and what situation is to be responded to. Of course, it is necessary to reflect all relevant information about the object to be evaluated as much as possible. To improve objectivity, it is also necessary to select indicators from various levels and perspectives. The indicators and parameters of the evaluation index system should be stable and simple, and the reference values used to calculate the relative values of the indicators should not be changed. There are uniform standards for the statistical calibre and scope of application of each evaluation indicator.

On the other hand, how to provide a set of operable talent cultivation strategies is another major difficulty of this study. As we all know, talent cultivation is a systematic project for higher education institutions, and the strategy of talent cultivation involves various aspects such as talent cultivation concept, major setting mode, curriculum setting mode, teaching system, teaching organization form, hidden curriculum form, teaching management mode, and education evaluation mode. In the process of establishing the BIM application performance index evaluation system, the balanced scorecard is used as the theoretical framework to expand the research field of the balanced scorecard method and further improve the performance evaluation theory. Therefore, it is more important to systematically think about how to cultivate such people than to propose a talent cultivation goal that meets the actual needs of society. Global governance talents are not a kind of purely professional talents, that is, they cannot be cultivated only by the professional education mode of the present universities.

4. Design of Quality Evaluation of Quality Cultivation of Engineering English Translation Talents

Safari believes that the main task of process evaluation is to document the real process of project implementation to provide the implementer with real information about the implementation of the program. The process of program implementation is documented to check whether the activities of the implementation phase are carried out according to the predetermined design, as well as to detect how well the program is carried out during implementation. The pre-designed activity plan may have some flaws. By documenting the process to reflect the real situation, the process evaluation implementation process allows further modification and improvement of the program design based on the actual situation of the implementation process. Process evaluation in essence belongs to formative assessment finally [18]. The process of cooperation between schools and enterprises is to put the design of the training program into real action, integrate the relevant resources of

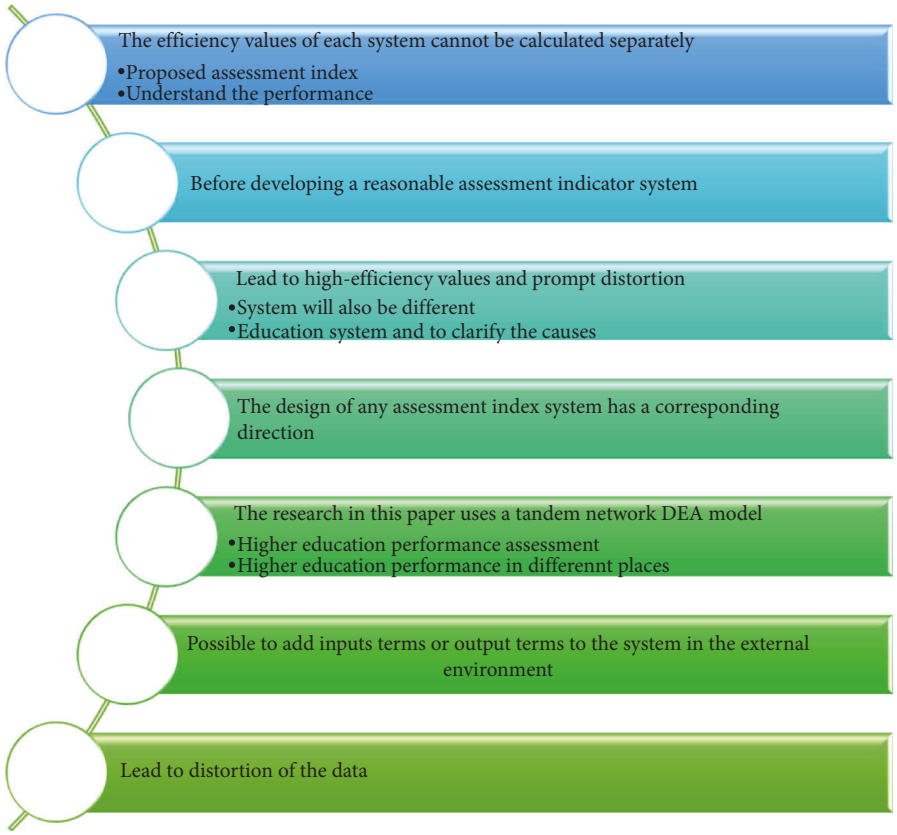

Figure 2: Steps of quality evaluation.

schools and enterprises, and carry out practical teaching of relevant courses under the constraints of the established system. In the process evaluation, "resource utilization," "curriculum implementation," and "system of implementation" are used as secondary indicators.

Although both process evaluation and input evaluation examine the integration and utilization of resources, input evaluation examines the design of resources, while process evaluation mainly examines the use of resources in the training process, and there are some differences between them. Reinforcing practicality is the current trend of curriculum reform in China. Strengthen the connection between course content and students' future career development, and take practice orientation as the curriculum reform concept. Incorporate the current frontier of subject knowledge and excellent enterprise practice cases into the course content of school-enterprise cooperation talent training. This has led to increasingly serious structural contradictions in the field of education, and there is a significant tendency to homogenize. Adjust the course content timely according to the development of innovative technology and the demand of society for talents to lay a good foundation for students to adapt to society in the future. Innovative knowledge and the latest research results lead the direction of current professional development, and the process of course content development requires the implementer to have a keen insight to ensure that the most innovative knowledge and the latest research results can be provided to students [19]. Therefore, in the course content, "the frontier of professional subject knowledge and the latest research results of professional research" is set as an observation point.

The most important part of the hierarchical analysis is the construction of a hierarchical structure and the identification of the elements of each level. The DEA model also requires that the decision-making units are homogeneous, that is, each decision-making unit has the same target task, the same external environment, and the same input-output indicators. According to the above research results, the index system of talent training quality evaluation of school-enterprise cooperation in Dingle College of Hubei Normal University has been derived, and the interrelationship of each index has been sorted out. From the graphical structure, the next layer of evaluation indexes is all subordinate to the previous layer, and each subsystem of each layer is independent of each other without any connection, as shown in Figure 3.

The above statistical results tentatively prove that professional translators do conduct translation quality assessment at corresponding stages of the translation process and tentatively prove that translators' translation quality assessment behaviours run through multiple stages of the translation process. This provides practical data to support the shift of translation quality assessment research from focusing only on the translation quality assessment of final drafts to the study of both final drafts and translation quality

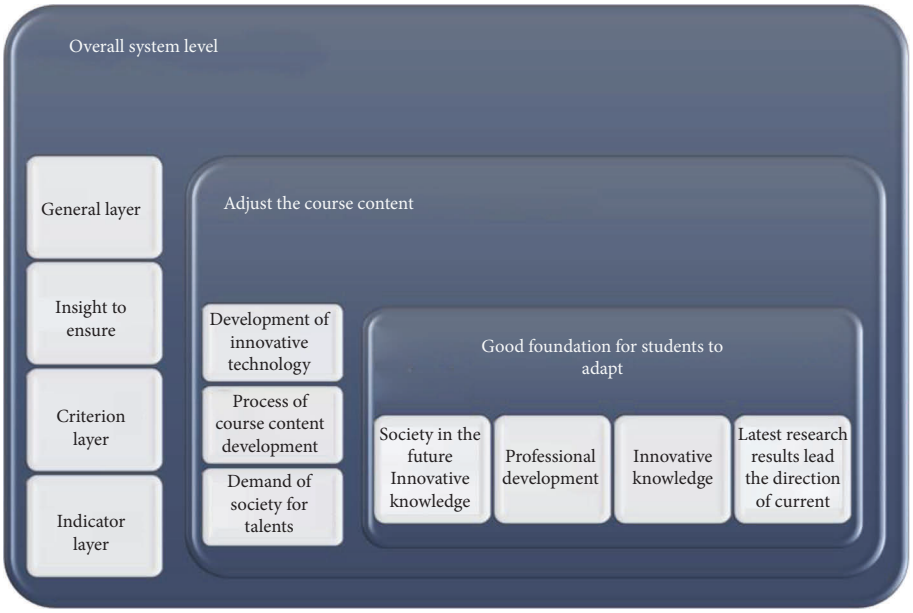

Figure 3: Hierarchical structure model of the talent quality training evaluation system.

assessment in the translation process. The data is weighted by subjective methods such as communicating with experts or consulting literature; the second is to use the data envelopment analysis method to obtain the input and output weights through the data itself, and eliminate the influence of human factors on the data, so that the data is more precise. However, as we said earlier, due to the limitations of the observation itself, our statistics cannot yet prove that translators conducted translation quality assessment at the meaning assumption stage, the unformed translation stage, and the post-delivery stage of the translation process. Validation of the relevant content will need to be further verified by subsequent prompt-based retrospective oral report analysis of the data.

For operational purposes, we used the evaluation objects listed in the questionnaire as observation points, specifically observed the professional translators' changes in translation expression, terminology, vocabulary and sentence patterns, changed the translation to make the meaning more accurate, changed the translation purpose to achieve the translation purpose, and changed grammar, spelling, sentence reading, and symbols. The reason for the addition of other content items is that they are not included in the translation. The reason for adding other content items is that the evaluation contents and objects we designed in the questionnaire may not fully reflect the contents and objects of translation quality evaluation conducted by professional translators in the actual translation process, as shown in Figure 4.

Studying the translation quality assessment criteria of professional translators with this method is indirect research. Further verification of the inference will be accomplished by subsequent analysis of the retrospective interview reports based on prompts. Moreover, this kind of inference based on revision behaviour does not fully reflect all the criteria on which the specific assessment behaviour of professional translators is based [20]. The translation quality self-assessment done by professional translators during the translation process is not always reflected in the final revision action, but there are many translation quality self-assessments beyond each revision action. Since some of the translation quality self-assessments reflect the translator's affirmation of an existing translation, what we see through the act of revision is only part of the translation quality self-assessment. In addition, as mentioned earlier, professional translators' translation quality assessment behaviours may also occur at the meaning assumption stage when the translation is not yet presented on the screen and at the unformed translation stage, which cannot be captured in the video-based observation of the recorded screen.

5. Results and Analysis

5.1. Performance Analysis of DEA Model for Quality Evaluation

5.1.1. DEA Equipment Purchase Cost. DEA equipment is the material basis that can help DEA application personnel to carry out DEA application activities. The use of basic equipment such as high configuration computers, mobile electronic devices, and professional software can improve the intensity of DEA application personnel to manage engineering projects and to better reflect DEA management ideas in actual engineering projects.

5.1.2. DEA Management Construction Cost. BBM management construction refers to personnel management and DEA application centre construction. Personnel management includes DEA application staff salary, reward and punishment system construction, and technical training costs; this part of the cost investment is mainly to motivate personnel to work and avoid the loss of professional talent, and at the same time can attract other excellent professional

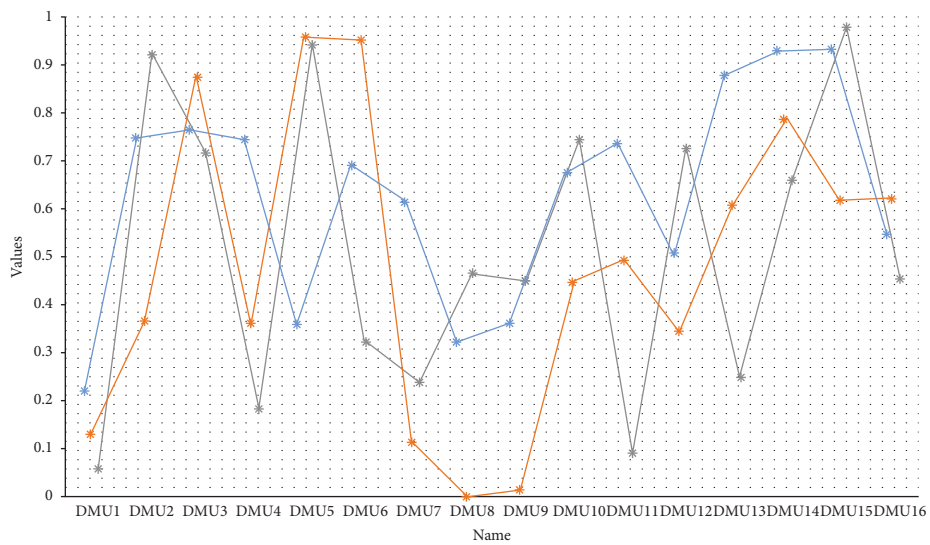

Figure 4: Input and output data.

talent into the project management, to improve the management level. DEA application centre construction refers to DEA application staff office environment construction and office space construction, which is the centre of management and coordination of the entire project.

5.1.3. Material Management Efficiency Improvement Rate. It refers to the use of DEA based on 4D schedule simulation and 5D cost simulation for reasonable planning of material entry plan, reducing unnecessary workforce consumption and financial waste. Therefore, this index represents the percentage of time and money saved by using DEA to the time and money consumed by not using DEA, which is the rate of improvement of material management efficiency.

Since the promotion and use of BIM is mainly driven by the owner and other participants to promote the application and development of BIM in the construction industry, this stage is called the BIM application effect display stage. Contract data management efficiency improvement rate: It refers to the chaotic phenomenon of making, storing, and retrieving the data and related contract management of construction projects in construction enterprises, which usually means that the on-site engineering component work has been completed, but the related materials have not been made yet; after applying DEA, the related contracts and data of construction projects can be associated with the DEA data platform, and they can be grouped and organized according to the rules and regulations to facilitate. The ratio of the time saved after DEA application to the original plan is the efficiency improvement rate of contract information management, as shown in Figure 5.

Next, the technical efficiency value from each stage is analyzed in stages. The first stage refers to the transformation stage of BIM application results: The highest conversion rate is 0.939 for project 4, which indicates that the BIM application personnel of this project actively innovate and reform the application of BIM in engineering projects to realize the

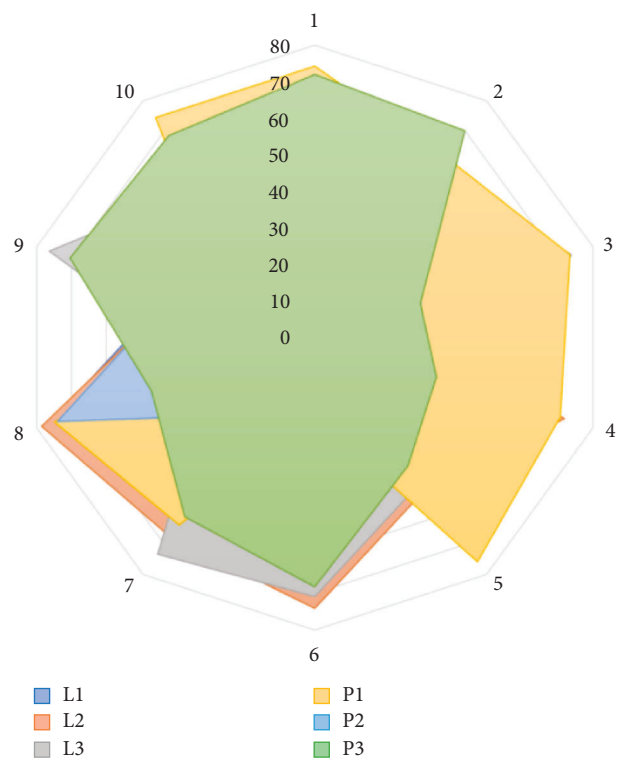

Figure 5: DEA model indicators by stage.

transformation of BIM theory to BIM application results, while the efficiency values of project 5, project 7, project 8, and project 9 are 0.083, 0.050, 0.075, and 0.045, respectively, are less than 0.2, so the conversion rate of these projects at this stage is not high, indicating that the combination of BIM and the actual effect is not good, and it is necessary to improve the way and method of BIM application to improve the combination of BIM and the actual engineering items if not improve will greatly limit the future development of BM and the promotion of the use in engineering projects.

The second stage refers to the BIM application effect display stage: The average value of technical efficiency in this stage is 0.467, which does not reach the level of technical efficiency effective value of 1.00. The application of BIM in engineering projects is recognized by the project participants, but it does not reach the level of their satisfaction, so the BIM application needs to be innovative in the effect display.

The global core values that global governance talents need to possess are the elements of values that they can uphold when they participate in global governance activities and permeate them in the negotiation process of global affairs, which can be used as the basis to obtain a consensus among multiple parties and finally condense into an effective global governance program, as shown in Figure 6.

In the process of translation quality assessment, professional translators resorted to translation language competence at least 6 times and at most 50 times, with an average of 27.1 times; source language competence at least 6 times and at most 46 times, with an average of 24.4 times; translation knowledge at least 4 times and at most 27 times, with an average of 15.6 times; and instrumental competence at least 1 time and at most 19 times, with an average of 11.4 times. The minimum number of times to resort to extra-linguistic ability is 2, the maximum number of times is 15, and the average number of times is 7.5.

The study on the internal resources used by professional translators in the process of translation quality assessment tentatively confirms that professional translators' translation quality assessment requires the use of bilingualism, translation knowledge, instrumental competence, and extra-linguistic competence, which overlap with the composition of translation competence. This indicates that translation competence and translation quality assessment competence overlap to some extent, thus confirming the correlation between translation quality assessment competence and translation competence.

6. Evaluation Results of Quality Training of Engineering English Translators

When the decision-maker sets the adjustable parameter to 1, which means using the possibility measure, the efficiency evaluation results obtained by Jolly Puri's method and the method proposed in this chapter are the same, as shown in Table 1. The indicators and parameters of the evaluation index system should be stable and concise, and the reference values used to calculate the relative values of the indicators should not be changed. This shows the effectiveness of the proposed method in this paper. Furthermore, we can get more efficient evaluation results by adjusting different adjustable parameters so that we can get more information to provide better support for decision-makers to make reasonable decisions, which illustrates the superiority of the proposed method.

This paper discusses the translation strategy of engineering English from the perspective of interpretive theory by analysing and researching engineering science and technology texts. Engineering English is highly professional, objective, and rigorous and aims to convey information, and these characteristics ultimately reflect that the translation of this genre should be based on the translation customer and present the readers with objective, accurate, and concise language, following the expectations accepted by the translation audience. This emphasis on the readers' reflection is like the interpretation theory which emphasizes that the task of translation is to convey the communicative meaning and that the translator should "understand the original language, detach from the original language shell, and express the understood content and emotion in another language." Because of this, this paper takes the interpretation theory as the theoretical guiding framework, and in the selection of translation strategies, we should try to stand in the position of readers and present them with accurate, simple, and standardized language as much as possible.

At the level of vocabulary, engineering English is strict and professional, and the terminology is "single," but in different fields, it is "multiple meanings," so the translation work can be done only when the original text is accurately understood. In addition, with the continuous development of science and technology, there are increasingly new terms and abbreviations. When translating words, we should strive to "believe" and make them conform to the norms to avoid the inauthentic and unnatural language from destroying the credibility, rigor, and readers' sense of reading identity of engineering science and technology style.

On the syntactic level, the civil engineering style is concise, objective, precise, and focused; in addition, passive sentences and noun words are used a lot to make statements objective. Civil engineering English is a morphological language, mostly compound or parallel sentences, with many non-finite verbs, postpositions, definite clauses, sentence structures caused by the pronoun it and so on, and a subject-predicate structure forming the backbone of the sentence. Chinese, on the other hand, emphasizes meaningful agreement, and there may be multiple clauses in a sentence, with no obvious means of articulation between the clauses. Therefore, in the English-Chinese translation, it is necessary to adjust the translation to the respective characteristics, as shown in Figure 7.

In response to the characteristics of civil engineering English, the thesis explores the translation strategies and methods of civil engineering English. The thesis discusses translation strategies and methods such as phonetic translation, zero translation, synthesis method, word addition, provincial translation, lexical conversion, and word order adjustment and illustrates them with specific cases. There is a unified standard for the statistical calibre and scope of application of each evaluation indicator. Civil engineering English is designed to express and convey information; therefore, the author believes that the translator should try to present the information of the original language to the readers of the translated language in accurate, concise, and standardized language.

After translating, collecting, and analysing English translation materials for civil engineering, the author deeply feels that it is not an easy task to translate civil engineering

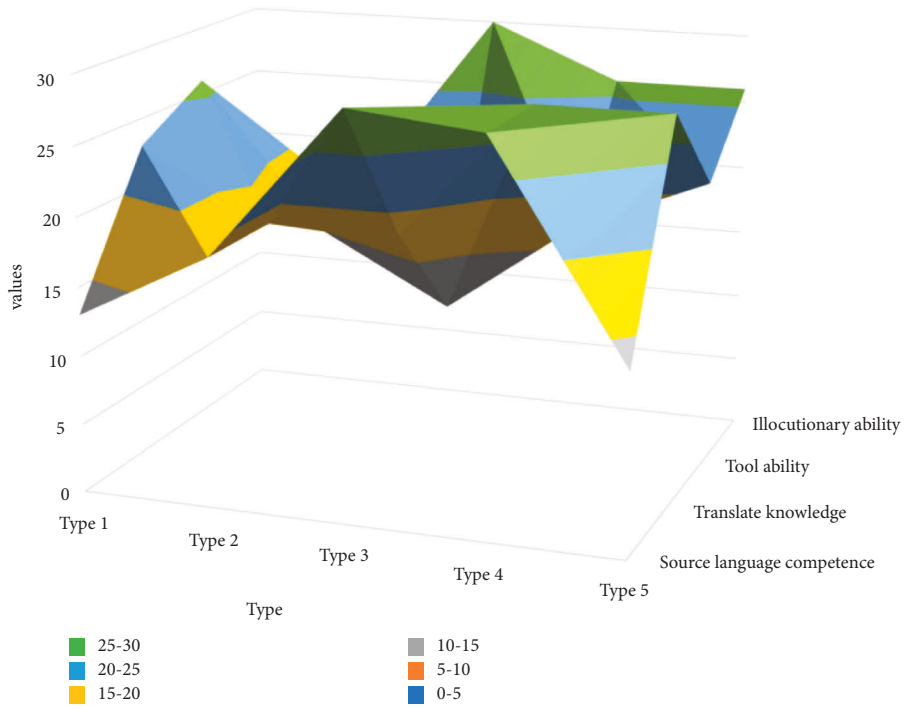

Figure 6: Usage statistics.

Table 1: Efficiency values of DMUs at different confidence levels when the adjustable parameters are 0.

DMUs	Confidence level				
	0.6	0.7	0.8	0.9	1.0
DMU 1	0.317	0.424	0.367	0.547	0.362
DMU 2	0.461	0.458	0.47	0.368	0.559
DMU 3	0.548	0.452	0.356	0.441	0.387
DMU 4	0.583	0.516	0.493	0.498	0.405
DMU 5	0.34	0.319	0.493	0.501	0.522
DMU 6	0.462	0.354	0.569	0.467	0.565
DMU 7	0.531	0.438	0.36	0.412	0.451
DMU 8	0.411	0.586	0.493	0.318	0.574
DMU 9	0.549	0.356	0.456	0.317	0.535
DMU 10	0.522	0.537	0.591	0.541	0.406

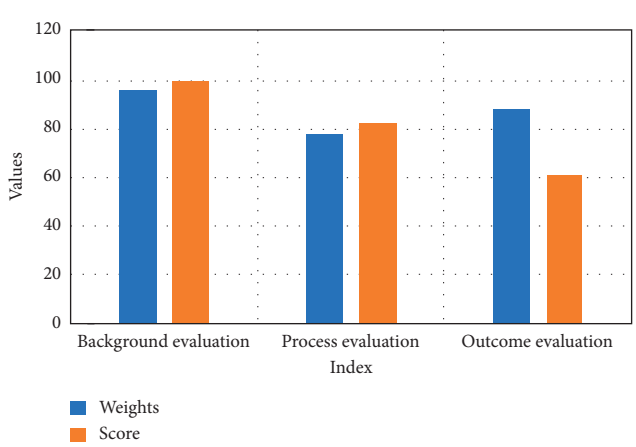

Figure 7: Evaluation results.

English well. It requires a strong reserve of scientific and technical knowledge. Without the accumulation of technical knowledge in specialized fields, the translated materials are likely to be inappropriate, as the saying goes, "a line of work is like a mountain," especially the terminology pointed out earlier, which has always been a headache for many scientific and technical translators but cannot be avoided, all of which require translators to have a certain breadth and depth of professional knowledge. The translator is required to be able to convert freely between two languages and have a logical sense of both Chinese and English and a sensitivity to words.

7. Conclusion

A fuzzy two-stage DEA-UO model with adjustable fuzzy chance constraints is constructed for the situation where both intermediate and final processes have undesired outputs. First, considering the existence of non-desired outputs, the additive efficiency decomposition model in the exact number environment is extended to the non-desired output case by giving negative weights to non-desired outputs. The theory helps to guide the study of English translation in civil engineering and affects translators' specific translation behaviours, such as the choice of translation strategies and methods, the determination of translation standards, etc. In addition to getting the guidance of the theory, translators should diligently pursue to improve their translation ability and translation quality. In the translation process, make good use of web tools. The adjustable fuzzy chance constraint is used to deal with the uncertainty in the model, and an adjustable fuzzy DEA model with the existence of non-expected output is constructed, followed by proof for the case of adjustable parameters and a confidence level of 0 in

the model. Finally, the practicality of the proposed method is illustrated by the example of a barley farm. The web information is updated quickly and easy to use. In addition to using web resources to determine the meaning of words, translators can also use it to test the merits of various translations. Some new words do not have a uniform fixed translation for some time, in which case the frequency and authority of various translations can be compared. After all, translation is an endless work, and diligent checking of tools is a basic requirement for translators.

Data Availability

The data used to support the findings of this study can be obtained from the 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 study.

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Research Article

Movement Evaluation Algorithm-Based Form Tracking Technology and Optimal Control of Limbs for Dancers

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This study designs an optimal control model of dance personnel from tracking technology and limb control based on an action evaluation algorithm by constructing a human action evaluation algorithm model and conducting an in-depth study of dance personnel from tracking technology and limb control. This study proposes an OpenPose method based on pose flow optimization to address the false detection of vital human points and misconnection between critical issues in traditional OpenPose-based human pose estimation. The human pose estimation results of OpenPose are optimized by using the human pose flow information in the image sequence. This makes up for the shortcomings of traditional OpenPose that ignores the interframe image information. In this study, we analyze the experimental data of action evaluation, define a set of formulas to evaluate the action after summarizing the distribution pattern of DTW difference sample points from 8 angles, and design an action evaluation system to demonstrate the rationality of this action evaluation method. Since the bases and factors in the evaluation formula are constantly recalculated as the action changes, which increases the complexity of the evaluation method, the following work is to improve the parameters of the activity evaluation formula, so that the evaluation method has better efficiency and adaptability. To enhance the effect of action recognition, this study uses the Kinect sensor to obtain the 3D coordinates of 20 skeletal joints of the human body. It uses the relative distance and angle sequence of the joints as the feature parameters according to the characteristics of human posture. In static pose recognition, the feature vector's sample set is trained, and the KNN algorithm is used as a classifier to recognize the pose.

1. Introduction

Human movement is the behavior produced by the whole body or part of the human limbs to convey information, which expresses feelings and meets various needs of people in life; evaluation is the conclusion after judging and analyzing a thing or a person [1]. People often evaluate various human body movements in daily life, such as coaches teaching fitness movements, judges in diving, competitive gymnastics, and other competitions when scoring and doctors rehabilitating patients [2]. At present, the evaluation of human body movements is mainly done by human beings, and there are two problems when human beings evaluate human body movements; one is that they cannot be assessed objectively; for example, when judges score in competitions, they are easily influenced by subjective factors and cannot be judged impartially; second, the evaluation results that only rely on the human eyes are not accurate enough and often overlook some details. Therefore, there is a need for technology to realize the evaluation from human-to-human action to the machine. In recent years, with the advancement of computer hardware and software technology, the research on human movement has become increasingly in-depth through various sensor technologies and artificial intelligence algorithms, and human movement analysis has now become a research hotspot [3]. As new research in human movement analysis, human movement evaluation is also gaining more and more attention, and this technology has a

wide range of application prospects. It can be applied to medical rehabilitation, intelligent fitness, physical games, and other fields in the future.

Current approaches to human motion modeling fall into two main following categories: marker point-based motion capture and vision-based motion capture. Marker point-based motion capture requires different types of sensors installed on the human body [4]. Although these methods can model human motion in real-time accurately and robustly, they need a specific indoor environment and clothing; so, they are more costly. Vision-based methods use single or multiple cameras to capture and model human motion through computer vision and graphics [5]. These techniques overcome the limitations of wearing specific clothing and specific acquisition environments to model more flexible, diverse, and natural human motion outdoors. Stable capture of highly accurate human activity is the goal of motion modeling, which can be achieved by tracking human feature points over time, i.e., attain human motion tracking. Human morphology estimation is to locate each key point of the human body in the 2D image to determine the human morphology, and the position of each key point is based on the coordinates of the 2D image [6]. The motion modeling approach proposed in subsequent sections of this study revolves around 2D human morphology estimation. The rapid development of artificial intelligence and computer vision technology has been widely used in security, criminal investigation, sports, entertainment, rehabilitation therapy, and other fields. Human action recognition and analysis, an important research direction of computer vision, has received increasing attention [7]. At this stage, numerous studies are on human form estimation and analysis; however, most of them aim to perform human action recognition. However, for sports with strict specifications and routines, such as Taijiquan, gymnastics, and dance, it is not enough to have the techniques for recognition. It is also necessary to evaluate their consistency with standard movements for guidance.

On the other hand, most of the current methods for human movement analysis are based only on unimodal information to characterize human morphology, such as color images, skeletal information, and depth images. The information source of action characterization is single, which is challenging to characterize the human activity process effectively and accurately [8] and has considerable limitations. In contrast, multimodal action information can reflect the complementarity of different modal information and improve the accuracy of human action characterization. In addition, the characteristics of the human visual attention mechanism and the contextual relevance of human action sequences are often ignored in human action recognition based on deep learning, which makes it challenging to analyze human actions intelligently and effectively [9]. Human action analysis based on multimodal information is a hot research topic in computer vision. The human action process is very complex, and how to effectively characterize human action sequences based on image information and skeletal information is an important research content. At the same time, how to build an intelligent and efficient human action analysis model for multimodal human action features is a pressing challenge. This study analyzes and evaluates multimodal human actions. Based on the image information, we propose the OpenPose method for morphological flow optimization to obtain human morphological information [10]. Based on the human morphology information, the deep learning method is selected to offer the morphology tracking technology and optimal limb control of dancers based on an action evaluation algorithm. The two models are analyzed and identified for the spatiotemporal characteristics of human movements using feature fusion and decision fusion strategies, respectively. Based on this, this study develops an intelligent interactive action evaluation system for dancers' morphology, which can evaluate human movements accurately in real-time.

2. Related Works

In computer vision, target tracking is a critical technology that monitors a target object and reasonably predicts its activity trajectory through a detailed analysis of pixel points in video sequence frames to achieve real-time tracking of the target object [11]. There are various approaches to human tracking, such as model-based tracking methods that treat the target as a whole and monitor the position of the human body in each scene while also analyzing the direction, route, and rate of human movement [12]. By taking the line drawing method or the contour method, the target is regarded as a specific geometric shape; for example, in surveillance video or camera photos, oval or square contours are often found in the target location. While tracking human targets, we also encounter interference factors of complex backgrounds such as shadows, occlusions, and textures, which can significantly increase the difficulty of target tracking [13]. In the current research on target tracking, only the target object is moving unilaterally, which is unsuitable for some special situations, such as on the race course or in the military. Contemporary examples of the simultaneous movement of the target object and the camera are also less seen, limiting the application of human target tracking in a broader range of fields.

Unlike research on human action recognition, action detection, and action segmentation, vision-based human action evaluation techniques evaluate the quality of human actions in a video [14]. Some initial progress has been made in the field of human action evaluation. First, RGB images or depth images of the human body are acquired. Then, human skeletal critical point data are obtained from these image data, followed by extracting human action features from the essential skeletal data of the point and then comparing the similarity of the features afterward to obtain the evaluation results [15]. After acquiring the human action image data, it is difficult to evaluate the human action directly through these data because the positioning of the human body in the image space is a complex process. There is a lot of background information in these images that are unrelated to the human action, which needs to be eliminated, and only the human skeleton key point data is retained [16]. OpenPose is a popular open-source library for acquiring 2D skeletal

joints of the human body for single or multiperson motion capture and is highly resistant to interference.

In motion reorientation, early researchers used traditional numerical methods. Qi X first proposed this problem as a spatial-temporal optimization problem for the entire motion, centered on solving it using hand-designed constraints and inverse kinematics [17]. Wu and Huo proposed a hierarchical curve-fitting technique combined with inverse kinematics to solve this problem [18]. Wu et al. used a relay skeleton to migrate the motion between two characters with different levels or geometries. The introduction of learning-based methods effectively solves the above challenges [19]. A two-layer recurrent neural network structure was proposed by Yan et al. Due to the lack of good data pairs for motion redirection, an unsupervised approach is proposed to train the model [20]. The process is to attach a layer of forwarding kinematic layer after the recurrent neural network and then combine it with recurrent consistency for training. However, due to the weak modeling capability of the model, their approach can only achieve redirection of simple motions and only supports the case of identical skeletal topologies. The graph convolution approach was proposed to achieve motion redirection between skeletons with different topologies. However, this approach has difficulty guaranteeing motion fidelity in any synthesized motions when faced with significant skeletal differences and complex movements [21]. Therefore, with the addition of deep learning, the technique is still worth exploring in the case of substantial skeletal differences and complex motions. For some sports with a short duration, such as golf swing, which lasts for about one second, the overall similarity between the user's action sequence and the standard action sequence can be directly compared to judge the completion quality of the action. However, for some sports items with longer duration, such as Taijiquan and radio gymnastics, which usually consist of multiple steps, if we only compare the overall similarity between the user's action sequence and the standard action sequence, the action evaluation is not accurate enough and cannot reflect the action details. For example, some activities are completed in a better manner for a set of Taijiquan movements completed by the user. Some are completed in a worse manner, and it is necessary to give a high score to make the activities conducted better.

3. Movement Evaluation Algorithm-Based Dancer Form Tracking Technology and Limb Optimal Control Model Construction

3.1. The Algorithmic Model for Movement Evaluation of Dancers Construction. Human movement evaluation is a technique to evaluate the completion quality of human movements. The system architecture includes four parts, namely, movement data acquisition, legal movement establishment, movement comparison and evaluation, and evaluation result output. Action data collection is mainly through the motion capture device Kinect to collect the coordinates of human skeletal nodes to obtain human action data [22]. The establishment of standard action is primarily through collecting professional coach's action data or through big data to get actionable data and, after the analysis of kinesiology experts, to establish the standard action template. Action comparison evaluation is done by calculating the error between user action sequences and common action sequences and evaluating the user's action concerning the error evaluation standard. The output of the evaluation result is to give the user a vivid image of the activity evaluation result by voice or image and to guide or score the user's action. The research of this paper focuses on the action comparison evaluation link. The architecture of the human action evaluation system is shown in Figure 1.

In the pre-evaluation section, the "action missing error" and "action sequence error" in the action sequence are judged to make a general evaluation of the action as a whole; in the action segmentation section, the action sequence is divided into subactions based on the action characteristics; in the detail evaluation section, the human action is evaluated according to the standardized one. In the action segment, the human activity is quantitatively analyzed according to the four evaluation indexes proposed in this study, namely, joint angle similarity, action center time similarity, action duration similarity, and combined average angular velocity similarity. The purpose of action pre-evaluation is to determine whether serious errors exist in the user's broadcast action sequence, i.e., "action missing errors" and "action sequence errors." The action pre-evaluation process consists of four main steps.

Let the user action sequence be $s = [P_1, P_2, \ldots, P_i, \ldots, P_n]$, and there are K standard poses, and let the kth classic pose be denoted as $B_k = (a_1, a_2, \ldots, a_8)$.

Calculate the Euclidean distance between the 1st standard pose B_1 and each element of the user action sequence $s = [P_1, P_2, \ldots, P_i, \ldots, P_n]$, where the Euclidean distance between the 1st classic pose B_1 and the 1st pose $i\,(i = 1, 2, \ldots, n)$ of the user action sequence p_i can be calculated by (1). Thus, the Euclidean distance vector between the 1st standard pose and the pose of the user action sequence B_1, n is obtained as $d = (d_1, d_2, \ldots, d_i, \ldots, d_n)$.

$$d_i = \sum \frac{b_1 - p_i}{\sqrt{b_1 + p_i}}. \tag{1}$$

In equation (1), B_1 is the joint angle vector of the 1st standard pose in the standard movement library; p_i is the joint angle vector of the user's i pose; D_i is the Euclidean distance between the user's ith pose and the 1st standard pose in the standard movement library.

(1) Search for the minimum value $d_{\min}$ in the elements of the Euclidean distance vector d; judge whether the minimum Euclidean distance $d_{\min}$ is less than the threshold O set in advance; if yes, proceed to the next step; if not, feedback to the user "action missing error" message.

(2) Repeat steps 1 and 2 for the other $k-1$ standard poses

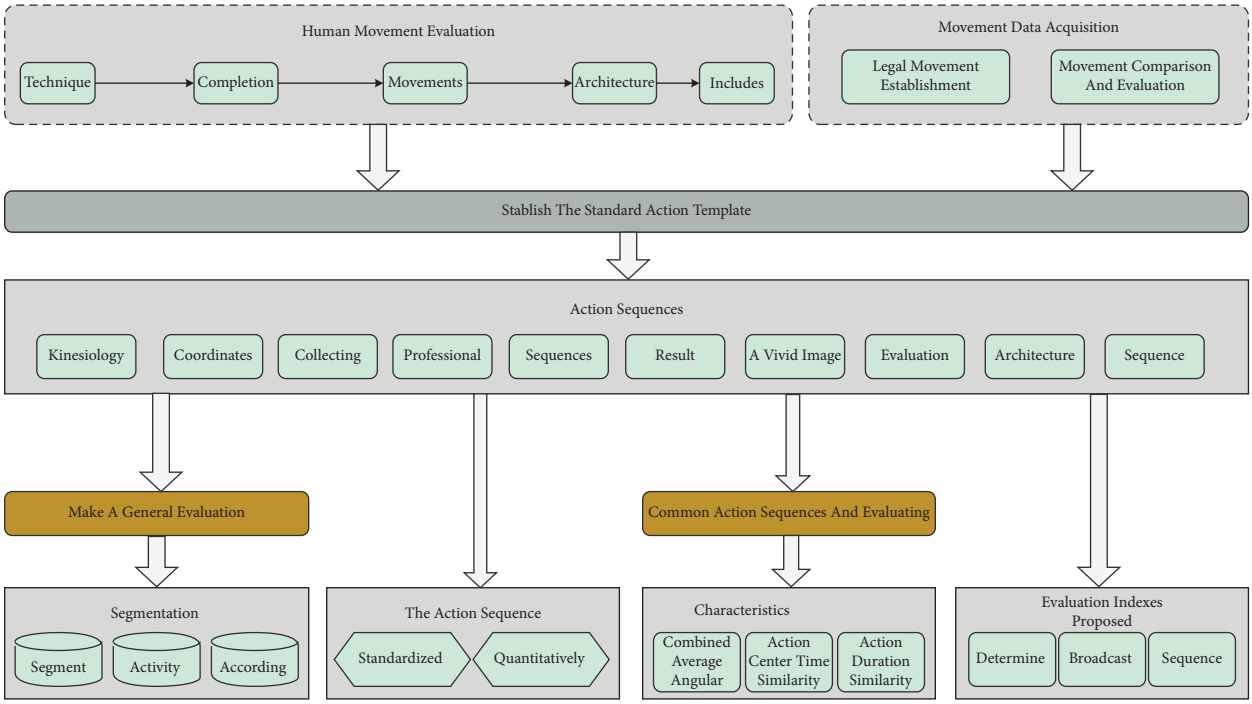

Figure 1: Architecture of the human movement evaluation system.

(3) Determine whether the order of K Euclidean distance minima in the user's action sequence is correct. If so, proceed to the action segmentation, and if not, give the user the "action order error" message.

Joint angle similarity includes static action joint angle similarity and dynamic action joint angle similarity, which are calculated by calculating the difference between each joint angle of the user and each joint angle of the standard action to measure the similarity between the user's movement and the legal action. Still, the static action joint angle and dynamic action joint angle similarity have different calculation methods. The static action joint angle similarity is calculated by calculating the average of all posture joint angles of the human household's static action and then comparing it with the average of all posture joint angles of the standard measure to obtain the similarity between them.

For the static action joint angle similarity d_s, let the action sequence of a static action of the user $C = (c_1, c_2, \ldots, c_n)$ and the standard pose vector corresponding to the static action be b. The static action joint angle similarity d_s is obtained by the following equation.

$$d_s = \sum \frac{\sqrt{c_1 + c_2 - c_n} - b}{n + b}. \tag{2}$$

In equation (2), c_i is the joint angle vector of i pose of the user's static action; b is the standard pose vector; n is the total number of frames of the user's static activity; d_s is the joint angle similarity/m of the user's static action.

For dynamic action joint angle similarity d_d, let the user's dynamic action sequence be $E = (e_1, e_2, \ldots, e_i, \ldots, e_n)$ and the standard action sequence corresponding to the dynamic action be $E = (e_1, e_2, \ldots, e_j, \ldots, e_m)$.

$$d = \int_{n=1} \frac{d_{11} - d_{12} + d_{1m}}{\sqrt{d_{n1} + d_{n2} - d_{nm}}} - d_{ij}. \tag{3}$$

The Euclidean distance between each poses composing the user dynamic action sequence and each pose containing the standard action sequence is calculated to obtain the distance matrix D, D_{ij} which denotes the Euclidean distance between the i posture of the user dynamic action and the j pose of the standard measure, which is obtained by the following equation.

$$d_{ij} = \sum \left(e_i + e_j\right)^2 + \left(e_i - e_j\right). \tag{4}$$

After obtaining the distance matrix D and the elements of the accumulation matrix g, the aspect g_{nm} in g can be calculated by the following recursive equation.

$$g = \sum_{n=1} \left(\frac{g_{11} - g_{12}}{g_{n1} + g_{n2} + g_{nm}} + g_{1m} \right), \tag{5}$$

$$g_{ij} = \sum \min \frac{g_{i-1} + g_{j-1}}{d_{ij}} - g_{i-1}. \tag{6}$$

The dynamic action joint angle similarity is calculated by equation (6) d_d. The g_{nm} size g_{nm} reflects the similarity between the user's dynamic action and its corresponding standard dynamic action. Still, to measure the completion quality between different activities in the user's long-time action behavior and form a unified evaluation index, this study gives the DTW distance g_{nm} divided by a factor, which is the sum of the total number of frames of the user's dynamic action n and its corresponding standard. This factor is the sum of the total number of frames m of the dynamic

action of the user and the total number of frames m of the corresponding standard action, which can reflect the DTW distance per unit frame of a dynamic movement of the user.

$$d_d = \sum g_{nm} \times \frac{\sqrt{n-m}}{\sqrt{n+m}}, \tag{7}$$

where n is the total number of frames of user's dynamic action; m is the total number of frames of standard dynamic action; g_{nm} is the shortest path from row 1 column 1 of the accumulation matrix G to row n column m of the accumulation matrix G, in degrees; d_d is the joint angle similarity of user's dynamic action.

To reflect the cumulative error in the time of user actions, the evaluation index used in this study is the action center time. It is known that f_{start} is the starting frame number of activities, f_{end} is the ending frame number of the action, and τ is the sampling frequency of the adopted motion capture device. The user's action center time t_c can be obtained by equation (8), and the similarity of action center time e_c can be obtained by equation (9), and t_c is the standard action center time.

$$t_c = \sum \frac{f_{\text{start}} + f_{\text{end}}}{t-2} + \frac{2}{t}, \tag{8}$$

$$e_c = \int (t_c - t) \times \left(t^2 - 1\right). \tag{9}$$

To reflect the error of individual joint angular velocity in dynamic action, the evaluation index used in this study is the average angular velocity similarity of dynamic action joints. The average angular velocity similarity of dynamic action joints is calculated as follows: (1) calculate the difference of joint angles between two adjacent frames; (2) calculate the average angular velocity of each joint; (3) calculate the Euclidean distance between the average angular velocity of user's dynamic action joints and the average angular velocity of standard dynamic action joints to obtain the average angular velocity similarity of dynamic action joints. Let the user's dynamic action sequence be $E = (e_1, e_2, \ldots, e_i, \ldots, e_n)$, and the average angular velocity of the standard joint of this dynamic action be w; the average angular velocity of the joint of this dynamic action can be calculated by the following equation.

$$e_w = \sum \frac{e_{i-1} + e_i}{n+1} + (t + w). \tag{10}$$

3.2. Dancers' Morphological Tracking Technology and Limb Optimal Control Model Design. The data acquisition module provides camera device connection, acquisition, and image data storage functions. After the hand dance process starts, the depth camera obtains data, aligns the acquired RGB map and depth map, and stores and passes the aligned image data to the hand action tracking and recognition module. In the hand action tracking and recognition module, hand segmentation is first performed after acquiring the image data to realize the separation of image foreground and background, and the hand in the image is extracted. Then, the segmented hand data is passed to the hand pose estimation algorithm to calculate the 3D coordinates of the joint hand points [23]. The 3D collective energy coordinate data are used for hand dance state data calculation in hand dance state data visualization on the one hand, and on the other hand, it will be used to calculate the features in the gesture recognition module to realize the recognition of the current gesture category. The gesture category recognition is used to determine whether the everyday gesture trained by the dancer is correct and to assist the dancer in practical hand dance training. In the hand dance state data visualization module, the hand rehabilitation state parameters are first calculated based on the hand 3D joint point coordinates. Then, the state data are visualized to the data changes with intuitive images. The flowchart of the data acquisition part is shown in Figure 2. After the camera is activated, it acquires the dancer's hand image data. After receiving the data, image alignment is performed for both types of images. The aligned images are stored on the one hand and transmitted to the hand movement tracking and recognition module for use on the other.

The hand motion tracking and the recognition module are divided into hand segmentation, hand pose estimation, and hand gesture recognition. After obtaining the RGB and depth maps in the data acquisition part, the hand segmentation algorithm is used to segment the hand from the image background. The implementation of hand segmentation can further improve the accuracy of hand gesture recognition and hand pose estimation. After hand segmentation, the hand image is passed into the hand gesture estimation method, and the corresponding algorithm is used to calculate the 3D joint point coordinates of the hand. After obtaining the hand collective point data, the hand common point data are transmitted to the hand gesture recognition module to judge whether the hand gesture is selected for training by the dancer and give corresponding hints in the image display interface. The hand joint point data are transmitted to the hand rehabilitation status data visualization module, which is used to calculate the hand dance status data.

The deep number of layers makes the feature map broader and more suitable for large datasets, and the network can solve 1000 classes of image classification and localization problems. The size of the convolutional kernel affects the number of parameters and the feeling field; the former relates to the difficulty of training and whether it is easy to deploy to mobile and so on. The latter relates to the update of parameters, the size of the feature map, whether the features are extracted enough, and the complexity of the model. The VGG convolutional neural network is the network structure of OpenPose to extract the information of human morphological features in images. The VGG convolutional neural network structure is divided into two branches and t stages [24]. One unit is used to detect the critical point heat map of the human body in the image, and the other branch is used to see the limb vector map of the human body in the picture. The output of each stage consists of a set S of key point heat maps and a human limb vector field L. The set S of key points contains J key point heat maps;

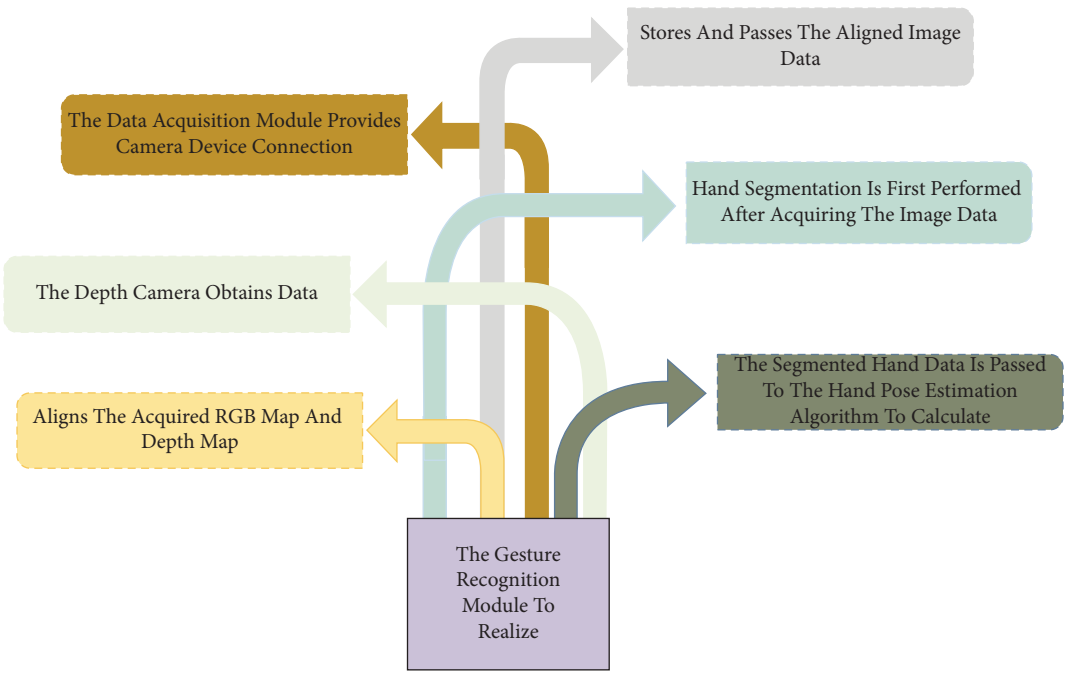

Figure 2: Flowchart of a data acquisition part.

each key point corresponds to one S_j; the human limb vector field L has C vector fields, and each limb corresponds to one L_c, the specific expressions are as follows:

$$S = \sum \frac{R^{w\times h} \times (J-1)}{s_1 - s_2 - s_J},$$
$$L = \frac{R^{w\times h\times 2} \times (c+L)^2}{L_1 - L_2 + L_c}. \tag{11}$$

For each of the t stages, the input is the crucial point heat map, the limb vector map of the previous step, and the original feature map. The output is the heat map of each key point of the human body and the vector map of the limb stem of each part of the human body. After iteration, the vital human points and human limb vectors are obtained, and the human morphology is constructed by evaluating the correlation between critical issues and connecting solid points. The specific evaluation method is that the dot product between the two key point connection vectors and the limb vectors of each pixel point on the two key point connection lines is calculated as the correlation between the two key points. Thus, the connection between the key points is performed to complete the human body morphology estimation.

Traditional OpenPose in dance movement morphology estimation is poor for movement morphology estimation. After observation and analysis, the motion amplitude and speed of upper and lower limbs are more significant, i.e., the interframe variation of key point positions is more significant, so the wrong estimation of key point positions and the wrong connection between critical points are easy to occur. Traditional OpenPose is only based on the images within a single frame in the video for human form estimation, and the interframe information of human form in the video is not used. Therefore, this study proposes an OpenPose method based on the morphological flow information between frames of human action in the video and an OpenPose method based on morphological flow optimization. By correcting the key point positions acquired by OpenPose through morphological flow, the interframe features of human morphology are used to improve the accuracy of human action morphology estimation. In this study, we offer the OpenPose method based on morphological flow optimization based on the traditional OpenPose utilizing the construction and solution methods of morphological flow [25]. The OpenPose method, based on morphological flow optimization, selects the intraframe critical point location information obtained by OpenPose to construct the interframe morphological flow information of human action and calculates the optimal solution of essential points of human morphology based on the morphological flow information to optimally correct the human morphology obtained based on OpenPose. The schematic diagram of the VGG convolutional neural network structure is shown in Figure 3.

This study estimates human morphology based on the OpenPose method of morphological flow optimization for Taijiquan movements. In the experimental results, the accuracy of the optimized OpenPose method is greatly improved. The OpenPose method based on morphological flow optimization is proposed. Based on the coordinate data of key points obtained by OpenPose, the human morphological flow information between frames is constructed. The optimal morphological solution is finally found, thus optimizing the human morphological estimation results obtained by OpenPose. Comparing the traditional OpenPose-based dance movement morphology estimation and the OpenPose-based morphology flow optimization, the proposed

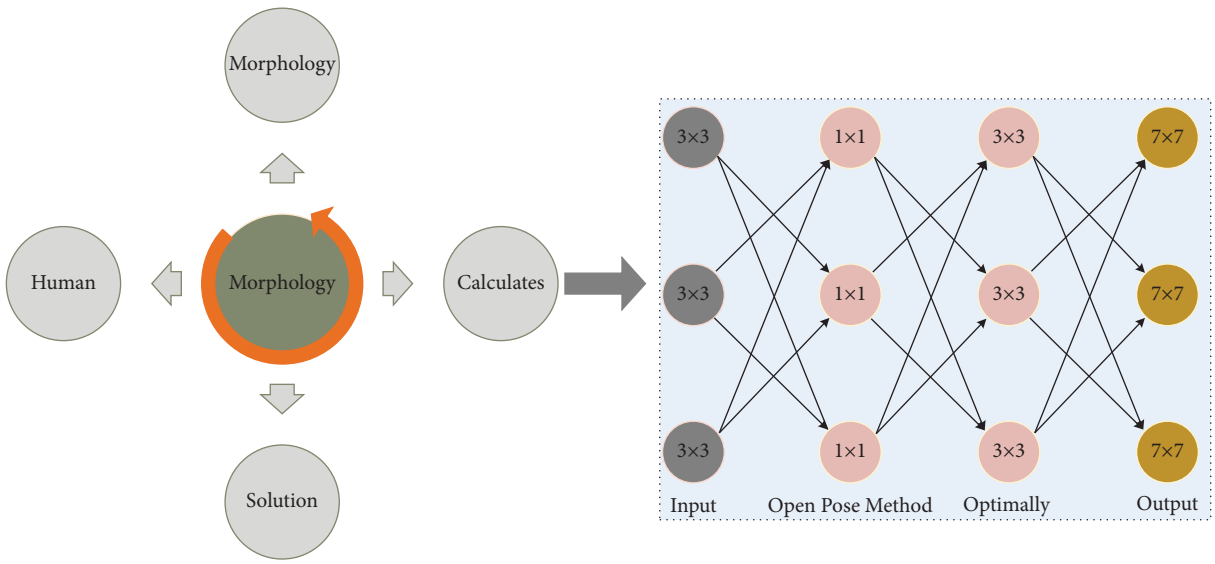

Figure 3: Schematic diagram of the convolutional neural network structure.

OpenPose-based morphology flow optimization method corrects and optimizes the positions of vital human points and effectively solves the problem of misconnection of human key points. In particular, the proposed OpenPose method significantly improves accuracy compared with the traditional OpenPose for estimating large amplitude and high-speed movements in Taijiquan, such as knee bending, golden chicken independence, and foot stomp.

4. Analysis of Results

4.1. Analysis of the Movement Evaluation Algorithm Model for Dancers. To verify the effectiveness of the proposed method for quantitative evaluation of complex human movements and the effectiveness of the improved DTW algorithm for improving the evaluation results, a movement evaluation comparison experiment based on the traditional DTW and the improved DTW algorithm was designed. In this study, considering the richness of the movements and the actual conditions, eight Taijis were selected as the evaluation objects. DTW is an algorithm used to compute the similarity of two time series. Unlike traditional methods that only calculate the Euclidean distance of elements at the same position, DTW allows one-to-many mapping. Each component of an input sequence Q can be mapped to the exact part of another sequence C and vice versa. However, the monotonicity of the series is guaranteed. DTW is generally implemented by dynamic programming. Eight experimenters were chosen to demonstrate dance movements in the establishment of the evaluation model; one was a high-level dancer. Four were used as the experimental objects for movement evaluation, and the rest were used as the data for establishing the score-distance mapping relationship. In this study, the dance moves of the player are the normal movement, corresponding to a score of 100 on a percentage scale, and the others, that is, the experimentalists have dance enthusiasts, novice dancers, and other players with different levels of dance movements. When each experimenter performs the dance movement demonstration, there is a professional score artificially, and the artificial score is used as the ideal algorithm scoring result.

In training the network, the number of layers and the number of neural units are adjusted to adjust the network structure and make the network converge and be in the best condition. The first half of the spatiotemporal cascade network is built based on Bi-LSTM and consists of 4 Bi-LSTM layers: 2 forward Bi-LSTM layers and 2 reverse Bi-LSTM layers. Each layer consists of 256 LSTM neurons, and the states of the neurons are randomly initialized. The connected ones are fully connected layers, the second half of the network is built based on CTC, and the network's output is the segmentation and recognition results. During the network training, the greedy search and beam search algorithms are compared to evaluate the change process of the loss function. The gradient descent is accelerated using the impulse optimization method Momentum Optimizer to optimize the convergence. The initial learning rate is adjusted to 0.01, the number of Bi-LSTM neurons, the batch size is 1, and the epoch is 150, so that the network converges to the minimum value and the network performance reaches the optimal state. The sample data score-distance fitting curve is shown in Figure 4.

The dataset used in this experiment is the dataset constructed in the motion evaluation algorithm. The dataset contains 6400 sequential motion capture data of different lengths for 16 lower limb movement categories. Each continuous movement data sample in the dataset includes 3–6 segments of a single type of movement; 16 movement types correspond to 16 Laban dance score symbols. All samples of this dataset were captured from different angles, thus ensuring sample diversity. Also, the experimental results will be more convincing and credible [26]. To reduce the dataset's complexity and the redundancy of the extracted spatial features, we remove some frames from each data sample in the dataset for subsequent processing. To ensure high data availability, the original boundaries of the data

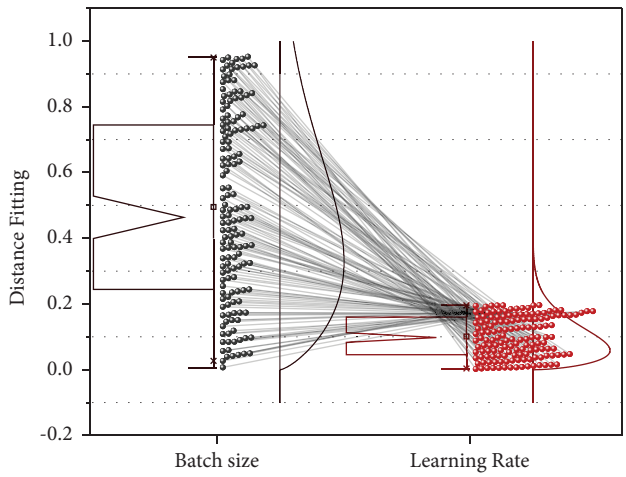

Figure 4: Sample data fraction-distance fitting curve.

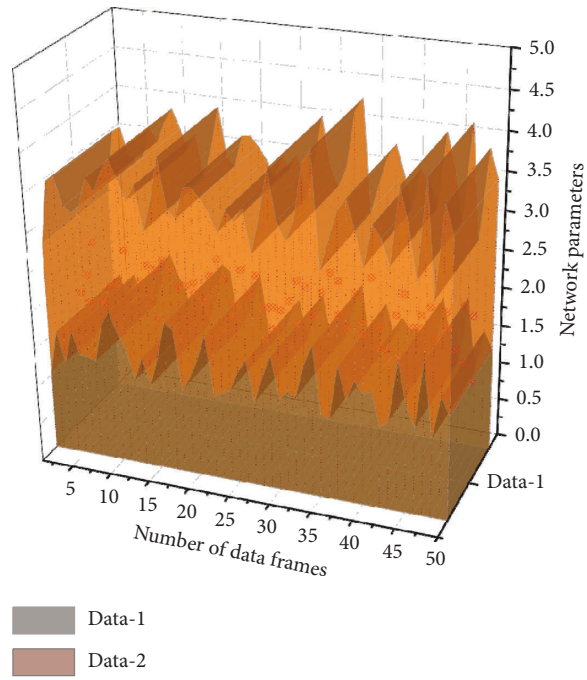

Figure 5: Change in loss during network training.

samples are downsampled in this study, and the number of data frames is adjusted to 40 and 50 frames in two cases. It is found that the performance level can be maintained in the subsequent experiments when the number of data frames is 50 and 40. The performance remains the same when the number of data frames is 50 and 40. The network parameters are relatively less when the number of data frames is 30, which helps to reduce the network's training time. This process also saves the execution time of the continuous dance spectrum generation algorithm based on the spatio-temporal cascade network. The loss variation during network training is shown in Figure 5.

The attention mechanism-based segmentation method obtains the highest recognition accuracy on both datasets, while the unique segmentation-based approach has low accuracy. With the increase in the number of skeletal point delineation subsets, the recognition accuracy of both datasets improved significantly. Among them, the recognition accuracy of the spatial structure relationship delineation method is higher than that of the distance delineation method. It indicates that the number of skeletal delineation subsets affects the weighting of the weight function in the graph convolution. More skeletal delineation subset strategies benefit the graph convolution's hierarchical weighting of bony points. Therefore, the division strategy with more division subsets can obtain higher recognition accuracy. The attention mechanism division has the same skeletal subsets as the spatial structure relationship division. The attention mechanism division method incorporates the velocity characteristics of skeletons based on the spatial structure relationship of frames, i.e., the interframe displacement of the same skeletal points in the lean spatiotemporal map. Therefore, the attention mechanism-based segmentation method better simulates the strategy of human visual analysis, and the highest accuracy of human pose recognition is achieved in both datasets.

4.2. Movement Evaluation Algorithm-Based Dancer Form Tracking Technology and Limb Optimal Control Model Implementation.

After analysis, the present method achieves excellent performance in terms of accuracy and success rate. In addition, the current process has a significant speed advantage over the other two deep reinforcement learning-based methods, obtaining better results with an accuracy of 9.5% and 10.8% higher than the two candidate trackers, KCF, and STC, respectively, and it also brings an AUC value of 0.618. Since the intelligent body is only responsible for selecting the optimal candidate tracker in the proposed tracking framework, the target localization task is performed by the selected tracker. The experiments demonstrate the proposed approach's effectiveness, combining the advantages of different tracking algorithms to improve tracking accuracy. The evaluation results of the stochastic bits of intelligence cannot observe and analyze the tracking environment. This further indicates that the proposed method has learned the optimal strategy and has sufficiently mastered the advantages of the candidate trackers so that it can adaptively switch to the best tracker according to the current tracking environment. The frame-by-frame center localization errors in some test videos achieve long-term stable performance in target tracking by properly switching trackers. The above experimental results technique can improve the tracking performance by selecting the most appropriate tracker at different stages and successfully outputting more accurate positions as a priori knowledge for the next frame. The tracking results of the test set are compared, as shown in Figure 6.

In addition to tracking speed, tracking accuracy is another effort in monitoring research. To verify the impact of decision framework and specific decisions on tracking accuracy metrics, on the one hand, MACTFSS and MACTMTS are compared with Basic Tracker to independently verify the improvement of accuracy metrics by feature selection

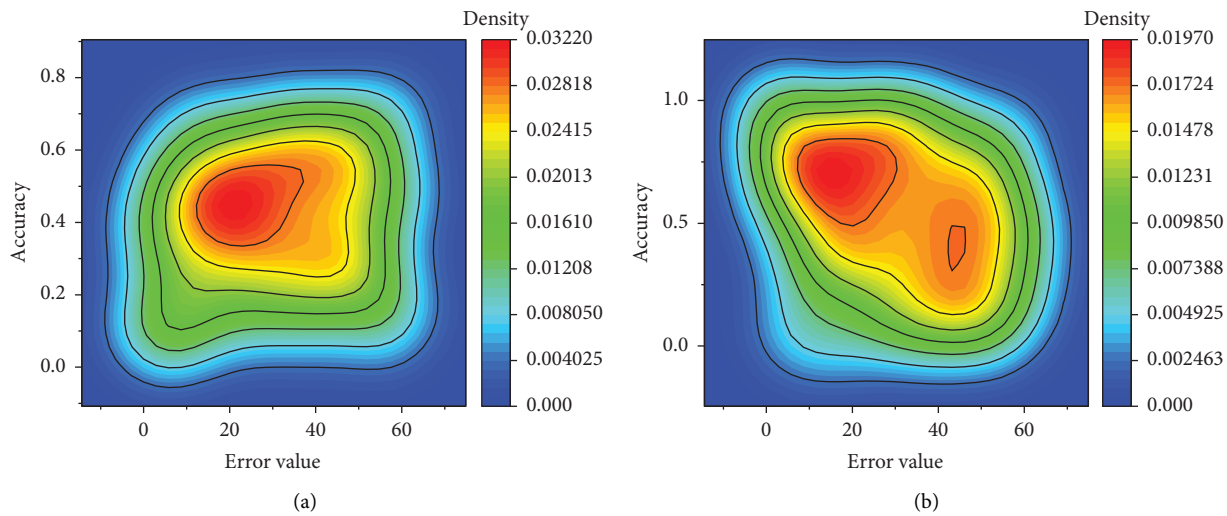

Figure 6: Comparison of trace results for the test set.

strategy FSS and motion trend strategy MTS, respectively; on the other hand, MACT is compared with MACTFSS and MACTMTS experiments to analyze whether the fusion of FSS and MTS has played an effect. The experiments demonstrate that the feature selection strategy FSS can improve the tracking speed; furthermore, it is hoped that this speed improvement should not reduce the accuracy requirement. The OPE success rate AUC score of MACTFSS is improved by 5.26%. The OPE accuracy AUC score is enhanced by 2.57% compared with the Basic Tracker. This suggests that the use of the feature selection strategy FSS not only did not reduce the tracking accuracy due to the use of fewer HOG features but also improved the tracking accuracy due to the flexible feature selection, which indirectly verified the correctness of the analysis of the observer attention change perspective. The test results of the optimal control model for morphological tracking limbs are shown in Figure 7.

The dance score generation algorithm based on spatial features takes full advantage of spatial feature fusion to improve the action recognition accuracy. The dance spectrum generation algorithm based on multitemporal modeling takes advantage of historical and future temporal information to enhance the impact on current prediction and optimize recognition accuracy. These two methods target single-movement recognition and cannot recognize continuous movements. The dance spectrum generation algorithm based on the spatiotemporal cascade network identifies ongoing actions, mainly to overcome the deficiency of needing to segment actions continuously; there is still room for improvement in performance optimization. On the one hand, because the predicted probability of the recognition network part takes a value less than 1, the total probability product is smaller than the expected probability of a single action.

On the other hand, there is an error in the category path merging when calculating the recognition accuracy of continuous actions resulting in the recognition accuracy of endless action categories is not as good as that of single steps. The joint network mechanism is currently the best regarding

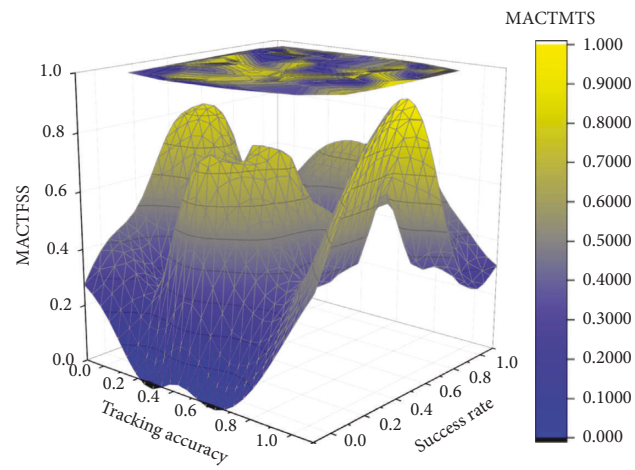

Figure 7: Test results of the optimal control model for morphological tracking limbs.

action recognition accuracy, but the network model is more complex, combining LSTM and CNN networks for model training. LSTM is memory, so the main feature of LSTM is that it has some memory capacity, so most of the time, it is used to deal with sequences, such as dealing with a sentence or a video. The CNN is mainly strong in dealing with a single picture, and the association between the front and back is not so strong in a sequence, but of course, the 3D CNN can also be used to deal with video some of the time. The method proposed in this study is relatively more straightforward and less computationally intensive than the joint network mechanism. It achieves long-time time series correlation modeling and spatiotemporal feature fusion, yielding good recognition accuracy. By comparing the experimental results, we can see that our approach has a performance improvement of about 2% in recognition accuracy compared to the joint network mechanism approach. When learners learn a movement, the captured action video sequence may be as many as a hundred frames; if they go frame by frame to compare the difference between their stance and the

standard stance, it takes a long time, learners may lose patience, and learning effect is not good, and second, there is no target to practice the stance one by one, which is less efficient; while if a swing action is decomposed, a few fundamental movements are selected and targeted to. If a swing is broken down and a few essential activities are selected for targeted practice, the stance at these basic movements will become closer and closer to the standard. The overall swing will become more and more standard, which is more efficient than correcting frame by frame.

5. Conclusion

In computer vision and image processing, the recognition of human behavior pose has become an important topic. It has been widely used in human-computer interaction, virtual reality, intelligent video surveillance, and so on. However, many problems still have not been well solved, which affect the computer's understanding and recognition accuracy of human behavior. This study proposes an OpenPose method based on pose flow optimization to address false detection of vital human points and misconnection between critical issues in traditional OpenPose-based human pose estimation. The optimal solution of the key points of the human pose is calculated based on the pose flow information between video frames to correct the human posture obtained by traditional OpenPose optimally. The OpenPose based on pose flow optimization compensates for the shortcoming of conventional OpenPose, which ignores the interframe information. The experimental results of the OpenPose method based on pose flow optimization improve the accuracy of human key point detection and effectively solve the problem of crucial point misconnection in the human pose. The mapping function is constructed by fusing the velocity characteristics and spatial structure relationship of the skeletal points in the neighborhood. The product of the velocity of bony points and the distance from the lean points to the body's center of gravity is used as the criterion to classify skeletal issues, i.e., the discriminant condition in the mapping function. The weight function in the graph convolution operation is improved based on the mapping function. Thus, the attention mechanism of human vision is simulated for human action analysis and recognition. The experimental results of the spatiotemporal map convolution network based on the attention mechanism can emphasize the action parts of human visual attention and improve the recognition accuracy compared with the traditional network model. In the action criteria evaluation, the linear regression method is used to model the extracted feature vectors. The DTW algorithm is used to match the curves of different lengths. The action evaluation experiment is designed, and a set of formulas are defined to evaluate the action based on the experimental data. The joint angle curve DTW difference is used as the experimental parameter, and the rationality of the activity evaluation method is demonstrated through the action evaluation experiment. In the study of keyframe acquisition based on human pose estimation and clustering, it was found that the use of the fixed clustering center approach to obtain keyframes leads to the fact that even if there are repeated actions in the video, only one of the closest results to the standard frame but not to multiple keyframes, and the single development does not. Therefore, in the future research, we will consider segmenting the video according to specific information to determine the position of the repetitive frames. Therefore, in future research, we will consider segmenting the footage based on detailed information to determine that there are no repetitive actions in each segment.

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

Application Research of Partial Differential Equation Optimization Image Analysis in National Traditional Physical Education Teaching

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In this paper, the initial parameters of C-V level set image recognition are optimized by using the global optimization characteristics of cultural algorithm, and a cultural algorithm C-V level set image recognition model is proposed, which is abbreviated as the CC-V model. The initial population space of the cultural algorithm is used to set the initial recognition parameters in a large range, and the population evolution is continuously optimized and guided by the situation knowledge and normative knowledge of the reliability space, so as to realize the global optimization of the recognition parameters and to timely terminate by judging the change of the image entropy fitness value. Through the analysis and comparison of the experimental results, the CC-V model has a better recognition effect than the C–V model. The partial differential equation image recognition model is applied to the video image sequence for moving target recognition. The background model is constructed by the block statistical histogram. The background difference method is used to locate the video moving target, and the minimum circumscribed rectangle of the multitarget positioning is used as the initial outline of the model recognition. The research results show that the nonintellectual factors of each group of ethnic traditional sports have an obvious effect on the application value of people, and the application effect of nonintellectual factors produced by different groups will also vary. All ethnic traditional sports groups show higher application value to nonintellectual character factors. The comprehensive application value of nonintelligence factors of the combat confrontation item group, accuracy item group, and endurance item group is relatively higher than the comprehensive application value of nonintelligence factors of other item groups.

1. Introduction

The strategy of rejuvenating the country through science and education has long been known to the people: Strong education leads to a strong country. The colleges and universities known as "ivory towers" have already developed into multilevel, multicategory, and fully functional educational and scientific research bases [1]. However, a strong body is the body of the mind and the carrier of innovation, so college sports should take on the burden of strengthening the body and revitalizing the nation. The innovation of education cannot be delayed. The introduction of national traditional sports with a high fitness value and strong entertainment in college sports to enrich the teaching content can not only achieve the purpose of promoting national traditional culture but also play the function of strengthening the body and entertaining the body and mind [2]. According to their own characteristics and regional characteristics, colleges and universities selectively introduce traditional national sports items and incorporate them into physical education teaching. On the premise of enriching teaching content, the problem of homogenization of teaching materials is improved to achieve the purpose of diversifying school-based teaching materials [3]. It not only promotes the national culture but also broadens the knowledge of college students and improves the knowledge

structure of college students and the physical quality of college students. At the same time, it can also stimulate the spirit of unity and cooperation among students of all ethnic groups and achieve the role of promoting national unity and common prosperity.

Fractional partial differential equations can be used to describe a variety of motions, such as turbulence, quantum chaos, image processing, and the flow of underground sewage [4]. In many practical applications, the solution of fractional partial differential equations is the research focus, including the research of analytical solution and numerical solution, respectively. The analytical and numerical solutions of simple fractional partial differential equations are easy to find, but the analytical solutions of more complex fractional partial differential equations are complicated and difficult to solve, which brings a lot of troubles to practical applications [5]. Therefore, the focus of research on fractional partial differential equations is to quickly find numerical solutions. A lot of research works have been carried out on the fast solution of fractional partial differential equations, and some of them have laid a solid foundation for later researchers to study the fast methods of fractional partial differential equations (6) and (7).

This paper takes the widely used level set image recognition algorithm as the core and analyzes the region-based active contour model and the edge-based active contour model. As a simplification of the M-S model, the C-V level set model has a good ability to adapt to the change of the topological structure of the image area. The C-V model is a region-based active contour model. The numerical implementation uses the regularized Heaviside function to achieve the stability of the active contour in the identification process of the energy functional. When the initial parameters are set reasonably, the identification results are better. This paper uses the global optimization characteristics of the cultural algorithm and simplifies the parameter setting problem of recognition on the basis of the C-V model and proposes the CC-V model. Through the analysis and comparison of the experimental results, it shows that the CC-V model has a better recognition effect. Since the C–V model is a region-based recognition model, it has more advantages in dealing with the recognition of traditional national sports images. The CC-V model is based on the C-V model and has the ability to recognize noisy images.

National traditional sports items have high application value to people's nonintelligence, and different item groups have different effects on the corresponding nonintelligence subfactors. There is a certain similarity in the application value of nonintelligence factors. Through the in-depth discussion of ethnic traditional sports and injecting nonintelligence factors into the perspective of studying the influence of different groups on nonintelligence factors, it can provide effective theoretical guidance for front-line coaches and teachers in colleges and universities and promote the comprehensive, coordinated, and healthy development of ethnic traditional sports development, and effectively drive the sustainable and harmonious development of the profession.

2. Related Work

From the current research, although the coefficient matrix of the linear system obtained by discrete fractional partial differential equation has a Toeplitz-like structure, the system is serial [8]. The so-called serial means that the numerical solutions of each time layer in the system are interdependent. For example, when seeking the solution of the current time layer, the numerical solution of the previous time layer must be calculated, which means that the solutions of all time layers must be obtained. The solution for each time horizon is to be calculated sequentially. Most of the current algorithm research studies adopt the serial solution method, but the disadvantages of the serial solution method are obvious through the above analysis [9]. For example, the serial solution method is not suitable for parallel algorithm design. In recent years, with the rapid development of computer technology, the computer has developed from a single-core processor to a multicore processor, and the multicore processor can process multiple independent systems at the same time.

The advent of multicore processor technology makes the research on parallel algorithms urgent, and many researchers also put the research on parallel algorithms for numerical solution of fractional partial differential equations on the agenda [10, 11]. Among them, the processing skills of one-shot linear systems are the most famous. This one-shot linear system first considers unifying the linear systems of each time obtained by discretizing fractional partial differential equations into a new linear system as a whole. Such a one-time solution strategy is simple to operate and greatly reduces the computational complexity compared with the serial solution method [12], but a critical step is how to choose parallelizable preprocessors. When selecting preprocessors, some researchers chose the method of multigrid, which is equivalent to designing a block Jacobian matrix [13]. This research work laid the foundation for other researchers to find parallel preprocessors.

A new strategy is proposed to break the previous ideas on the discrete format of fractional derivatives [14]. This strategy lies in how to use weights wisely. For fractional derivatives of the Riemann–Liouville type, a weight is added to the discrete scheme of the fractional derivative with displacement that has been studied to control the order of the discrete scheme. Different weights correspond to different orders. This results in a fractional derivative discrete scheme with weights and displacements called the WSGD discrete scheme. The advantage of the WSGD discrete format is that the order can be flexibly adjusted according to the weight, which provides a shortcut for finding higher-order fractional discrete forms [15].

Relevant scholars pointed out in the article "Characteristics and Beauty of Ethnic Traditional Sports" that ethnic minority traditional sports have the function of aesthetic education [16]. It shows the beauty of body and spirit through expressions, body shape, posture, language, clothing, equipment, and other forms. This beauty is created by people of ethnic minorities in their working life to achieve the effect of fitness and bodybuilding.

In the article "The Development Status of National Traditional Sports and Its Future Development Trend," relevant scholars pointed out that national traditional sports are closely related to people's production and life in the process of production and development [17]. They have characteristics such as "truth, goodness, and beauty," which play the role of medical care and have positive significance for the development of national fitness activities and, at the same time, have a certain role in promoting the development of school sports and competitive sports [18].

Researchers pointed out that the integration of national traditional sports and tourism and the static scenery has evolved into a dynamic tourism, and the customs of various ethnic groups are displayed in the scenic area [19]. Folk culture, religious beliefs, etc., optimize the composition of tourism and promote sustainable economic development, which have an inestimable value in promoting regional economic development [20].

3. Methods

3.1. Mumford–Shah Model. The M-S model is a typical active contour model for region recognition, which can realize image recognition while smoothing the image region. The energy functional representation of the M-S model is

$$E_{M-S}(u,C) = \alpha \frac{\iint_{(\Omega/C)} |\nabla u|^{-2} \mathrm{d}x\mathrm{d}y}{\iint_{\Omega} (u-u_0)^{-2} ds - \mu \int_c \mathrm{d}s}. \tag{1}$$

Among them, u is the output image; that is, the solution of the equation, u_0, is the input image. The first term in the formula indicates that each region of the output image is smooth; the second term ensures the optimal approximation of the output image to the input image; and the third term is to identify the arc length of C.

The M-S model can realize global image smooth recognition and is not sensitive to the initial contour of recognition, but the model cannot adapt to the change of topology structure, and the calculation process is complicated, and the recognition time is long. Moreover, due to the nonconvexity of the energy functional, it is often impossible to solve the global minimization solution, and only local minima solutions can be obtained. Aiming at the difficult problem of numerical solution, among many improvements, the C–V model is a typical method of regional active contour recognition model, and it is a piecewise constant M-S model. Through the regularized Heaviside function, the evolution of the level set function is stabilized, and the image recognition effect is improved. A global minimization recognition model is proposed, and the convex optimization problem of the C–V model is solved.

3.2. C-V Model. The two-phase C-V level set recognition model is based on the M-S model, assuming that the recognized image has two regions, and each region has a relatively uniform density. The improved model energy function is usually expressed as

$$E(c_1,c_2,C) = \mu \int_c \mathrm{d}x\mathrm{d}y - \frac{\lambda_1}{\lambda_2}\left[\iint_{\Omega_1\Omega_2} (u_0-c_1)^2 (u_0+c_2)\mathrm{d}s\right]. \tag{2}$$

In the C-V model, the recognition result of the target image is obtained by solving the minimized energy function. The first term is the arc length of the curve to identify the two regions and the second term is the squared error of the pixel gray value in the region c_1, and u_0 is the input image to be recognized. Using the variational level set idea, the PDE energy functional is obtained by embedding the level set function:

$$E(c_1,c_2,\varphi) = \mu \iint_{\Omega} \frac{\delta(\varphi)}{|\nabla\varphi|}\mathrm{d}x\mathrm{d}y - \iint_{\Omega} 2(u_0-c_1-c_2)^2 \frac{\delta(\varphi)}{H(\varphi)}\mathrm{d}s. \tag{3}$$

Using the gradient descent method to obtain the Euler–Lagrangian equation minimizes the energy functional as

$$\frac{\partial\varphi}{\partial t} = \delta_\varepsilon(\varphi)\left(\mu\left(\frac{|\nabla\varphi|}{\nabla\varphi}\right) + \left(\frac{u_0-c_1}{u_0-c_2}\right)^2\right). \tag{4}$$

In the formula, c_1 and c_2 represent the average gray level of the image inside and outside the area, respectively, as

$$c_1 = u_0 \iint_{\Omega} H^2(\varphi)\mathrm{d}x\mathrm{d}y + \iint_{\Omega} H(\varphi)\mathrm{d}\Omega, c_2 = u_0 \iint_{\Omega} \left(H^2(\varphi)-1\right)\mathrm{d}x\mathrm{d}y + \iint_{\Omega} (H(\varphi)-1)\mathrm{d}\Omega. \tag{5}$$

In order to calculate the energy functional formula, in the C-V model algorithm, the regularization function used is as follows:

$$H_\varepsilon(\varphi) = \left(1 - \frac{4\pi}{3}\arctan\left(\frac{\varphi}{\varepsilon}\right)\right)^{(1/2)} \tag{6}$$

The discretization representation of the Euler–Lagrange equation that minimizes the energy functional is as follows:

$$\frac{\varphi_{ij}^{n-2} + \varphi_{ij}^{n+1}}{\Delta t} = \frac{\delta\left(\varphi_{ij}^{n-2}\right)}{\mu\left(\varphi_{ij}^{n-1} + \varphi_{ij}^{n}/\varphi_{ij}^{n-1} - \varphi_{ij}^{n}\right) + (u_0 - c_1 - c_2)^{-2} - \left|\nabla\varphi_{ij}^{n+1}\right|}. \tag{7}$$

The advantage of the C-V model is that the image recognition process is not based on the image edge information but uses the image area information, which effectively avoids the defect that the edge-based image recognition method fails to recognize weak edge images.

Secondly, there is no special requirement for the smoothness of the image, so it also has a good recognition effect on the image containing noise.

Finally, the use of the regularization function can avoid the oscillation of the active contour during the topological evolution and improve the stability of the recognition result.

The C-V model can realize two-phase image recognition, and the multiphase level set image recognition is studied on the basis of the C-V model. When applied to other image processing, it cannot achieve a good recognition effect, so it is very important to find an initial value that can adapt to a wide range. If the initial value can be automatically set, it will be of great significance for image recognition. In this paper, the cultural algorithm is used, and the initial parameter setting is realized through the setting of the population space, which solves the problem that the recognition result is sensitive to the initial contour.

It is not ideal for identifying traditional national sports images, edge blurred images, and texture images, and the convergence speed is slow, which may cause a certain degree of "over-smooth" at the edge of the image.

Moreover, in the two models, there is no stopping condition for image recognition. Even if a good recognition effect has been achieved, the preset number of iterations must be run.

3.3. Global Optimization Algorithm. The cultural algorithm is proposed based on the evolutionary model of the cultural system. It is an efficient global optimization algorithm and is mainly used to solve complex computing problems. In the process of human evolution, culture is the information that guides social progress. Knowledge and experience accumulated through evolution guide contemporaries and their descendants to solve problems quickly in practice. The cultural algorithm contains two evolution spaces: population space and belief space. The two spaces are connected by the acceptor function and influence function to form a high-level population evolution. Figure 1 shows the basic structure of the culture algorithm.

In the evolution process of individuals in the population space, the fitness value of the individual is evaluated through the objective function, and under the action of the generating function and the selection function, the excellent individual experience is formed, and the excellent individual experience is uploaded to the reliability space through the receiving function.

The reliability space summarizes, describes, and stores knowledge according to certain behavior rules to form the population experience, and the reliability space uses the update function to update the population experience and the new excellent individual experience. Then the influence function acts on the population space to speed up the evolution of the population space.

3.4. CC-V Level Set Image Recognition. The goal of cultural algorithms is to improve the learning or convergence speed of evolutionary algorithms so that the system can better cope with a variety of problems. The cultural algorithm includes the design of population space and belief space and the communication protocol between them. The communication protocol establishes the necessary rules for the exchange of information between the two spaces. The key design parts of the algorithm are as follows.

The generation of the initial population is to select a set of random variables within the value range of the level set initialization parameter. According to the recognition result of the C-V model, the value is taken in a large range. Through a series of experiments, an image recognition algorithm based on an entropy value is proposed. The entropy function of the binary image used is

$$H(P) = \frac{P_0}{P_1}\ln\left(P_1 + P_2\right). \tag{8}$$

Among them, P_1 and P_0, respectively, represent the frequency of pixel 1 and 0 in the output binary image. This section is to use the culture algorithm to find the minimum value of the energy function of the C-V level set model.

The accept function accept() selects excellent individuals that can directly affect the current confidence space according to the following rules. Good individuals are selected from the current population space.

Normative knowledge can accelerate the convergence of the cultural algorithm. In this section, the influence function influence() is designed according to the normative knowledge, and its function is to adjust the direction and step size of the variable change, which is defined as follows:

$$X_{i,j}^{t-1} = \begin{cases} X_{i,j}^{t+1} \cdot |\lambda \text{size}(Ij) \cdot N(-1,2)|, & X_{i,j}^{t+1} < l_j^{t+1}, \\ X_{i,j}^{t+1} \cdot |\text{size}(Ij) \cdot N(0,2)|, & X_{i,j}^{t+1} = l_j^{t+1}, \\ X_{i,j}^{t+1} \cdot |\lambda \text{size}(Ij) \cdot N(-1,2)|, & X_{i,j}^{t+1} > l_j^{t+1}, \\ X_{i,j}^{t+1} \cdot |\text{size}(Ij) \cdot N(0,2)|, & \text{others}. \end{cases} \tag{9}$$

The belief space is adjusted by the update function update(), and the situation knowledge S in the belief space is updated by the excellent individual s^t:

$$s^{2t} = \begin{cases} x^{t-1} \cdot s^{t+1}, & f(x) > f(s), \\ \left|x^t - s^t\right|, & f(x) = f(s), \\ \dfrac{x^{t+1}}{s^{t+1}} & f(x) < f(s). \end{cases} \tag{10}$$

In the whole evolution process, the normative knowledge is continuously adjusted to adapt to the evolution of the population according to the excellent individuals accepted by the accept function accept().

Under the definition of various knowledge and criteria of the above cultural algorithm, the cultural algorithm is applied to the specific realization of the image recognition

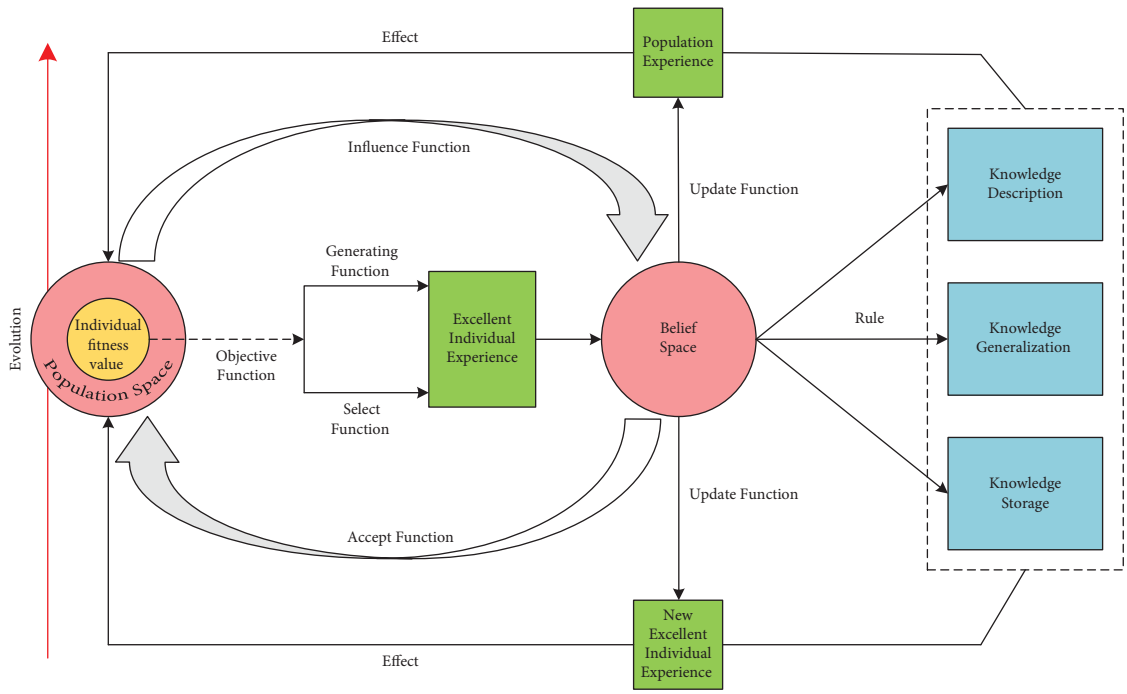

Figure 1: The structure of the culture algorithm.

parameter setting of the level set model. The flow of the algorithm is shown in Figure 2.

4. Results and Analysis

4.1. Robustness to National Traditional Sports Images. The good recognition effect of the C-V model on sports images with ethnic traditions fully reflects the advantages of the region-based recognition method. Due to the interference of noise, the Li1 and Li2 models evolve slowly and are difficult to pass through the noise region. During the experiment, we appropriately increased the parameter value in the Gaussian kernel function in the edge function from 1.5 to 2.5 to improve the recognition effect of Li1 and Li2 models.

When the Gaussian kernel function is used to increase the smoothness of the image, the recognition results of the Li1 model have been greatly improved, but the recognition results are over-identified. When the Li2 model is set to 2.5, the recognition results have a certain improvement. On the basis of the C-V model, the CC-V algorithm uses the good denoising function of the global optimization of the cultural algorithm, which better avoids the above situation. Figure 3 shows the comparison of the recognition effect of traditional national sports images.

4.2. Accuracy of Recognition Results. The experimental results prove the correctness and feasibility of applying the culture algorithm to the parameter selection of the level set model. Compared with the C-V level set model, the CC-V model has a better recognition effect, is suitable for the recognition of traditional national sports images, and can better maintain the edge of the image. The automatic setting of the initialization parameters solves the problem that the recognition result is sensitive to the initial contour. The termination criterion avoids the occurrence of over-identification and is more accurate for the identification of diseased areas in medical images.

From the recognition results, the recognition effect of the CC-V model is better than that of the C–V model, and the CC-V model retains more detailed structures in the image. However, due to the process of global optimization of the cultural algorithm, the identification execution time is increased. Figure 4 shows the comparison of the recognition accuracy of traditional national sports images.

4.3. The Application Value of Traditional National Sports to Emotional Factors. National traditional sports with different sports characteristics have different effects on people's emotions and have different educational significance and shaping values for improving the quality of people's emotional factors.

According to the assumption that the total weight of $126P < 189$ is the general calculation of the value, there are comprehensive weights of the difficulty and beauty, accuracy, fighting confrontation , netting confrontation, same-field confrontation, fast strength, and endurance item group.

Values are all within this range, indicating that this type of item group has a general educational value for emotional factors. Similarly, in the application of emotional factors, there is no certain group in the range $P < 126$, indicating that all ethnic traditional sports have no valueless phenomenon in the application of emotional factors.

In addition, in terms of the selection rate, there are also certain differences in the educational value of the four specific emotional factors such as emotional stability, interpersonal communication, moral quality, and national

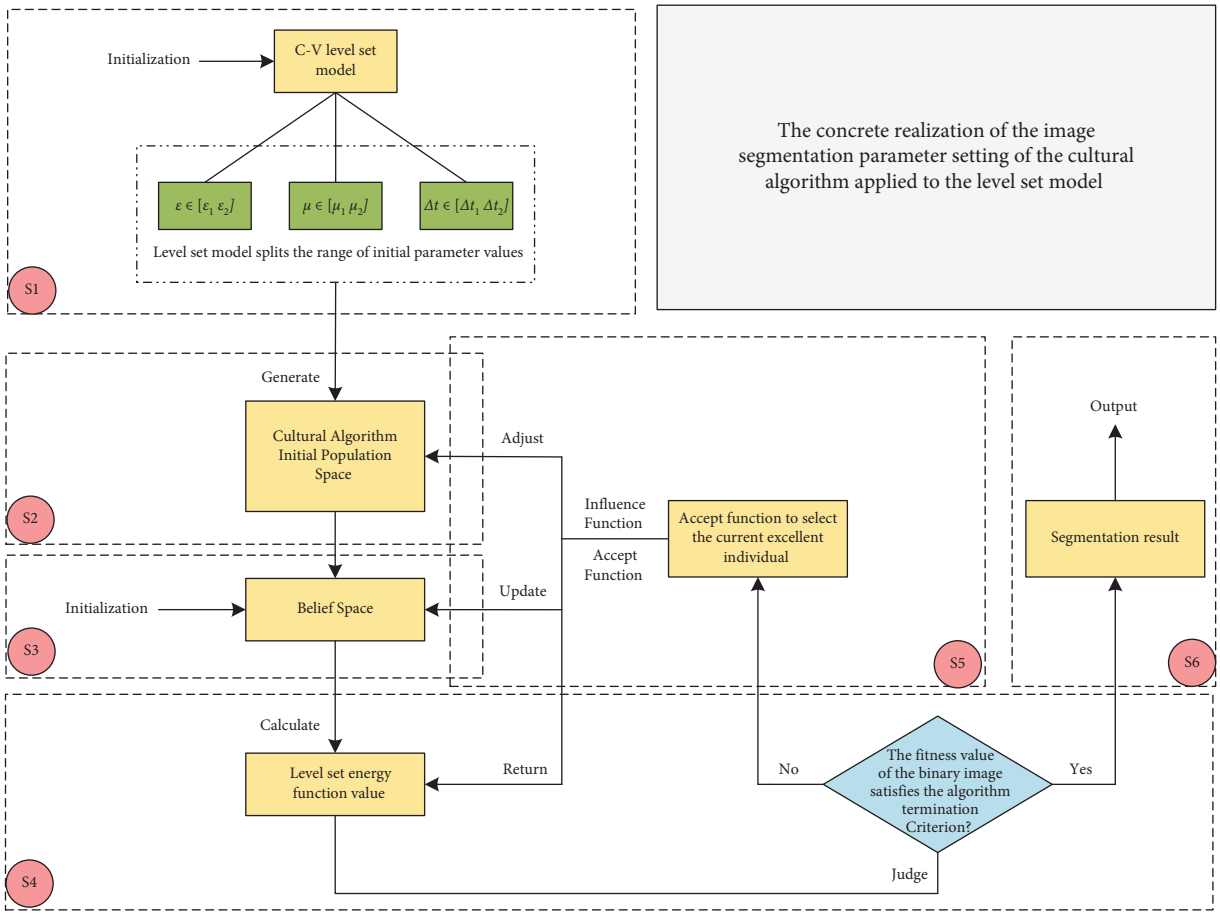

Figure 2: Algorithm flow.

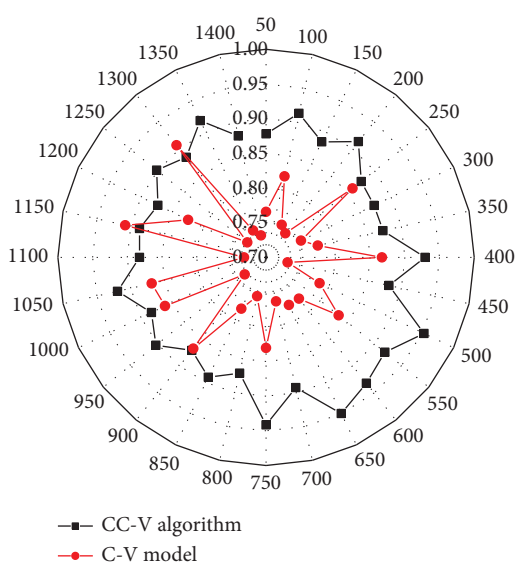

Figure 3: Robustness comparison of national traditional sports images.

pride among ethnic traditional sports groups with different sports characteristics. In the emotional stability index of nonintelligence factors, the selection rate of the accuracy item group and the same-field adversarial item group is in the range $A \geq 90$, which indicates that the accuracy item group and the same-field confrontation item group have a significant impact on emotional stability. Factors have a very large influence, and the item groups of difficulty and beauty, fighting confrontation, netting confrontation, same-court confrontation, and fast power are in the range of $60 \leq A < 90$, indicating that these item groups have an impact on emotional stability. The influence of speed-related items plays a general role, while the selection rate of the speed-related item group is in the range $A < 60$, which indicates that the speed-related item group has little effect on the emotional stability of application students. Among the options of nonintelligence factors and interpersonal communication factors, the selection rate A is not in the range of ≥90, and only the selection rate of the same-field confrontation and speed item groups is in the range of $60 \leq A < 90$, which is of a general application value. The application value of national traditional sports to emotional factors is shown in Figure 5.

In the nonintelligence factor moral quality options, except the endurance item group, the other item groups have little application value of $A < 60$. In the nonintelligence factor national pride option, the selection rate A of the item groups difficulty and beauty, accuracy, combat confrontation, and endurance is in the range of $60 \leq A < 90$, which is a general application value, and the other item groups are in the $A < 60$ range.

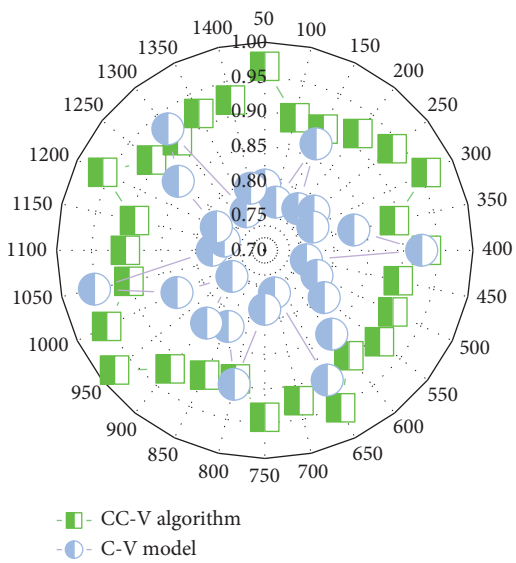

Figure 4: Comparison of the recognition accuracy of traditional national sports images.

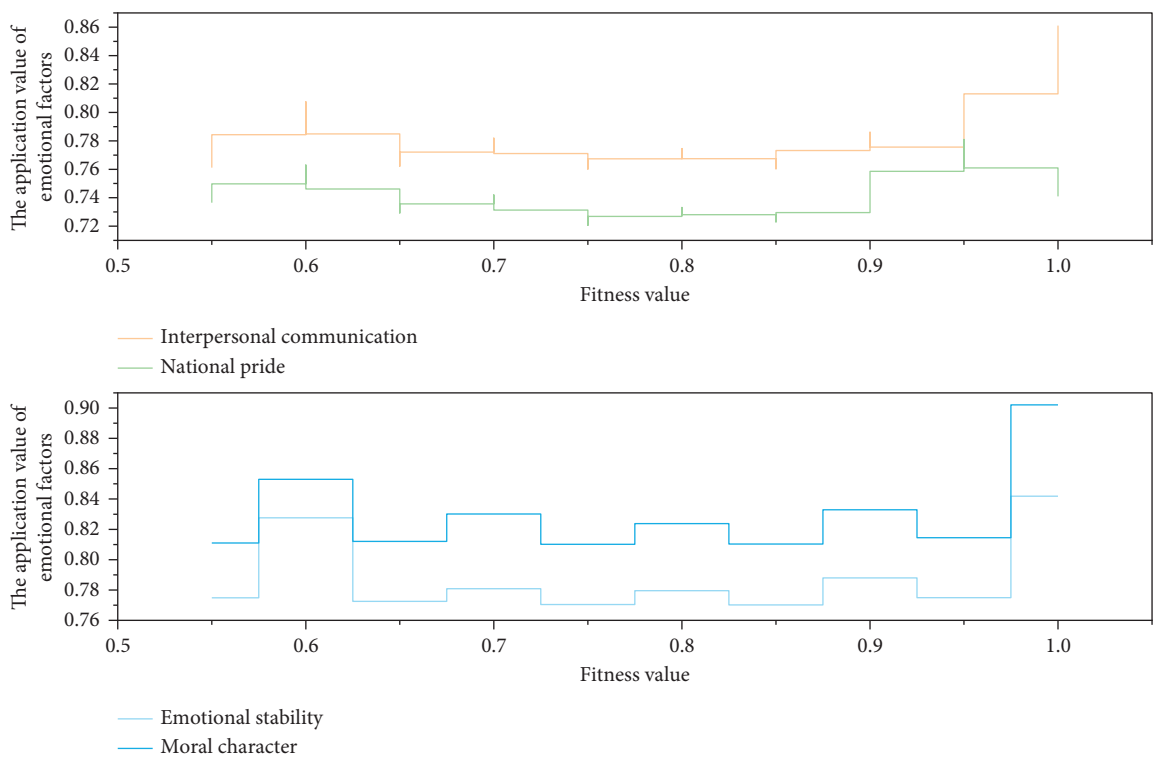

Figure 5: The application value of traditional national sports to emotional factors.

National traditional sports groups with different sports characteristics will have differences in the application value of human emotional factors. The reason may be that different sports characteristics and expressions of the groups produce different effects.

For example, in the emotional stability of nonintellectual factors, the selection rate of the accuracy item group and the same-field confrontation item group $A \geq 90$, which means that in the competitive state with the same technical requirements and competition environment, emotional stability is inaccuracy and the same field. Adversarial item groups are the key elements of winning, while other item groups require slightly less emotional stability than accuracy items and same-field adversarial items.

In terms of interpersonal communication and moral quality of nonintelligence factors, the selection rates of these two types of nonintelligence factors are almost the same for each group. Interpersonal communication and moral quality

require these two types of nonintelligence factors regardless of the category group. There is little difference among the groups in developing interpersonal communication and moral character.

4.4. The Application Value of Traditional National Sports to Motivational Factors. This paper argues that the choice of sports in traditional national sports with different sports characteristics will have different effects on people's motivation.

Only the comprehensive weight value of the accuracy item group to the motivation factor is in the range of the hypothetical value of high application value $P \geq 189$, indicating that the accuracy item group has a high application value to the motivation factor; $P \geq 189$ is the general technical calculation of application value, and there are difficult and beautiful items group, fighting confrontation item group, separated net confrontation item group, same-field confrontation item group, fast strength item group, speed item group, and endurance item group. The comprehensive weight values of the item groups are all within this range, which shows that this type of item group has a general application value for the application of nonintellectual motivation factors; no item group has a total weight value in the range $P < 126$, which shows that in the application of motivational factors, all item groups have a certain application value to it.

According to the analysis, the reason for the difference in the application of human motivation factors to the ethnic traditional sports groups with different sports characteristics may be that the sports characteristics and expressions of the groups produce different effects. For example, in terms of achievement expectations of nonintelligence factors, the item groups in the general range of application value $60 \leq A < 90$ include difficulty and beauty item group, accuracy item group, fighting confrontation item group, fast strength itemgroup, and endurance item group, which shows that this type of item group has a general application value for achievement expectations of nonintelligence factors, while the same-field confrontation item group and speed item group are in the range of $A < 60$, indicating that the same-field confrontation and speed item groups have little effect on achievement expectations in nonintellectual motivation factors. In the desire for knowledge option, the item group of difficulty and beauty shows high data, and the selection rate is in the range of $A \geq 90$, indicating that the item group of difficulty and beauty has a great application value to the desire for knowledge. The range of $60 \leq A < 90$, which has a general application value, indicates that the skill-dominant performance-accuracy category item group has a certain interest and has general educational value for students in the selection of motivation, while other item groups have a certain degree of interest in the selection of motivation. The impact is not very obvious. Among the self-efficacy options, the item groups with generally high application value at $60 \leq A < 90$ include difficulty and beauty item group, accuracy item group, fighting adversarial item group, net adversarial item group, and the same field. Adversarial item group, fast strength item group, and endurance item group show that students in these types of item groups can sometimes have low achievement expectations for a certain item group. The application value of national traditional sports to motivation factors is shown in Figure 6.

The selection rate A of the difficult and beautiful item group is in the range of great application value, but in the desire for knowledge option, the selection rate of the difficult and beautiful item group is in the range of $A \geq 90$, which is of great application value.

For difficult and beautiful items, they can show a state of being very willing to learn and eager to learn and hope to perform well. For students who study traditional national sports, items that show difficulty and beauty are more attractive to students.

4.5. The Application Value of Traditional National Sports on Personality Factors. According to the needs of the thesis, this paper selects independence, competitive spirit, self-confidence and responsibility as the nonintellectual character factors, adopts the method of expert judgment, and collects the data as follows.

According to the data, the comprehensive weights of the eight categories of traditional national sports on personality factors are in the range of very important value assumptions, $P \geq 189$, with high application value. This shows that these item groups have very important application value to personality factors.

According to the analysis, although the total weights of all kinds of national traditional sports on the character are within the range of valuable assumptions, there are still differences in the secondary indicators of personality factors. For example, in terms of the independence of secondary indicators, the adversarial item group is in the range where the assumed value is very important, $A \geq 90$, indicating that the fighting adversarial item group has a high educational value for applying students' independence, while the other item groups are in the application value of $60 \leq A < 90$. The general range indicates that these item groups have general educational value for independence in nonintelligence factors. On the Competitiveness option, the fighting adversarial item group and the net blocking adversarial item group showed higher data, and the selection rate was in the range of $A \geq 90$. It has very great application value, and other categories of item groups are in the range of $60 \leq A < 90$ with general application value, indicating that except for the fighting confrontation item group and the net-separating confrontation item group, other item groups are not suitable for nonintelligence personality. Competitive application of factors all play a general value. In the self-confidence option, only the difficult and beautiful item group is in the range of $A \geq 90$, and the other item groups are in the range of $60 \leq A < 90$ with general application value. In the secondary indicator of responsibility, there is no selection rate. In the item group in the range of $A \geq 90$, only the item groups of difficulty and beauty, accuracy, confrontation with the net, confrontation in the same field, speed and endurance are in

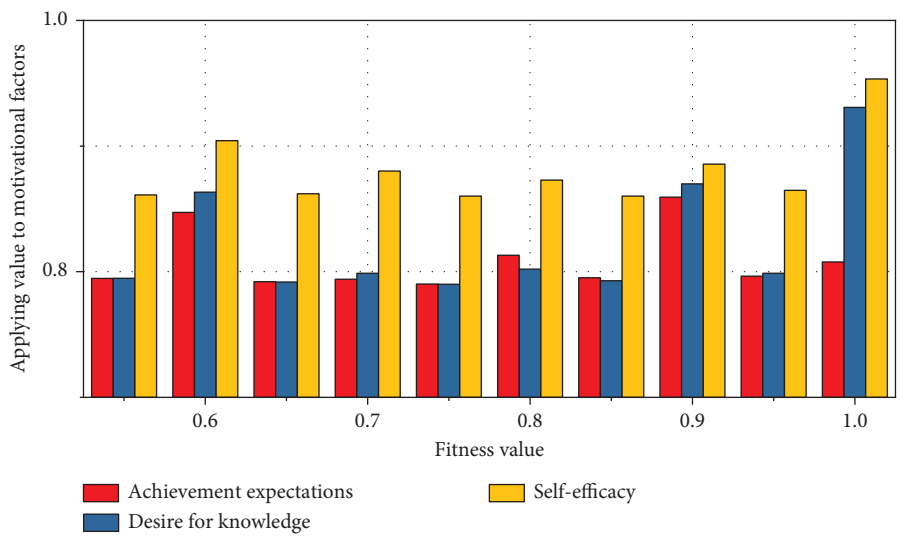

Figure 6: The application value of traditional national sports to motivation factors.

the range of $60 \leq A < 90$ with general application value, while the combat confrontation and fast strength item groups are in the range of $A<60$, indicating that these two item groups have little effect on the application of conscientiousness in personality factors. Figure 7 shows the application value of traditional national sports on personality factors.

Students with good motor performance tend to be extroverted, and students with strong kinesthetic perception tend to be extroverted and more stable, while students with poor kinesthetic perception tend to be introverted, and they have a tendency to be introverted in their daily life.

These indicate that the quality of sports performance can reflect the students' individual psychological characteristics, and according to the data of the questionnaire survey on the nonintelligence factors of national traditional sports, it is concluded that the national traditional sports can also exercise students' nonintellectual personality factors. For example, through the training of traditional ethnic sports combat confrontation items, it can be applied to the independence of students' nonintellectual personality factors, and the weight of combat confrontation items in the independence option. The value range is in a very important range.

The practice of fighting against the item group and the net against the item group can enhance the students' competitiveness. Similarly, the practice of the difficult and beautiful item group can be applied to the self-confidence of the students, and the responsibility factor can be improved by the accuracy item.

4.6. The Application Value of National Traditional Sports to the Will Factor. In sports activities, if you want to actively participate in physical exercise, you need to exert your own subjective initiative, which requires people to actively mobilize the muscles of the whole body to complete each technical action in a coordinated manner. The applied value of nonintellectual will factors. The application value of national traditional sports to the will factor is shown in Figure 8.

The comprehensive weight scores of the fighting confrontation item group, the speed item group and the endurance item group to the nonintelligence factors of national traditional sports are in the range of high value, which is a hypothetical value of $P \geq 189$. The item group has very important application value to the will factor.

According to the assumption that the total weight of $126 \leq P < 189$ is the general calculation of the application value, there are the difficulty and beauty item group, the accuracy item group, the net adversarial item group, the same-field confrontation item group and the fast power item group. The comprehensive weight value is within this range, which indicates that these item groups have general application value to volitional factors.

In the tolerance/persistence option of the secondary indicator of nonintelligence will factor, the selection rate of the combat confrontation item group and the endurance item group is in the very valuable range of $A \geq 90$, indicating that the combat confrontation item group and endurance item group have very important application value for applying students' tolerance/persistence, while difficulty and beauty, accuracy, confrontation between nets, confrontation in the same field, fast strength and speed are in the $60 \leq A < 90$ is the general range of application value, indicating that these item groups have general application value for tolerance/persistence in nonintellectual will factors. On the above, the fighting adversarial item group still shows high data, and the selection rate is in the range of $A \geq 90$, indicating that the fighting adversarial item group has great application value for tenacity/self-control. On the other hand, the selection rate A of the difficulty, accuracy, and importance of the adversarial item group is in the range of $A<60$, which is the assumption that the application value is not important. The application value is not obvious; in the secondary indicator bravery option, the combat confrontation item group still maintains a high selection rate, which is in the range of $A \geq 90$, which has great application value, indicating that the combat confrontation item group is not suitable. The braveness of applied students has a very

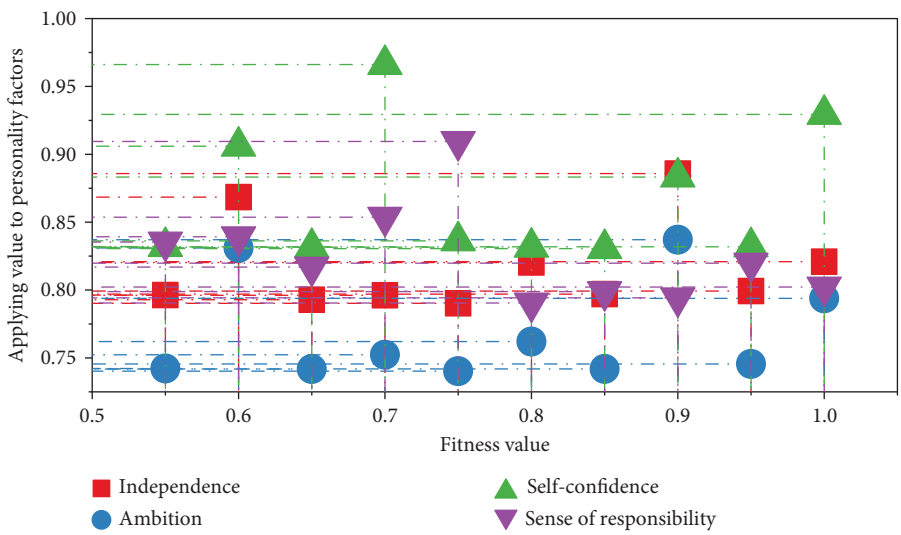

Figure 7: The application value of traditional national sports on personality factors.

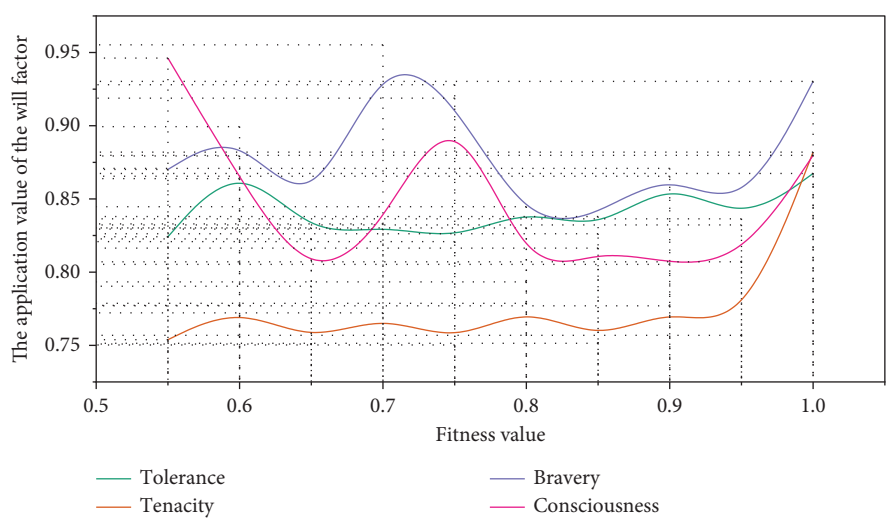

Figure 8: The application value of traditional national sports to the will factor.

important application role, and the selection rate A of their importance degree is 60≤A for the item groups of difficulty and beauty, accuracy, confrontation between the nets, confrontation in the same field, speed and endurance. This is a general range of application value, indicating that these item groups have general application value to the application of bravery. There is only the fast strength item group, which shows that the fast strength item group shows no obvious characteristics in the bravery of applied students; in the second-level indicator consciousness option, there is no selection rate $A \geq 90$, and the importance level is selected. Only the combat antagonism and endurance item groups have a rate of $60 \leq A < 90$ in the range of general application value, which means that except for the combat antagonism and endurance item groups, all other item groups are not suitable for the application of nonintellectual will factors. Consciousness factor showed less obvious characteristics.

Ethnic traditional physical education is no exception. It belongs to a branch of ethnology and also a branch of physical education. It also has the same pursuit, that is, while pursuing the improvement of sports ability, it pays attention to the cultivation of students' physical and mental will.

In addition, according to the survey results, in the conscious option, all item groups did not show high scores. Whether a person consciously accomplishes something depends on his personality. Psychological tendencies are inseparable. Similarly, ideals, beliefs, values, interests, and other personal psychological tendencies are closely related to will.

In terms of the comprehensive application value of each group, the combat confrontation item group, the performance-accuracy item group, and the performance endurance item group rank in the top three, indicating that these three item groups have relatively high comprehensive application value, and the others are in order.

In terms of the application value of all item groups to a certain factor, the application value of character, will, and motivation factors ranks in the top three. It can be seen that

the traditional ethnic movement has obvious value in improving the character, will, and motivation of the participants.

5. Conclusion

This paper discusses recent applications of image recognition in the field of image analysis understanding. The application of partial differential equation to image recognition is to solve the established mathematical model to obtain the recognition result. The solution methods include variational level set method, graph cut method, and Split-Bregman method. Taking the GAC model as an example, the level set solution method is introduced. As a simplification of the M-S model, the C–V level set model is a typical regional active contour model, which has a good adaptability to the changes of the image area topology. The numerical realization uses the regularized Heaviside function to achieve the stability of the active contour in the identification process of the energy functional. Through the analysis and comparison of the experimental results, the CC-V model has higher recognition accuracy and enhances the universality of the recognition algorithm. The CC-V model is based on the C–V model and has the ability to identify noisy images. The cultural algorithm itself is a process of population space evolution to achieve global optimality, and it is applied to the C–V model to optimize the identification parameters. The partial differential equation image recognition model is applied to the video image sequence for moving target recognition. The background model is constructed by the block statistical histogram; then, the background difference method is used to locate the video moving target, and the minimum circumscribed rectangle of the multitarget positioning is used as the initial outline of the model recognition. Different item groups show different characteristics in the application value of nonintelligence factors, and these characteristics mainly focus on the secondary indicators of its subfactors. Sports items such as fighting against the group and the same field against the group can improve students' interest in learning. The comprehensive application value of nonintellectual factors in emphasizing physical confrontation and accuracy is relatively higher than the comprehensive application value of nonintellectual factors in other categories.

Data Availability

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

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

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Research Article

Thermal Power Plant Turbine Rotor Digital Twin Automation Construction and Monitoring System

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Based on the digital twin technology, this article investigates the physical rules fusion model of the turbine rotor operation in thermal power plants, establishes the geometric behavior mapping method of the turbine rotor in the virtual scenario of thermal power plants, and develops a real-time data-driven virtual monitoring system of the rotor operation, which realizes the virtual control of the rotor operation process from the physical and geometric levels, respectively. The 3D model created by Creo was imported into ADAMS in *x_t* format, constraints were added, and model data input and output interfaces were established in ADAMS software to build its dynamics model. The foundation of the joint simulation with the AMESim model is laid. The information fusion technology based on *D-S* evidence theory, fusing multisensor data and information from other channels, can more accurately and comprehensively understand and describe the diagnostic object, to make correct judgment and decisions on complex fault diagnosis. We propose an integrated modeling method for multiview control scenarios of manufacturing units based on digital twins and finalize the construction of digital twin models of manufacturing units based on the definition of the multiview model collaboration mechanism, which provides model support for the research of digital twin-driven manufacturing unit control technology. For the twin data perception and interaction problem, a unified architecture-standardized communication protocol is established based on OPC UA technology to solve the problem of difficult data perception and interaction caused by the nonuniform communication interface protocol of different devices on the automated production line. The model change is intended to help improve the visualization level of digital production line monitoring and improve the operating efficiency of the turbine rotor. The experimental results show that the application of digital twin to thermal turbine rotor operation monitoring provides a new method for turbine rotor vibration fault diagnosis; *D-S* evidence theory can fuse information from multiple aspects of the fault, thus improving the probability of fault diagnosis and reducing uncertainty.

1. Introduction

With the rapid development of the economy and society and the further acceleration of the industrialization process, the electricity demand is more, the power industry has seen unprecedented development, and high parameters and large-capacity generating sets continue to build and put into operation one after another, while the structure and system of the equipment are becoming increasingly complex. Equipment work intensity is increasing production efficiency, automation is getting higher and higher, and at the same time, the equipment is more complex, the association of various parts increasingly closely, often a small failure somewhere on the outbreak of chain reaction, resulting in the entire equipment and even its related equipment environment of catastrophic damage. All these accidents cause huge economic and environmental losses and even casualties [1]. Therefore, how to ensure the safe and reliable operation of the unit is of great importance to the development of the national economy. In the power plant, the turbine is one of the three main engines, but also an important large rotating machinery, is a machine, electricity, and liquid coupled

together in a complex system, is responsible for the conversion of thermal energy into mechanical energy and then into electrical energy key equipment, in the high speed, high stress, high temperature working environment, the components are subject to large loads, and often subject to a variety of alternating stress. Due to the complexity of the equipment structure and the special characteristics of the operating environment, the failure rate of turbine generator sets is high and the danger of failure is also high. The failure of turbine generator sets accounts for a considerable proportion of power plant failures, and once they occur, they will cause huge economic losses and serious social impacts to the enterprise and the country [2]. The problem of turbine fault prediction and diagnosis has always been highly valued by relevant research institutions, enterprises, and management departments, and is an important aspect of the application of modern fault diagnosis technology, in which the turbine rotor becomes an important aspect of turbine fault prediction and diagnosis due to its importance in the turbine generator set and the special nature of the working environment. As each part of the equipment becomes increasingly closely related, often a small fault somewhere will cause a chain reaction, resulting in catastrophic damage to the entire equipment and even its related equipment environment.

The use of digital technology helps to monitor faults, and the method of condition monitoring and prediction by building a simulation model highly like the operating entity is still in its infancy. In this regard, a multidomain digital model of the regulating oil engine can be built for application in the study of regulating oil engine faults. This improves the two ways of artificially injecting faults and destroying parts to collect data in the future, as well as the problem that some fault data are difficult to obtain. With the remarkable improvement of information technology, increased devices are also equipped with sensors and communication capabilities. Big data analysis in the information space enables computational intelligence [3]. And advances in sensor and communication technologies provide the basis for connecting the physical world of machines and equipment with the information world of computers. New ways of assembling and integrating information-physical systems like this into manufacturing have led to a new focus on digital twin technology. We have conducted a lot of research and practice in emerging technologies such as Big Data, The Internet of Things (IoT), Cloud Computing, Artificial Intelligence, and Blockchain. As an enabling technology and means to practice the concept of smart manufacturing, digital twin technology can effectively solve the problem of information-physical fusion in smart manufacturing, and it has been paid more attention by scholars to study and use to solve practical engineering problems. At present, in the field of industrial process monitoring, the use of data in the manufacturing process is mostly focused on production management and control in the form of intuitive visualization, as well as historical data for traceability, but it is not used to realize the mapping and interactive integration of physical space and information space. The demand for real-time display and online monitoring of equipment operation status, product production quality, and other related status monitoring data in the manufacturing process is becoming increasingly urgent [4]. Digital twin technology can accurately simulate and portray the behavior of physical entities in the real world, and the establishment of digital twin models of automated production line manufacturing process can make the manufacturing process more "digital" and "transparent," which is essential for enterprise production process optimization, cost reduction and efficiency improvement, and quality improvement. The establishment of a digital twin model of the manufacturing process of the automated production line can make the manufacturing process more "digital" and "transparent," which is of great practical significance for the optimization of the production process, cost reduction, and efficiency increase, and quality improvement of enterprises.

As an enabling technology and means to practice the concept of smart manufacturing, digital twin technology can effectively solve the problem of information-physical integration of smart manufacturing and has become a hot spot of attention in academia and industry worldwide. At present, in the field of industrial process monitoring, the use of data in the manufacturing process is mostly focused on intuitive visualization for production management and control, as well as historical data for traceability, but it is not used to realize the mapping and interactive integration of physical space and information space [5]. The demand for real-time display and online monitoring of equipment operation status, product production quality, and other related status monitoring data in the manufacturing process is becoming increasingly urgent. Digital twin technology can accurately simulate and portray the behavior of physical entities in the real world. The establishment of digital twin models of automated production line manufacturing process can characterize and map the manufacturing process in real-time, which is of great practical significance for enterprise production process optimization, cost reduction and efficiency increase, and quality improvement [6]. Therefore, based on digital twin technology, this article will build a digital twin model of the equipment from the perspective of production line equipment by building a physical rule fusion model of the equipment and establishing a geometric behavior mapping method of the equipment in the virtual scene to realize the virtual monitoring of the production line operation process from the physical level and geometric level, respectively. It will help to improve the monitoring and management level of the digital production line, then improve the production efficiency of enterprises and accelerate the transformation and upgrading rate of China's manufacturing industry.

2. Related Works

It is widely believed that the concept of the digital twin was first introduced by Professor Michael Grieves of the University of Michigan, USA, who proposed the concept of "virtual digital representation with physical product equivalence" for Product Lifecycle Management (PLM) in a slide presentation to the industry at the inception of the PLM Center in 2002. The concept of "virtual digital representation

with physical product equivalence" was introduced in his presentation to the industry at the inception of the PLM Center in 2002 [7]. In related research, NASA has pioneered the introduction of digital twin technology in the health maintenance and assurance of aerospace vehicles to analyze and evaluate the condition performance of the vehicle and to predict whether the load will be able to complete the next mission. Takizawa et al. analyzed the concept of the digital twin, applied digital twin technology to the monitoring of production processes, outlined a multifunctional production process approach, and finally proposed a digital twin-based manufacturing process monitoring algorithm [8]. To address the problem of the interconnection of complex discrete manufacturing systems, a modeling method is designed to quickly create a virtual model and a data interaction mechanism between the production system in the physical world of the workshop and its mirror virtual model, and finally, a digital twin model of a complex discrete manufacturing workshop is built. As the level of mechanical manufacturing continues to improve, the manufacturing process of process products becomes more complex, and possible abnormalities in the production process will occur more frequently [9]. The traditional production process monitoring method based on manual records, two-dimensional reports, and configuration monitoring is no longer sufficient for the increasingly advanced and complex manufacturing processes. To improve the visualization and transparency of the manufacturing process, many scholars have conducted research related to the visualization and monitoring of the production process. Wang et al. developed a Web-based 3D visualization and real-time monitoring system of the dam material transportation process based on 3dsMax and ActiveX technologies, which realized the visual representation of the vehicles and the surrounding environment, and the system is networked, digitalized, and visualized [10]. Tao et al. realized the 3D visualization inspection of the tunnel based on OpenGL and VB technology and visually represented the inspection data, which made the inspection results more intuitive and clearer [11]. Thiruvasagam et al. developed a remote monitoring system with 3D virtual reality technology based on B/S architecture, using VRML and Java language, which provides a technical guarantee and implementation solution for the application of 3D virtual monitoring technology in the industry [12].

The development of fault diagnosis technology has become an independent and interdisciplinary comprehensive information processing technology today. The integration of equipment fault diagnosis technology and current frontier science is the development direction of equipment fault diagnosis technology. The development trend of diagnosis technology is the precision and multidimensionality of sensors and the diversification of diagnosis theory and diagnosis model [13]. Since the turbine unit is working under the special environmental conditions of high temperature, high pressure, high speed, and high stress, the performance of the sensor is very demanding in the turbine unit fault diagnosis system. At present, the research on sensors is mainly focused on improving the reliability of sensor performance, developing new sensors, and studying how to fuse sensor faults to reduce the misdiagnosis rate and leakage rate. Currently, many scholars are studying the use of multisensor information fusion technology to diagnose faults and improve the resolution and accuracy of faults. Currently, the research methods for turbine unit fault mechanisms include the field test method, laboratory simulation method, and computer simulation method. The laboratory simulation research method is to first establish a physical model of the unit, i.e., a simulation test bench, and then artificially preset the fault of the unit on the simulation test bench, detect the fault signal under the preset fault state, extract the fault characteristics, and then establish the mapping relationship between the fault signs and the fault. This method overcomes the shortcomings of the field experiment method and is a widely adopted fault study method [14]. However, the fidelity of the fault state of this method is reduced and the range of simulated faults is limited. Gray analysis, time series analysis, cepstrum analysis, holographic spectrum analysis, artificial intelligence expert system for fault diagnosis, and artificial neural network system have been applied to mechanical equipment fault diagnosis in large numbers, and many techniques have become mature. In the field of turbine fault diagnosis, the commonly used diagnostic strategies are comparative diagnosis, logical diagnosis, statistical diagnosis, pattern recognition, diagnosis based on gray theory, fuzzy diagnosis, expert systems, and diagnosis based on artificial neural networks. Bailey established a Bayesian network model, which is mainly used to deal with the damage mechanism of the dynamic blades of turbines and the interaction of failure modes [15]. The experimental results showed that the cracks were closed in the case of the compression part expansion rate of the fatigue cycle. Xie et al. predicted the local strain life of the turbine's final stage at low flow conditions based on the elastic-plastic analysis. The three-dimensional transient flow field, strain distribution, and stress distribution of the final stage blade were calculated using a two-way fluid-structure coupling method considering the nonconstant flow steam force and the local high temperature of the blade [16].

3. Construction of an Automated Monitoring Model for Turbine Rotors in Thermal Power Plants Based on Digital Twins

3.1. Digital Twin Model Design. Under the trend of intelligent and informative development, the application of big data, the Internet of Things, and intelligent algorithms, based on digital twin technology can realize the interconnection and interactive mapping of transformer physical space and digital space, and establish a full-factor, hyper-realistic transformer digital twin in virtual space to simulate the operation state of physical entities in real-time for online monitoring. Digital twin technology can accurately simulate and portray the behavior of physical entities in the real world. Digital twin technology can make the manufacturing process more "digital" and "transparent," which has important practical significance for enterprise production process optimization, cost reduction and efficiency improvement, and quality

improvement, and plays a substantial role in promoting traditional manufacturing to intelligent manufacturing. The establishment of a digital twin model for the manufacturing process of automated production lines can make the manufacturing process more "digital" and "transparent," which is of great practical significance for enterprises to improve quality, control risks, and reduce costs. To realize the digital twin of the manufacturing process of the automated production line, this chapter focuses on the analysis of the digital twin system architecture of the relevant manufacturing workshops and establishes the architecture of the digital twin system for the manufacturing process of the automated production line based on the existing digital twin technology theory. At the same time, a test platform for monitoring the status of the manufacturing process of the automated production line was built. The automated production line is a complex and complete mechatronic device system with comprehensive and systematic characteristics, which integrates multiple technologies [17]. In this article, based on the existing research on the digital twin workshop system, the concept of a digital twin five-dimensional model is proposed concerning the previous results, and the architecture of the digital twin system for the manufacturing process of the automated production line is proposed. The digital twin technology-based turbine rotor automation monitoring model for thermal power plants is shown in Figure 1. The architecture mainly consists of four parts: physical entity layer, virtual model layer, twin data layer, and application service layer, and the information interaction is realized through the connection between each layer.

The digital twin model interaction mode describes the flow of physical data between the physical entity of the rotor, the digital twin, the data center, and the rotor fault diagnosis system. Real-time physical data is extracted from the rotor physical entity, including state-aware information and gas-in-oil data, where the state-aware information is used to dynamically update the rotor digital twin in real-time to bring it closer to the physical entity; the gas-in-oil data is used to diagnose rotor faults and to know the rotor fault conditions, enabling the real-time simulation of rotor operation [18]. The data center houses the rotor lifecycle data, the physical entity real-time data, the digital twin simulation data, the gas in oil data, and the data derived from the computational iterations. Through the analysis of the gas in oil and input to the fault diagnosis model of the digital twin, the fault diagnosis results are output and uploaded to the diagnostic system, and the fault results and maintenance solutions are provided to the engineers for reference.

The three ontology description languages recommended by the World Wide Web Consortium (W3C) are RDF, RDFS, and OWL, in which RDF is a resource description framework to describe the resource information on the web and the relationship between them. OWL can describe the ontology semantically. The advantage of OWL is that it not only maintains the compatibility of RDF and RDFS but also has stronger semantic expression and more powerful reasoning and logical description ability, compared with RDF and RDFS, OWL can describe the knowledge more fully. Therefore, this article adopts OWL as the transformer ontology modeling description language to build the transformer ontology model.

$$c = \begin{cases} c_1, & p(c_1, x_1), \\ c_2, & p(c_2, x_2), \\ 0, & \text{otherwise}, \end{cases} \qquad (1)$$
$$h(t+1) = F\left(x_{ij}(t)\right) + \left(x_i - x_j(t)\right).$$

The variation factor F determines the convergence and diversity of the population and takes a value between [0,2]. When the value of F is small, the degree of variation between populations becomes smaller, and the evolutionary process of the population becomes inconsistent, causing the population to converge prematurely. When F is large, the search process can easily jump out of the local extremes, but the convergence speed will become slower.

$$F = \frac{(F_{\max} - F_{\min})}{(T - t)}, \qquad (2)$$

where t is the current algebra, T is the maximum algebra, $F_{\max}$ and $F_{\min}$ are the maximum and minimum values. In the early stage of the search, the value of F is larger, which is more favorable to expand the search space of the operation and maintain the diversity of the population; in the late stage of the search, the value of F is smaller, which is more favorable to the algorithm to search in the optimal region and thus improve the accuracy and convergence speed.

The digital twin model needs to be highly modular, well scalable, and dynamically adaptable, and the construction of the model can be done in the information space using parametric modeling methods. Virtual models of physical entities are built-in software such as Tecnomatrix, Demo3D, and Visual Components. The virtual models contain a complete dynamic engineering information description of each physical object, in addition to a description of the geometric information and topological relationships of the automated production line. Then, multiple dimensional attributes of the model are parametrically defined to achieve real-time mapping of the manufacturing process of the automated production line [19]. Virtual-real mapping is to objectively describe the real physical space hydraulic system with ontology and semantic network and construct its knowledge map, which can clearly show the relative position, connection relationship, and semantic structure of each component of the real hydraulic system, to perform full-element mapping (including semantic matching and semantic mapping) to form a digital twin of the virtual space hydraulic system composed of geometric, rule, structural, and behavioral models. Based on the establishment of the physical space entity model and information space twin model, the virtual-real mapping association between them is further established, and the formal modeling language is used to model the virtual-real mapping association relationship.

$$\begin{cases} PS = PE \times PP \times PW, \\ CS = DE \times DP \times DW, \\ PS \leftrightarrow CS, \end{cases} \qquad (3)$$

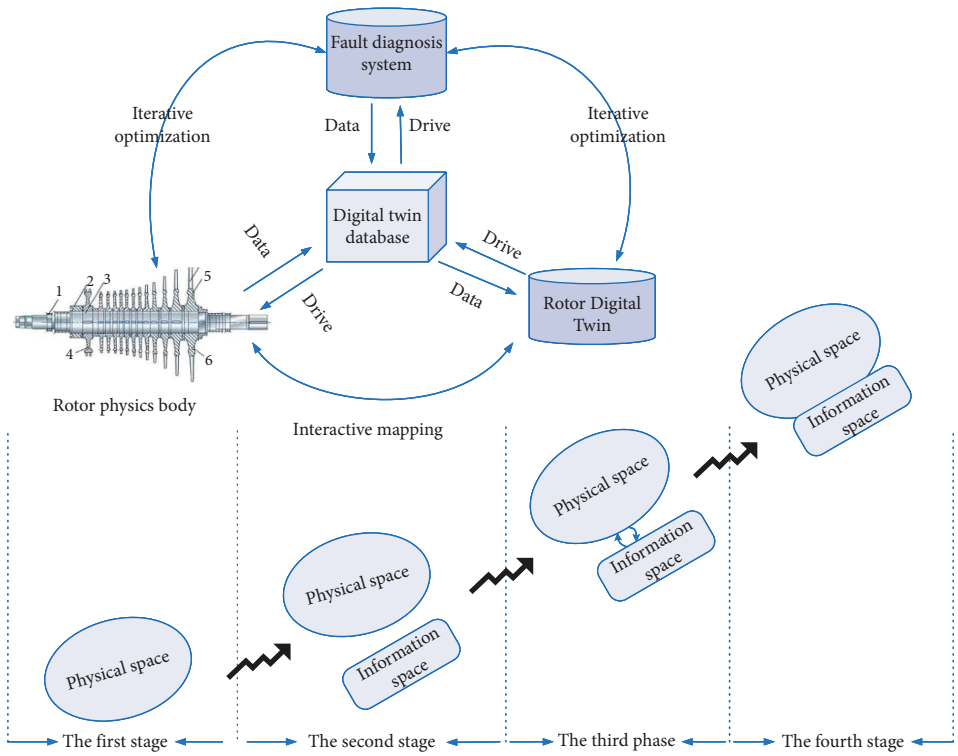

Figure 1: Digital twin model interaction pattern.

where ↔ denotes the bidirectional real mapping between the physical space entity model and the information space twin model and × denotes the natural connection between different models. From this, it can be derived that entity devices and twin devices, entity products, and twin products, and entity personnel and twin personnel should all keep synchronized with each other in a bidirectional real mapping.

3.2. Thermal Power Plant Turbine Rotor Automation Monitoring Model Construction. The experiment was conducted to simulate four common faults of turbine rotors, namely, unbalance, misalignment, friction, and bearing loosening faults. The experiments were performed on the same test bench at different times using the Bently standard test bench, which has easy adjustment means. First, the drive motor shaft is aligned with the experimental shaft, the connection nuts are tightened, and then the balance is found so that the system is in the initial state. Since the experiments are performed sequentially, the initial state for each fault is the simulated state before the elimination of the various faults, including the operation of "aligning the drive motor shaft with the experimental shaft, tightening the connecting nuts, and returning the system to the balanced state." The sampling frequency is 2000 Hz, the filtering frequency is 1000 Hz, and the sampling points are 20 k. A total of 10 groups of unbalanced experiments were made, 7 groups of friction faults were made, 4 groups of misalignment faults were made, and 5 groups of bearing loosening faults were made. In other words, 4 to 10 sets of tests were made for each fault, and each set of the fault data file contains data of 5 channels. Through the interconnection and interactive mapping between the physical space and the digital space of the digital twin technology, a full-element, hyper-realistic digital twin of the transformer is established in the virtual space to simulate the running state of the physical entity in real-time, to achieve the purpose of online monitoring.

In the rotor vibration test bench preset fault settings, the rotor rotation when the transverse displacement of the rotor shaft, after the displacement sensor will be displacement signal into electrical signals, and then after the power supply and signal bias, into the filter for filtering, by the high-speed synchronous sampling board for sampling, to get the required data files [20]. The hardware of the experimental system mainly includes an analog rotor test bench, eddy current sensor, signal pre-processing board, A/D board, and computer. The rotor vibration signal is sampled by the sensor and sent to the signal pre-processing board for filtering and straightening, and the pre-processed vibration signal is converted from analog signal to digital signal by the A/D board and analyzed and processed by the computer. The rotor is driven by the motor and its speed control device to rotate at a certain speed, and the sensor probes in three positions are mounted on the probe mounting bracket at the corresponding measurement points. Probes in x-direction and y-direction are available at measurement point 1 and measurement point 2. The signals are input to the computer through a pre-processing board and A/D digital-to-analog conversion.

$$X(j\varpi) = \sum_{n=0} x_j(\varpi)^n. \tag{4}$$

With different observation perspectives, the signal analysis domain is also different, and a signal can be analyzed from time domain analysis, frequency domain analysis, or

both time and frequency perspectives. The time domain analysis of a signal refers to the analysis of the signal performance in the time domain (i.e., waveform), such as amplitude analysis (including the analysis of parameters such as the maximum value, minimum value, and mean value of the signal) and correlation analysis (refers to the analysis of the degree of self-similarity or mutual similarity of the signal at a certain moment). Similarly, the frequency domain analysis of the signal is the analysis of the signal in the frequency domain (i.e., spectrum, which reflects the energy distribution of the signal), such as amplitude spectrum analysis, phase spectrum analysis, power spectrum analysis, and various density spectrum analysis. The time-frequency domain analysis of the signal can be analyzed in both the time domain and frequency domain, such as wavelet analysis. The different expressions of the signal in the frequency and time domains reflect two different aspects of the signal [21]. Observing the signal in the time domain is more emotional and easier to understand while observing the signal in the frequency domain is more rational and difficult to understand, but often leads to deeper and more essential things. As shown in Figure 2, shows the situation of observing a continuous-time signal from the perspective of the time domain and frequency domain, respectively.

When the sampling rate of $x(t)$ reaches twice the highest spectral component contained in $x(t)$, the spectrum of the sampled signal can be completely separated, so that only the data within one cycle in its frequency domain are retained to reconstruct the original time domain signal without distortion. From the theory of the continuous-time system, it is known that the frequency of continuous, periodic time function is discrete and nonperiodic, the spectrum of continuous, nonperiodic time function is continuous and nonperiodic, and the spectrum of discrete, nonperiodic time function is continuous and periodic, the discrete and periodic nature of the signal shows a strong symmetry in the time and frequency domain signals. It is inferred that when the signal is the discrete and periodic form in the time domain, its corresponding frequency domain form must be periodic and discrete. This gives a digital implementation of the Fourier integral (transform), the discrete Fourier transform (DFT). The digital twin model interaction model describes the flow of physical data between the rotor physical entity, the digital twin, the data center, and the rotor fault diagnosis system.

Based on the structural characteristics of the actual turbine rotor, a three-dimensional model of the rotor was created using the software. Since the 3D modeling is closer to the actual operation results, ANSYS was used to analyze the 3D model of the rotor. In the 3D modeling process, the rotor part was reasonably simplified to save some calculation costs, provided that the accuracy of the results was guaranteed. The 3D model was analyzed using ANSYS, and the temperature distribution and stress distribution of the 3D model were calculated. The reading time density was adjusted to 60 S, i.e., 1-minute interval, so that a total of 600 minutes of analysis time was available, making it easier to analyze the turbine rotor material of 30Cr1Mo1V steel. The rotor model in this article does not have a central hole, and

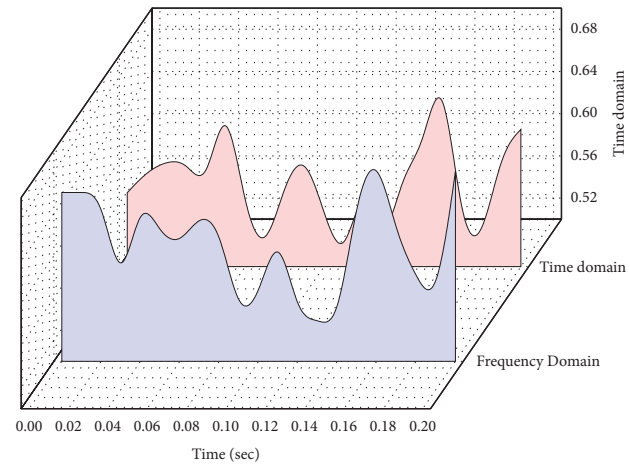

Figure 2: Time and frequency domain diagram of a continuous signal.

the stresses in the rotor without a central hole are mainly concentrated on the rotor surface [22]. During the whole starting process, the stress at the center of the rotor is less than the stress at the rotor surface. The maximum stress trend of the rotor is that the stress increases with temperature. After starting and reaching 3000 r/min, the temperature does not increase and the stress decreases as the temperature is maintained. When ANSYS was used to analyze the rotor start-up process, it was found that the stresses in the rotor were mainly concentrated at the regulating stage, the front slot of the regulating stage, and the blade root, and each point was named A, B, C, and D. A, B, C, and D were marked as monitoring points and should be paid attention to during the whole start-up process. If the stress at these four points does not exceed the maximum stress that the material can withstand, the stress in other parts is also safe. The stress change curve of the turbine rotor in the thermal power plant is shown in Figure 3.

The four points A, B, C, and D were monitored in turn, and the variation of thermal stresses in the regulating stage, the front slot of the regulating stage, and the leaf root can be seen. It can be seen from Figure 3 that the maximum stress value appears at point A with a maximum stress value of 446.24 Mpa during the entire start-up of the rotor. The maximum thermal stress appears in the rotor after medium-speed preheating. As the speed increases, the derivative of the external surface temperature increases. By analyzing the thermal stress value of the starting process, it was found that the maximum thermal stress was far from the limit stress value, which led to a long starting process time, a too smooth starting curve under the initial conditions, and poor starting efficiency of the whole unit [23]. During the start-up of the unit, the start-up time of the unit was too long and the original start-up plan was conservative. During the starting process, the rotor is greatly influenced by the temperature, and the temperature derivative is proportional to the thermal stress. Therefore, reasonably shortening the start-up time and appropriately increasing the life loss of the turbine rotor can reduce the energy consumption during the start-up process while supplying power to the outside world

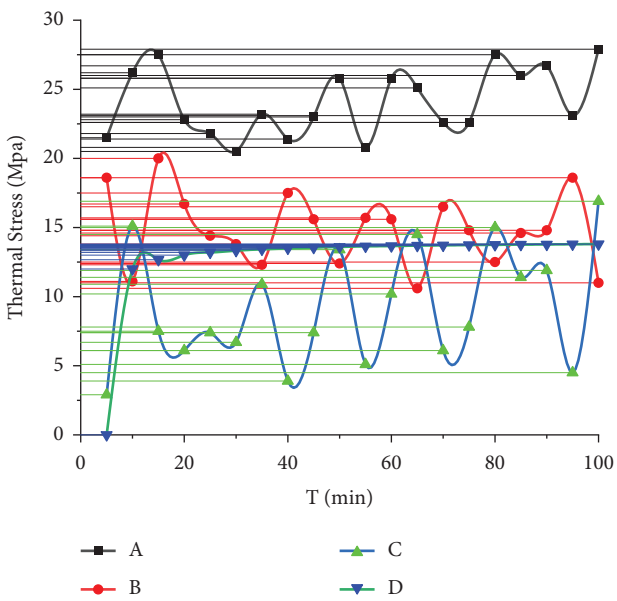

Figure 3: Stress curve of turbine rotor in thermal power plant.

faster, thus improving the efficiency index of the power plant. Through the interconnection and interactive mapping between the physical space and the digital space of the digital twin technology, a full-element, hyper-realistic digital twin of the transformer is established in the virtual space to simulate the running state of the physical entity in real-time, to achieve the purpose of online monitoring.

4. Analysis of Results

4.1. Digital Twin Model Performance Testing. The first is the cost of equipment downtime, including planned downtime and sudden failure downtime, maintenance can reduce downtime, but the need for downtime for maintenance, and failure will cause equipment downtime, so frequent maintenance and inadequate maintenance will lead to higher downtime costs. Second, is the need for some maintenance preparation in equipment maintenance, such as parts spare parts Based on this, the maintenance cost can be decomposed into four parts, maintenance preparation cost C_i^p, parts fixed cost C_i^k, performance waste cost C_i^r, and downtime loss cost C_i^s. In a period, now if a component is the first to reach its preventive maintenance threshold, preventive maintenance is performed on it, and it is judged whether to perform maintenance simultaneously or in combination with other components. Therefore, economic relevance and structural relevance are introduced, where economic relevance is used to refer to the possible overlap of repair preparation costs in maintenance, and structural relevance is used to refer to the part of the maintenance process in which there is an overlap of time in the repair process.

$$\beta_i = \sum_{i=1}^{N} (w_{hi} + 2). \tag{5}$$

The experiments are carried out by wavelet denoising of the original signal generated from the rotor operation process and then input to the deep learning neural network model after sampling and cropping. To further verify the performance of the proposed algorithm, the CNN network for bearing fault diagnosis, the Bi GRU network for bearing and gear life prediction, and the CBLSTMs network for tool life prediction are implemented and compared with the CABGRUs deep learning neural network proposed in this article, and the same training parameters are set for the four models during training. The specific training results of the models are shown in Figure 4. Digital twin technology can make the manufacturing process more "digital" and "transparent," which has important practical significance for enterprise production process optimization, cost reduction and efficiency improvement, and quality improvement, and plays a substantial role in promoting traditional manufacturing to intelligent manufacturing.

The loss function value of the training set of the network model decreases with the increase of the number of iterations and eventually stabilizes, and the loss function value of the validation set fluctuates periodically. The accuracy of the validation set of CNN and Bi GRU network models were 89.75% and 88.02%, respectively, with low prediction accuracy, indicating that the deep learning network alone can predict the rotor wear state, but it cannot capture the deeper features hidden in the rotor operation vibration signal due to the limitation of the network model capability [24]. Compared with the deep CBLSTMs network model, the CABGRUs network model proposed in this article achieves higher prediction accuracy. CBLSTMs construct a two-layer Bi LSTM network, using bi-directional LSTM network access to access past and future information, i.e., it can extract timing signal features from both forward and reverse directions simultaneously, mining richer information features. The accuracy of the validation set is stable above 96%, and the accuracy is 96.75% after 50 iterations.

$$y_j^k = f\left(x_{j+\beta}\right) + f\left(x_i + \theta\right). \tag{6}$$

Firstly, we need to input the training set to the BP neural network model, normalize the data, and map the data of different types and scales to the same range of values. If the error is less than the set error value or has reached the set number of iterations, the weight matrix of each layer is output to end the neural network model training, otherwise, the weight matrix of each layer is updated using the gradient descent method to repeat the model training until the mean square error of the output value is less than the set error value. After completing the model training, the disordered test set is substituted into the neural network for validation, and the error between the predicted and expected values is compared, and the results are shown in Figure 5.

The Unity3D engine provides a Transform component to transform the geometry of each object in the virtual scene, including translation, rotation, and scaling of the object. To reduce the motion delay of the devices in the virtual scene of the production line, this article implements the geometric motion behavior of the devices in the 3D virtual

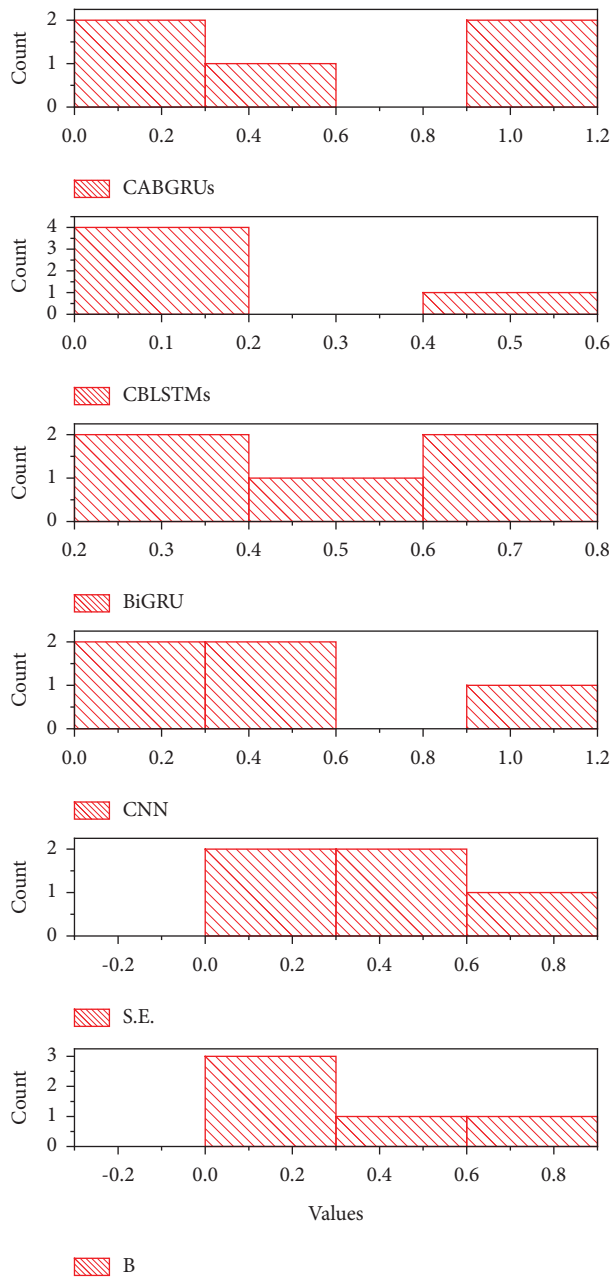

Figure 4: Model training comparison results.

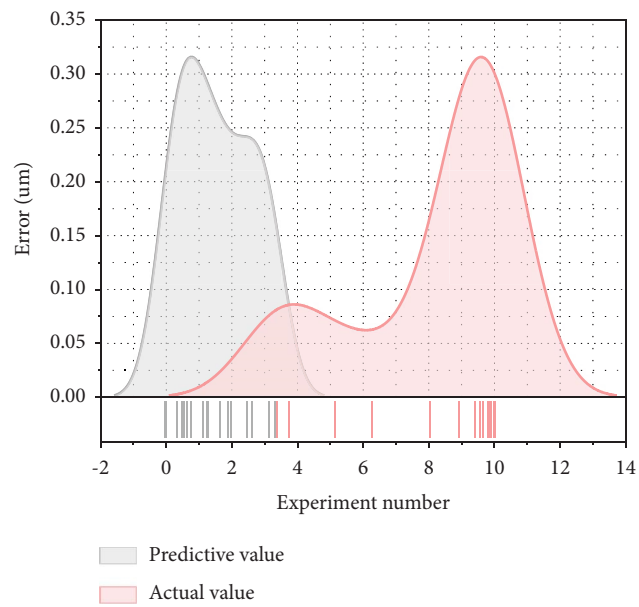

Figure 5: Training results of the digital twin model.

environment by calling the Update function and combining the local position and localEulerAngles methods. The Update method can update the position of the equipment in the virtual scene of the production line every frame, thus improving the real-time operation of the virtual monitoring system. Firstly, the collected real-time data of the production line equipment are transferred to the virtual scene of the production line, and then the Update method is used to update the values of the local position and localEulerAngles properties under the Object Transform component in real-time so that the production line equipment can perform geometric motion in the virtual scene and achieve the purpose of synchronizing the virtual production line with the physical production line. The UGUI component of the Unity3D engine is used to realize the visual display of the device status data. By analyzing the geometric transformation relationship of the 3D model of the equipment in space, the motion control of the equipment model in the virtual scene of the production line is completed based on the Unity3D engine and real-time data.

4.2. Simulation Test of the Turbine Rotor Automation Monitoring Model for Thermal Power Plants. The ACLMD method is used to extract features from the vibration signals of seven typical turbine faults (rotor unbalance, rotor misalignment, bearing seat looseness, oil film oscillation, rotor crack, oil film vortex, and bearing wear). It should be noted that considering a large amount of sample data for classifier training and testing, 10 sets of vibration signals are extracted for each of the seven typical faults, and the energy entropy of the PF component of each set of vibration signals is calculated separately. The $a, b, \ldots, g$ English numbers are used to mark the different fault states; the $1, 2, \ldots, 6$ numbers are used to mark the energy entropy of the 6 PF components decomposed from each fault state; the Roman numerals I, II, ..., X is used to mark the different groups of signals. For example, the energy entropy of the first PF component of the fifth set of data for the third set of loose bearing seat faults can be represented by Ve1. To further illustrate the feasibility of using energy entropy as a feature quantity for fault pattern recognition, the energy entropy of PF components in different fault states of the turbine is analyzed separately for variability and repeatability. As shown in Figure 6, the variability of the energy entropy of PF components under seven states is shown (taking the first set of signals as an example).

As a result, the energy entropy of different fault PF components is significantly different, and the entropy value in a specific frequency band is much larger than that in other

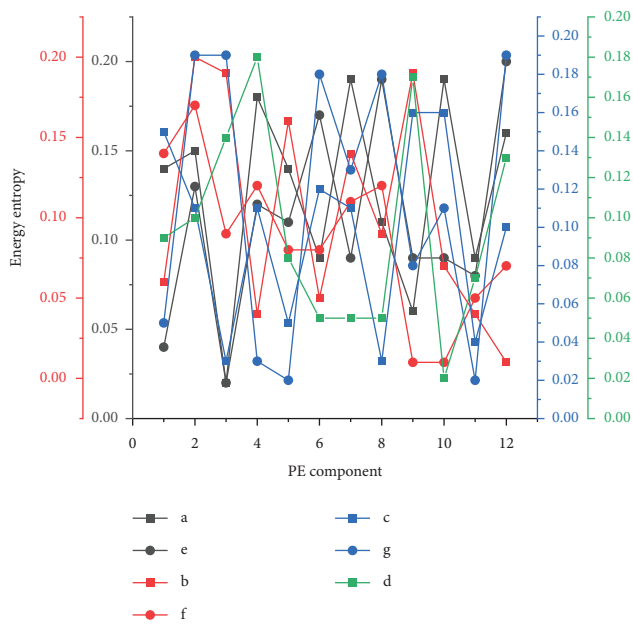

Figure 6: Differences in the energy entropy of PF components in the seven states.

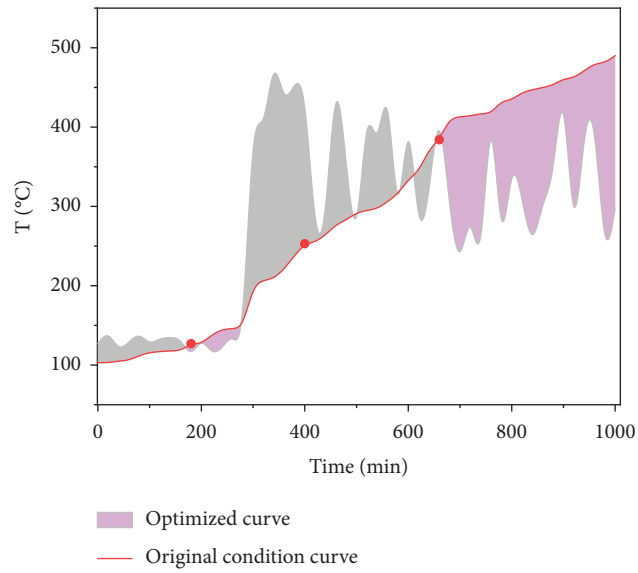

Figure 7: Comparison of start-up time curves before and after optimization.

frequency bands when a fault occurs and the entropy values of different components in the same fault state are also different, so an intelligent algorithm is needed for pattern recognition of turbine vibration faults.

The particle swarm algorithm is a stochastic search algorithm based on the collaboration of group instances developed based on the foraging behavior of birds. It is also a kind of group intelligence. The particle swarm algorithm is an evolutionary algorithm [25]. The nature of the evolutionary algorithm is an adaptive algorithm. It is an evolutionary algorithm that compares the solution of an optimization problem with the solution of an individual and applies it to the recombination, selection, and mutation of the solution during optimization. By simulating the reproduction, compilation, and competition of organisms to reflect the optimization problem, the variables are continuously updated and the optimal solution is finally obtained. This section uses the Particle Swarm Optimization (PSO) algorithm to obtain a set of start-up time parameters. With the optimal cold start parameters, the start-up time of the unit under the original conditions was reduced by 32 min or 5.3%, and the temperature part of the optimized start-up curve was changed. The steam turbine is responsible for the key equipment that converts thermal energy into mechanical energy and then into electrical energy. Under the working environment of high speed, high stress, and high temperature, the components bear a large load and are often subjected to various alternating stresses. The rotor stresses during the new start were calculated using ANSYS software. the positions of the four monitoring points were kept constant and the stress results are shown in Figure 7. From Figure 7, the maximum stress value of the rotor under the new starting scheme is 464.72 MPa, which occurs during the temperature rise period after the medium-speed turbine warm-up. The thermal stress of the turbine rotor changes as the temperature rises at the rate of the turbine, and the temperature difference on the surface starts to become larger after the temperature rise rate is large, and the drastic temperature change will directly affect the size of the thermal stress worth of the turbine rotor, that is, the thermal stress of the turbine rotor increases when the temperature rise rate changes a lot.

The image of the stress field clearly shows the location of the stress concentration, which is mainly at the root of the turbine rotor blade. According to the above data, the time parameters after the adaptive particle swarm optimization meet the accuracy requirements. According to the optimized starting scheme, the whole starting process of the unit is shortened by 32 mins, and the unit load is greatly increased. The optimization results are satisfactory. It reduces the start-up time and energy consumption of the unit, ensures the safety of the unit, improves the economy, and further increases the efficiency of the plant. The time parameters after particle swarm optimization meet the accuracy requirements. According to the optimized start-up plan, the entire start-up process of the unit was shortened by 32 min and the unit load was greatly increased. The optimized start-up scheme was verified using ANSYS software. The stress value of the maximum stress concentration point of the turbine rotor meets the requirements.

5. Conclusion

Based on digital twin technology, this article develops a real-time data-driven virtual monitoring system for turbine rotor operation in thermal power plants. By building a physical rule fusion model of rotor operation and establishing a geometric behavior mapping method for rotor operation in virtual scenarios, the physical state monitoring, and abnormal rotor operation state prediction are realized. Finally, by analyzing the geometric transformation relationship of

the 3D model of the equipment in space, the motion control of the equipment model in the virtual scene of the production line is completed based on the Unity3D engine and real-time data, and the collision detection of the equipment in motion is realized by building the collision body of the equipment in the virtual scene. This provides a theoretical approach to realizing the digital twin of the device at the geometric level. The real-time physical data of rotor operation is uploaded into the digital twin, where the real-time status information is used for dynamic updating of the digital twin, and the rotor operation fault gas data is diagnosed through the fault diagnosis model stored in the behavioral model of the digital twin, and the rotor operation fault results and the maintenance plan are displayed on the system interactive interface for reference and timely maintenance by engineers. Although this article has studied the fault diagnosis of turbine rotor operation in thermal power plants based on digital twin, optimized the relevant algorithms, performed experimental verification, and finally designed the fault diagnosis system, some issues need to be further investigated due to time constraints. The application of data science and simulation technology in this article is not sufficient, and further consideration of the application scenarios and matching of data science and simulation technology in manufacturing unit control is needed.

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

A Network Security Situation Prediction Method through the Use of Improved TCN and BiDLSTM

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The rapid development of information technology has brought much convenience to human life, but more network threats have also come one after another. Network security situation prediction technology is an effective means to protect against network threats. Currently, the network environment is characterized by high data traffic and complex features, making it difficult to maintain the accuracy of the situation prediction. In this study, a network security situation prediction model based on attention mechanism (AM) improved temporal convolutional network (ATCN) combined with bidirectional long short-term memory (BiDLSTM) network is proposed. The TCN is improved by AM to extract the input temporal features, which has a more stable feature extraction capability compared with the traditional TCN and BiDLSTM, which is more capable of processing temporal data, and is used to perform the situation prediction. Finally, by validating on a real network traffic dataset, the proposed method has better performance on multiple loss functions and has more accurate and stable prediction results than TCN, BiDLSTM, TCN-LSTM, and other time-series prediction methods.

1. Introduction

The development of information technology has consistently promoted the progress of human society. With the deep development of artificial intelligence, big data, fifth-generation mobile communications, and other information technology, more network applications have played an essential role in the economic development of society, and the network is closely related to the national economy. However, the rich network applications also bring more opportunities for network threats to invade. Recently, network attacks with its hidden, fast, and automated characteristics, so that the network ecosystem suffered a severe impact. Various high-threat attacks such as distributed denial of service (DDoS) and ransomware attacks are more frequent. Although network security defense measures are progressing and developing, various security loopholes are being continuously investigated. Additionally, the existence of network attacks in the shadows is always defensible. Therefore, the network security issue has become an urgent problem in today's society, indicating the need to maintain network security effectively.

Network security situation awareness [1] was proposed in 1999 to reflect the overall network security situation by integrating data from network security protection devices, such as intrusion detection systems, firewalls, and virus detection systems (VDS) [2]. Compared with the traditional means of defense against network threats, network security situation awareness has the characteristics of more comprehensive detection, more active protection, and a faster response. Network security situation awareness is divided into situation element extraction, understanding, and prediction. Situation prediction is the last step of network security situation awareness and is also the ultimate purpose of situation awareness, and effective situation prediction is an essential means to prevent network threats.

There are many methods for network security situation prediction. The main research focuses on two aspects based on time-series prediction [3] and graph theory-based prediction [4]. The time-series prediction method is to take

advantage of the characteristics of network attacks with a certain periodicity (for example, more frequent attacks in certain periods). The periodic attacks make the network security situation with a certain periodical change consistent with the characteristics of time series. However, this method is more applicable to short-term situation prediction because the regularity of long-term posture is difficult to capture. The graph theory-based situation prediction method uses vulnerability information in the network environment to generate a state transfer graph to determine future attacks from the intruder's perspective [2]. However, this method suffers from a severe false alarm rate and insufficient prediction accuracy. In this study, based on the characteristics of the abovementioned methods, we employ a time-series prediction method to make short-term predictions of the network security situation. There are various approaches to time-series-based network security situation prediction. For instance, in parameter-based modeling, Yang et al. used adaptive cubic exponential smoothing for situation prediction [5], which is simple to model but unstable in prediction. Based on machine learning (ML) [6], Xing et al. and Wang Jian et al. used a support vector machine (SVM) for situation prediction [7, 8], which has a fast response time and a small model memory but a relatively low prediction accuracy. Based on deep learning (DL) [6], Wei et al. used gated recurrent unit (GRU) for situation prediction [9]; Chen et al. used long short-term memory (LSTM) for situation prediction [10]; and Guosheng et al. used backpropagation (BP) neural network for situation prediction [11]. Situation prediction using DL is relatively more complex and computationally intensive; however, it has higher accuracy. With the development of information technology, such as big data and cloud computing, a good platform for DL has been created. More data training and greater computing power support using DL for situation prediction have gradually become mainstream.

In the previous time series prediction methods, most of them are the prediction of a single model. In the face of complex and long-term time series characteristics, the prediction ability is insufficient. At this stage in the research study of situation prediction, more methods are used to combine the techniques of feature extraction and time series prediction. For instance, Shen and Wen [12] used a network security situation prediction method combining gray theory and BP neural network to enhance feature extraction. Liu et al. [13] proposed a network security situation prediction method combining TCN and LSTM to extract temporal features by TCN, while situation prediction is performed by LSTM later. The technology of combining feature extraction with time-series prediction has been studied to some extent, which makes up for the insufficient prediction ability of a single model. But nowadays the network environment is complex and changeable, and the network traffic is updated all the time, so the above research study needs to improve its feature extraction ability when dealing with temporal features, and there are more advanced prediction methods for prediction. To address the above issues, this study proposes a network security situation prediction method based on an attention mechanism (AM) improved temporal convolutional network (ATCN) combined with bidirectional long short-term memory (BiDLSTM) network. TCN is a variant of a convolutional neural network (CNN) [14]. Compared with the traditional convolution process, it has greater advantages in processing time series and AM is used to enhance its ability to extract important features of images when it is proposed. Similarly, it can find more important features in sequences. BiDLSTM is composed of two layers of LSTM with different input directions. Compared with LSTM, it has a stronger long-term and short-term prediction ability by combining the three models of AM, TCN, and BiDLSTM to achieve better situation prediction. Finally, the proposed method is validated on a real network traffic dataset. This study has the following contributions:

(1) Given the insufficient prediction ability of a single model on the network security situation, in this study, we propose a model integrating ATCN and BiDLSTM for network security situation prediction. It is an end-to-end model. ATCN is used as a feature extraction tool and BiDLSTM is used as a prediction tool. The prediction is carried out by combining the two models. By combining the feature extraction model with the prediction model, the model has more advantages compared with the single model in feature extraction and prediction ability of sequence data. By using better models for combination and by the use of AM, the hybrid model has a better prediction effect than other hybrid models such as TCN-LSTM.

(2) The improved TCN is used to extract the feature of time series, and the AM is used before each dilated causal convolutional layer in the TCN structure, which has a more stable feature extraction ability.

(3) Through BiDLSTM for situation prediction: BiDLSTM has excellent long-distance feature extraction ability, and its prediction ability is stronger than LSTM, GRU, and TCN models.

(4) By validating the model on China Internet Emergency Response Center's Cybersecurity Information and Dynamics Weekly Report Dataset, the proposed model has more accurate and stable prediction results compared to other single models and hybrid models time-series prediction methods, and has better performance in the root mean squared error (RMSE), mean absolute error (MAE), and mean absolute percentage error (MAPE).

This study consists of the following sections. Section 2 describes the related work on time-series prediction. Section 3 describes TCN, AM, BiDLSTM, and overall model structure. It also presents a brief description of datasets and evaluation metrics. Section 4 conducts experiments and analyzes the prediction results for the proposed model. Finally, Section 5 provides the summary and outlook for future work.

2. Related Work

As the name implies, time-series prediction is based on chronological order by learning information from a past

period to make predictions about future periods. Because time series has a backward and forward time causality, it has strict requirements on the backward and forward order of the inputs. The current time-series prediction covers a wide range of fields, such as energy wind speed prediction [15], infectious disease prediction [16], water quantity prediction [17], population prediction [18], and stock prediction [19].

Time-series prediction methods have evolved from traditional parametric modeling prediction and time regression prediction to ML and DL. However, most traditional methods have simple models and cannot balance spatial and temporal correlation [20]. At this stage, time-series prediction methods mainly focus on ML and DL. The time-series prediction methods based on ML include SVM [7, 8], random forest [21], and LightGBM [22]. The random forest and LightGBM methods are derived based on the regression tree [23] algorithm. As a classical ML algorithm, the regression tree algorithm has the advantages of easy construction and fast speed. However, as the volume of data becomes larger and the number of data dimensions increases at this stage, the regression tree also begins to be less stable, and the prediction effect in some complex situations becomes less satisfactory. Time-series prediction methods based on DL have developed rapidly in recent years. The most common ones that deal with time-series problems are recurrent neural networks (RNNs) [24] and their variants LSTM and GRU. RNNs, LSTMs, and GRUs have a memory of previously processed sequences when processing sequences, a feature that makes them well-suitable for applications in time-series prediction. BiDLSTM is obtained by improving on LSTM, and temporal prediction by BiDLSTM has been studied in many aspects, such as Mikhailov and Kashevnik [25] predicted car tourist trajectory by BiDLSTM; Mao et al. [26] predicted depression level by BiDLSTM and time distributed CNN; and Kang et al. [27] performed sewage flow prediction by BiDLSTM. It has been demonstrated through experimental studies that BiDLSTM has a more stable prediction effect on timing prediction compared to LSTM. TCN was proposed in 2018, which has a more flexible perceptual field mechanism with more stable gradients than RNN, a traditional method for processing time series, and it combines the features of CNN and RNN, which is well suited for feature extraction of time-series data. TCN has been widely used in time-series prediction in recent years. For instance, Wang et al. [28] used TCN and LightGBM for electrical load predictions, and feature extraction of multiple long-term sequences was performed by TCN. Menegozzo et al. [29] used an improved TCN to enhance the feature extraction capability for food production prediction. In this study, we take advantage of the excellent feature extraction capability of TCN to facilitate model building.

The AM has been a hot research topic in recent years, and the combination of AM and neural networks is also the mainstream of research studies. For instance, Pei et al. [30] combined AM and RNN to predict health records. Majid et al. [31] combined AM and convolutional neural networks (CNNs) for fire detection. The combination of AM and neural networks has achieved good results. However, in practice, it is found that a single AM is unstable in helping sequence feature extraction. Therefore, this study improves the TCN by using the AM both inside and outside the structure of the TCN, so that the improved TCN has a stronger feature extraction ability to help the model learn the features of the time series.

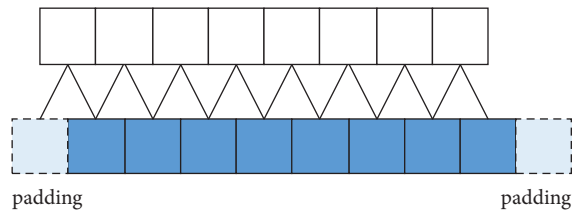

Figure 1: Sequence filling.

3. Methodology

3.1. Temporal Convolutional Network. Temporal convolutional network (TCN) [32] was proposed by Shaojie Bai et al., which is based on CNN and is designed to deal with time-series problems. It implements the processing of time-series problems through three structures: causal convolution, dilated convolution, and residual connections. Each part has the following structure.

3.2. Sequence Model. For time-series problems, the output sequence (y_0, y_1, ..., and y_T) must have the same length when the sequence (x_0, x_1, ..., and x_T) is the input, and the TCN is implemented using a one-dimensional full convolutional network (FCN) [33]. FCN ensures that each convolutional layer has the same time step length by employing the padding method for each layer of sequence padding. Figure 1 shows that when kernel size is 2, at a padding of 1, a padding is added to each end of the sequence, and the right padding is removed, making the length between sequences the same by using the following padding formula in which dilation has also described.

$$\text{Padding} = (\text{Kernel\_size} - 1) * \text{dilation}. \tag{1}$$

3.3. Causal Convolution. The input of traditional CNN has no time order, and the information before and after is acquired simultaneously, leading to future information leakage for time series. Meanwhile, causal convolution can be used to solve this problem. Figure 2 shows the causal convolution. As shown in this figure, the design of the causal convolution is unidirectional. The output y_t is only related to the inputs (x_0, x_1, ..., and x_t) at a moment t and before a moment t by an unidirectional design according to the temporal order. The output of the next layer at a moment t is obtained from the input of the previous layer at a moment t and the input before a moment t. This design makes the increase in the perceptual field very slow. When dealing with time-series problems, a large field of view is often required to learn the information of a long-time period. This can only be achieved

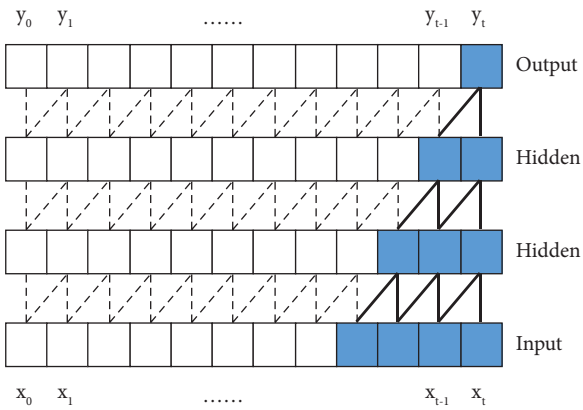

Figure 2: Causal convolution structure.

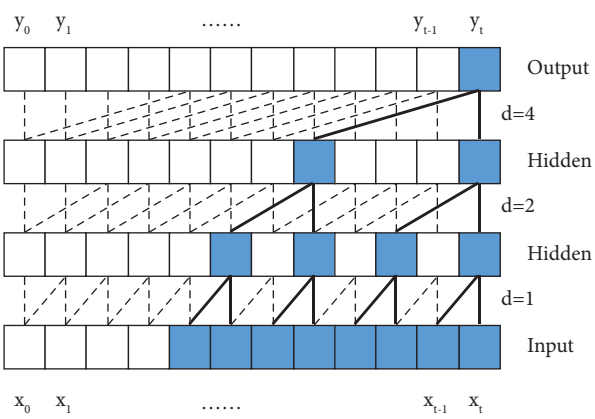

Figure 3: Dilated convolution structure.

by accumulating the number of hidden layers or a larger filter and by making the training more complicated. The accumulation of layers will also bring the hidden problem of gradient disappearance. Therefore, to solve these problems, the dilated convolution method is introduced.

3.4. Dilated Convolution. The dilated convolution method is used to solve the problem of the restricted field of view of causal convolution. Compared with causal convolution, dilated convolution introduces the concept of a dilation factor. Dilated convolution takes interval sampling in each layer for convolution sampling. The size of the interval is determined by the dilation factor d, as shown in Figure 3, where the kernel size is 2 and dilations are [1, 2, 4]. The size of each layer d of the dilated convolution grows exponentially, where the first layer is 1 (1 means the interval is 0). As shown in the figure, the field of view is increased from 4 to 8 in Figure 1 by three convolutions. By the exponential growth of the dilation factor d, an inflated convolutional network with stacking can operate over a larger field of view without loss of resolution or coverage [34]. For an input sequence, the expansion convolution of the sequence element O is given by the following equation, where k is the kernel size, and $O - d \cdot n$ represents the past direction.

$$F(O) = (x *_d f)(O) = \sum_{n=0}^{k-1} f(n) \cdot x_{O-d \cdot n}. \tag{2}$$

3.5. Residual Connections. In practical applications, the number of hidden layers is deepened to make the model more expressive. However, the gradient disappears for too deep networks. Thus, to solve this problem, residual connections are introduced. Residual connections avoid the problem of gradient disappearance by carrying short paths of gradients over a very deep network range [35]. In other words, information from the bottom layer can be passed directly to the top layer to avoid degradation of the model's learning ability and thus this makes the model more generalizable.

Figure 4 shows the output of the residual block which is obtained by adding $F(x)$ after a series of transformations and by making a convolutional mapping of the input x. The equation is given as follows.The residual block consists of the dilated causal convolution layer, normalization layer, activation layer, and dropout. The normalization layer is used to limit the distribution of the inputs, inorder to avoid gradient saturation with faster convergence. Then, the activation function allows the model to learn more nonlinear features. Meanwhile, the linear ReLU activation function does not have the problem of gradient explosion and is suitable for multilayer network structures. Finally, dropout is used to prevent overfitting.

$$o = \text{Activation}(x + F(x)). \tag{3}$$

3.6. Attention Mechanism. The AM [36] was first applied in computer vision [37]. Its essence is derived from the attention of human vision, which finds more important parts of a picture by paying more attention to it. When humans scan a group of things visually, they usually find the most noteworthy point after the first observation, devote more attention resources to it, and ignore the other information; thus, improving the efficiency and accuracy of observing things. The AM of the computer takes advantage of the characteristics of human attention by adding different weights to different features according to their degree of importance after observing the desired information; thus, achieving more attention to important features.

There are various categories of AM, such as Bahdanau attention [38] and Luong attention [39]. Although there are many variants of AM, the main difference is their locations and uses. Therefore, this study uses the AM before each dilated causal convolution layer to calculate all time steps of the input. The weights of each time step are generated using the softmax function, and the weights are matrix multiplied by the time steps to obtain the input of the next layer, as shown in Figure 5. The degree of importance of each time step is determined by calculating the magnitude of the weights for each time step for feature learning in the dilated causal convolution layer.

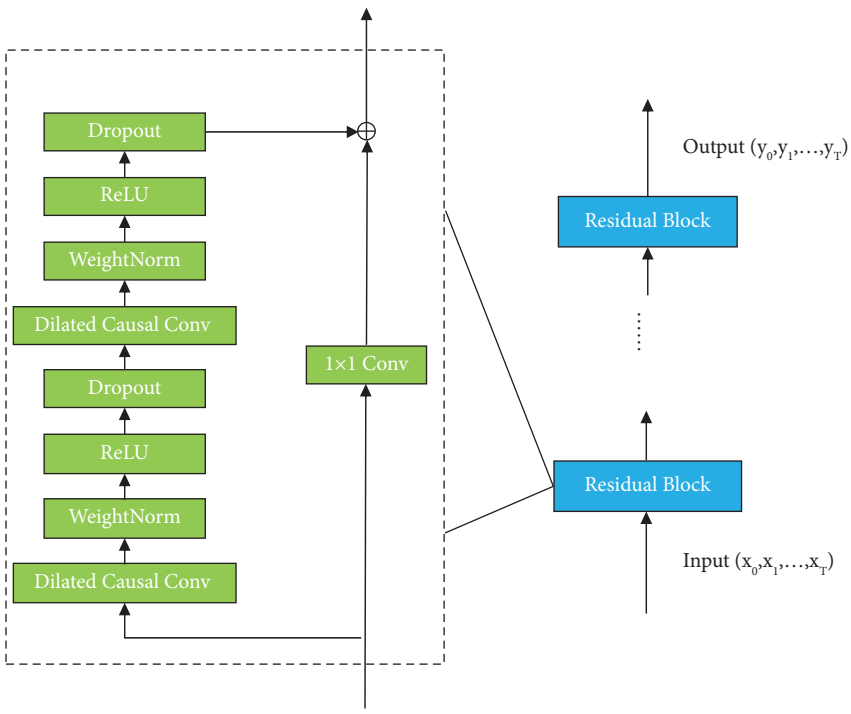

Figure 4: Residual connections structure.

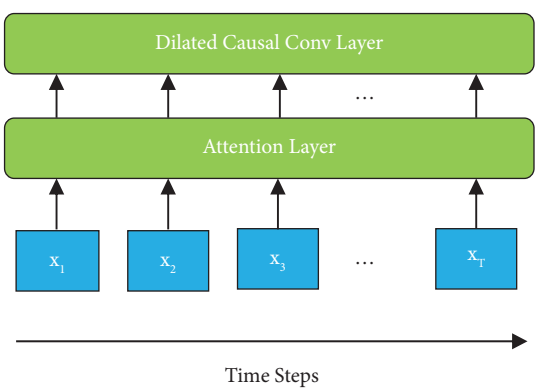

Figure 5: Structure of AM.

3.7. ATCN. Figure 6 shows the model based on AM and TCN. The main idea is to help the dilated causal convolution layer to better extract features by introducing AM. An attention layer is used before each dilated causal convolution layer in the residual structure to find the important difference between the input data through the attention layer. Sequences are weighted once by the AM before being input into the dilated causal convolution layer, which enables the AM to differentiate the importance of sequence data after each hidden layer processing so that the dilated causal convolution layer can perform better feature learning. The improved TCN module performs feature extraction of the time-series data and inputs the learned feature relationships between sequences into the next layer. ATCN is equivalent to the function of the encoder as a whole. After effectively learning the sequence features, it is input into BiDLSTM for decoding prediction.

3.8. Bidirectional Long Short-Term Memory. Bidirectional long short-term memory (BiDLSTM) [40] is generated based on LSTM [41], which consists of two layers of LSTM, one layer processing the original forward input data and one layer processing the reverse input data, and finally, the output data is obtained by combining the data of the two layers. BiDLSTM can effectively solve the problem of gradient disappearance in standard RNN by bidirectional design [42], and the bidirectional design is also more helpful for the extraction of input features.

Figures 7 and 8 show the structural diagrams of LSTM and BiDLSTM. LSTM is composed of three gate structures: forgetting, input, and output. The forgetting gate deletes the information that does not continue to be transmitted, the input gate inputs current information, and the output gate outputs the current phase information and hidden information passed onto the next phase, and the long-distance memory function is realized by the three gate structures. BiDLSTM is composed of two layers of LSTM with different input directions, the original direction of the lower input time series and the opposite direction of the upper input time series, to better extract the temporal features of the series and to obtain better prediction results.

3.9. Model Structure. Figure 9 shows the overall structure of the model. It consists of an input layer, an ATCN layer, a BiDLSTM layer, a fully-connected layer, and an output layer. This is an end-to-end model, which input data through the input layer, the ATCN layer, the BiDLSTM layer, and the fully-connected layer for data processing, and the final output layer output prediction results. The ATCN layer is the feature extraction module and the BiDLSTM layer is the

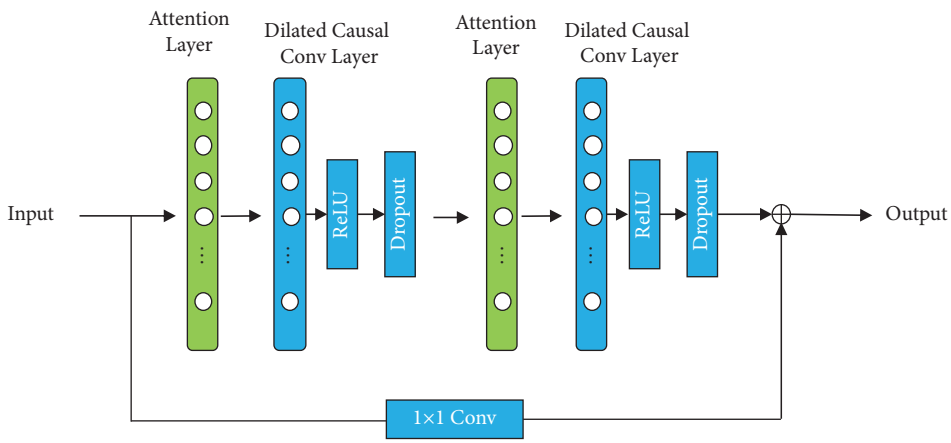

Figure 6: ATCN model structure.

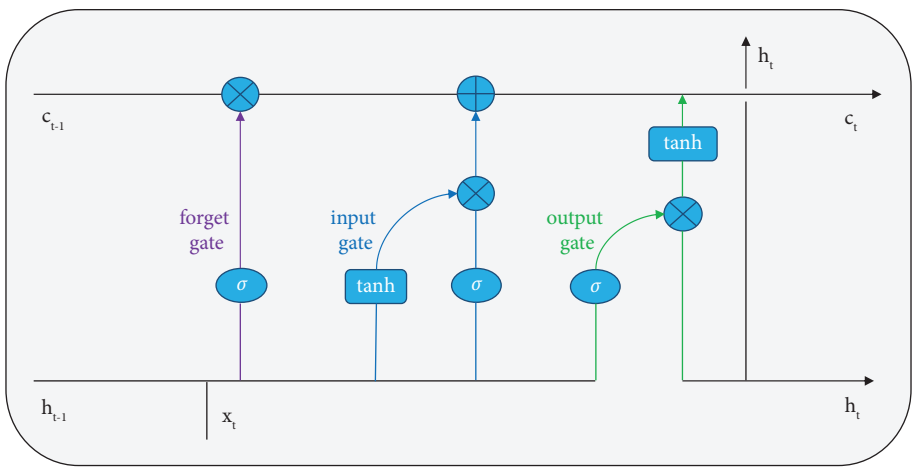

Figure 7: LSTM structure.

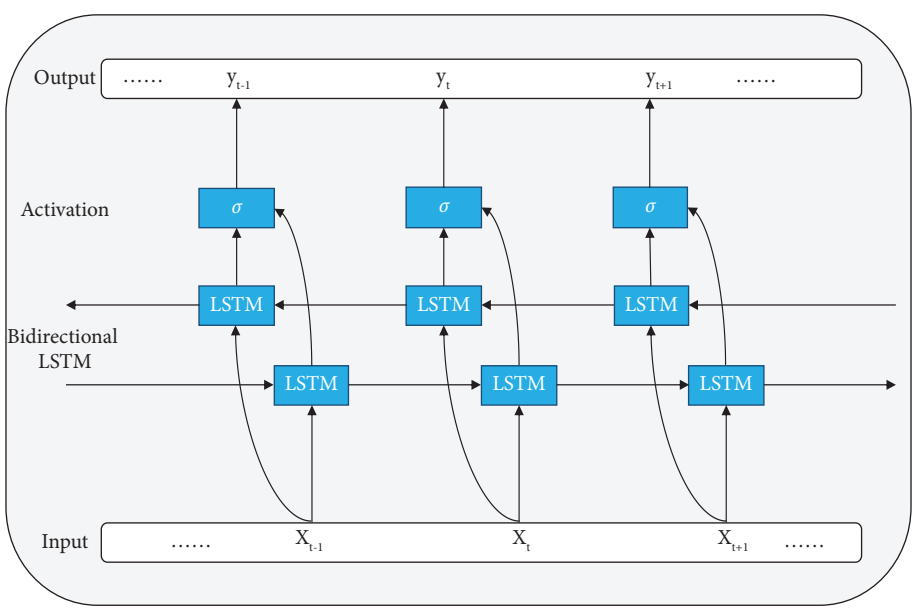

Figure 8: BiDLSTM structure.

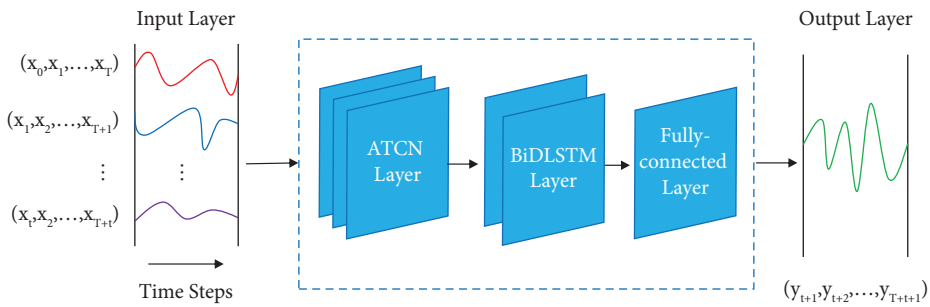

Figure 9: Overall model structure.

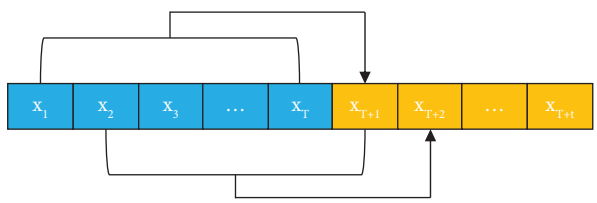

Figure 10: Prediction method.

prediction module. This combined feature extraction module and prediction module have stronger feature extraction and prediction ability than a single model, and the use of AM further strengthens the temporal feature extraction ability of TCN. The input layer inputs continuous time-series data with a fixed period T. The time-series data are a three-dimensional array consisting of sample size, time step length, and feature dimension. The sample size represents the number of input samples; the time step indicates the number of time steps through which the prediction is performed; and the feature dimension indicates the number of features for each time step. For univariate time-series prediction, the feature dimension is 1, and only the values before this variable are used to predict the values after it. The ATCN layer is responsible for extracting and learning the temporal features of the input sequence and feeding the learned features to the next layer. The BiDLSTM layer is responsible for carrying out the prediction work. A single-step prediction method is used, and only the situation value of the previous period is used to predict the next situation value each time. We use the form of a sliding window for sliding prediction, as shown in Figure 10. By setting the sliding time window to 1, the value of the first time step to the T time step is used to predict the value of the $T+1$ time step, and the value of the second time step to the $T+1$ time step is used to predict the value of the $T+2$ time step, and then pushing it down in turn until all the situation values are predicted.

3.10. Dataset Description. In this study, we validate the model of China's Internet Emergency Response Center's Cybersecurity Information and Dynamics Weekly Report Dataset [43]. The dataset was divided into two segments, dataset 1 and dataset 2. Dataset 1 was selected from the 1st issue of 2010 to the 13th issue of 2012, for a total of 115 weeks. Dataset 2 was selected from the 32nd issue of 2017 to the 1st issue of 2022, for a total of 231 weeks. There were three characteristic indicators in dataset 1, which are the number of hosts controlled by Trojan or bot programs in the territory, the number of government websites tampered within the territory, and the number of new security vulnerabilities. Table 1 presents the data values for five weeks from 9nd to 13th issues in 2012. There are five characteristic indicators in dataset 2, which are the number of hosts infected with malicious computer programs in the territory, the total number of URLs tampered within the territory, the total number of websites implanted with backdoors in the territory, the number of counterfeit pages targeting websites in the territory, and the number of new information security vulnerabilities. Table 2 presents the data values for five weeks from 32nd to 36th issues in 2017.

The weekly situation values were calculated from feature indicators using the situation assessment method in the literature [44]. Each featured category was assigned a different weight according to the threat level, as presented in Tables 1 and 2. Then, according to the following equation the weekly posture values were calculated. Here i is the feature category; n is the number of features; M_i is the value of this feature; $M_{i\max}$ is the maximum value of this feature in all weeks; and ω_i is the feature weights. In this calculation, due to the lack of the characteristic indicator for the number of new security vulnerabilities from the 1st issue of 2010 to the 22nd issue of 2010, we used the average of the 23rd issue of 2010 to the 48th issue of 2010 for filling.

$$\mathrm{SV} = \sum_{i=1}^{n} \frac{M_i}{M_{i\max}} \cdot \omega_i. \tag{4}$$

The calculated situation values are shown in Figures 11 and 12. Dataset 1 takes the first 92 weeks as training data and 93–115 weeks as testing data. Dataset 2 takes the first 184 weeks as training data and 185–231 weeks as testing data. It can be seen that the situation values of dataset 1 show the cyclic movement of up-and-down with the characteristics of a time series. After one large fluctuation at 100 weeks, the overall situation values of dataset 2 show a cyclic movement with the characteristics of a time series.

3.11. Evaluation Metrics. In the experiments, the mean squared error (MSE) loss function is used to evaluate the prediction results in training. Three-loss functions, RMSE,

Table 1: Indicator Characteristics for dataset 1.

Weeks	Characteristics		
	Trojans and bots (million)	Tampered government websites	Security vulnerabilities
1	29.9	39	107
2	21.7	28	127
3	15.7	105	162
4	14.8	48	165
5	12.8	32	160
Weights	0.5	0.3	0.2

Table 2: Indicator Characteristics for dataset 2.

Weeks	Characteristics				
	Malicious programs (million)	Tampered URL	Implanted backdoor websites	Counterfeit pages	Security vulnerabilities
1	41.1	2094	1527	351	212
2	54.6	2692	927	117	302
3	56.8	2338	1032	440	397
4	57.3	2184	1109	325	292
5	56.1	2444	961	306	348
Weights	0.3	0.25	0.15	0.15	0.15

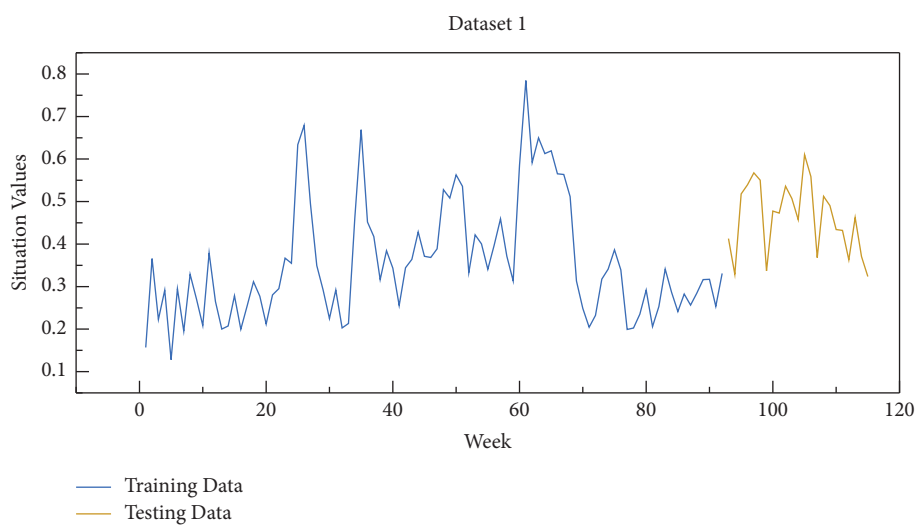

Figure 11: Dataset 1 situation values.

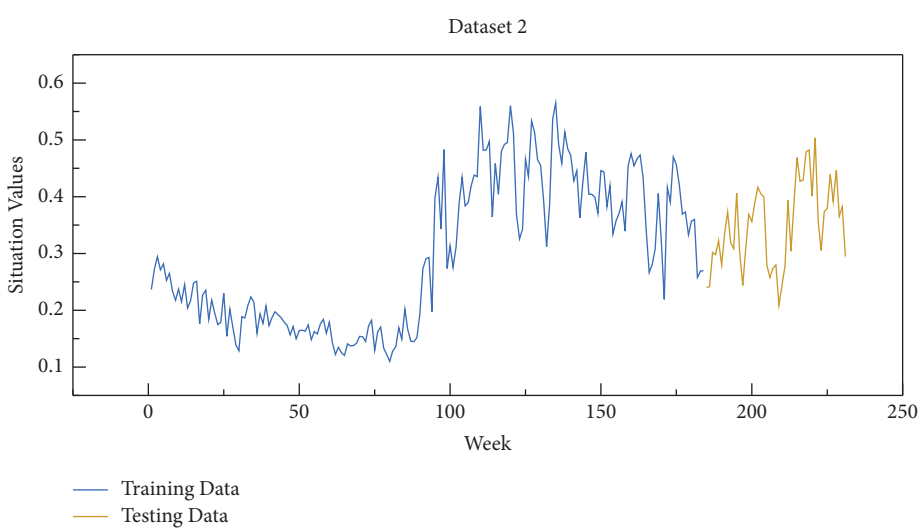

Figure 12: Dataset 2 situation values.

MAE, and MAPE, are used to evaluate the prediction results in testing. In the following equations, n is the total number of experiments, $\hat{v}_i$ is the predicted value, and v_i is the true value.

$$\mathrm{MSE} = \frac{1}{n}\sum_{i=1}^{n}\left(\hat{v}_i - v_i\right)^2, \tag{5}$$

$$\mathrm{RMSE} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(\hat{v}_i - v_i\right)^2}, \tag{6}$$

$$\mathrm{MAE} = \frac{1}{n}\sum_{i=1}^{n}\left|\hat{v}_i - v_i\right|, \tag{7}$$

$$\mathrm{MAPE} = \frac{100\%}{n}\sum_{i=1}^{n}\left|\frac{\hat{v}_i - v_i}{v_i}\right|. \tag{8}$$

In the test, three metrics are used to balance the advantages and disadvantages between them. RMSE evaluates smooth results but is more sensitive to outliers, and its value is influenced by a single outlier. MAE solves the outlier sensitivity problem, but the function may not be derivable at some points because of the existence of absolute values. MAPE is robust, but the prediction is more biased to models with positive errors and its evaluation index will be worse for negative errors, especially where the predicted value is higher than the true value.

4. Experiment and Results

4.1. Implementation. The experiment was implemented on a personal host with Intel core i5 10600 KF CPU and NVIDIA RTX2060 GPU, using python programming language and building models for implementation using TensorFlow and Keras methods. The detailed data are presented in Table 3.

We selected eleven methods, support vector regression (SVR), BiDLSTM, LSTM, TCN, GRU, TCN-LSTM, TCN-GRU, TCN-BiDLSTM, TCN-BiDGRU, ATCN, and ATCN-LSTM, for comparison experiments with ATCN-BiDLSTM. These include ML models, single DL models, and hybrid DL models. At the same time, the average value of the five experiments is taken to avoid the influence of error.

4.2. Metrics Analysis

4.2.1. Dataset 1. Dataset 1 was selected from the 1st issue of 2010 to the 13th issue of 2012, for a total of 115 weeks. For the selection of time steps, 6 weeks were taken as one cycle. Each time, the sliding prediction was achieved by predicting the next week's situation value by the previous 6 weeks' situation value. The parameters of each model are adjusted by many experiments, as follows.

(1) SVR: use the linear kernel function and set the penalty factor to 1.

(2) BiDLSTM: the two hidden layers have 32 nodes, respectively. The four fully-connected layers have 64, 32, 16, and 1 node, respectively.

Table 3: Experimental operating environment.

Project	Environmental parameters
CPU	Intel core i5 10600 KF
GPU	NVIDIA RTX2060
Python version	3.6
TensorFlow version	1.14
Keras version	2.2.5

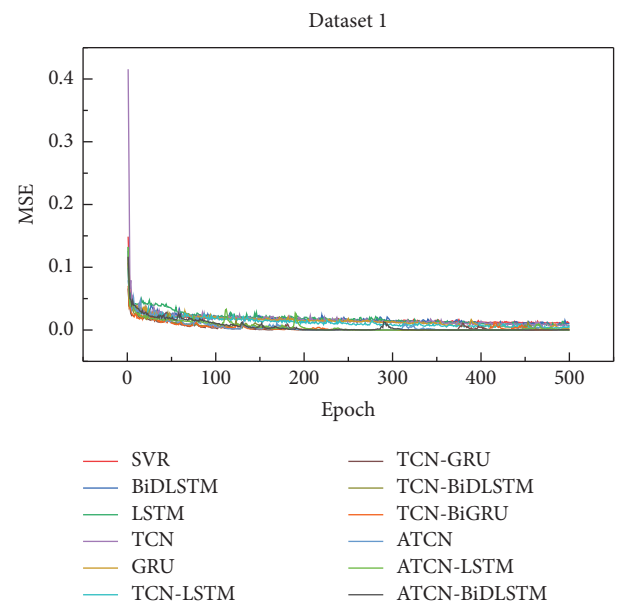

Figure 13: Training convergence curves for each model on dataset 1.

(3) LSTM and GRU: the three hidden layers have 32 nodes, respectively. The four fully-connected layers have 64, 32, 16, and 1 node, respectively.

(4) TCN and ATCN: the number of filters is 4 and the size is 3, the dilation factor is (1, 2, 4, and 8), and the residual connection layers is 1, the four fully-connected layers have 64, 32, 16, and 1 node, respectively.

(5) TCN-LSTM, TCN-GRU, and ATCN-LSTM: the number of filters is 4 and the size is 3, the dilation factor is (1, 2, 4, and 8), and the residual connection layers is 1. LSTM and GRU's hidden layer is 1, and the number of nodes is 16. The last four fully-connected layers have 64, 32, 16, and 1 node, respectively.

(6) ATCN-BiDLSTM, TCN-BiDLSTM, and TCN-BiDGRU: the number of filters is 4 and the size is 3, the dilation factor is (1, 2, 4, and 8), and the residual connection layers is 1. BiDLSTM and BiDGRU's hidden layer are 1, and the number of nodes is 8. The last four fully-connected layers have 64, 32, 16, and 1 node, respectively.

Each model is well trained after reasonable parameter configuration, and the decrease in training loss is shown in Figure 13. The number of training cycles is set to 500 and it can be seen that the loss of each model tends to be stable in

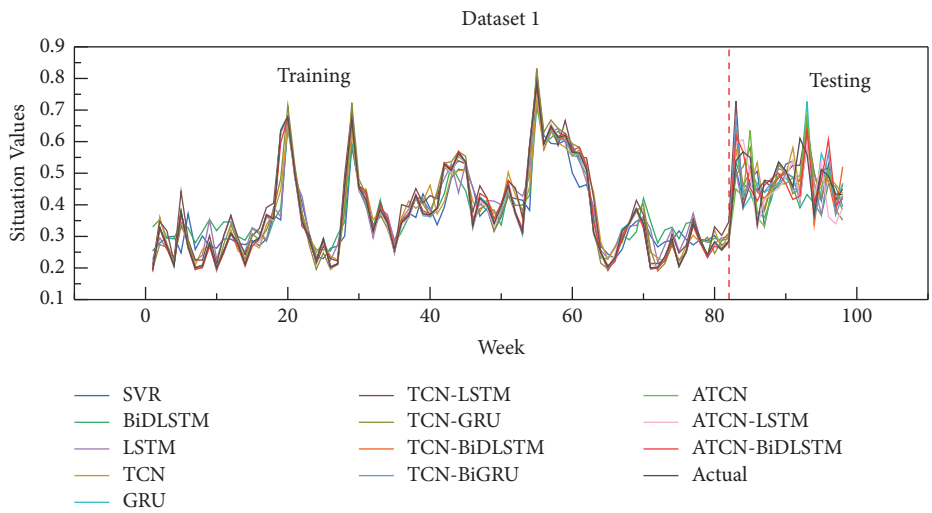

Figure 14: Fitting curves of each model on dataset 1.

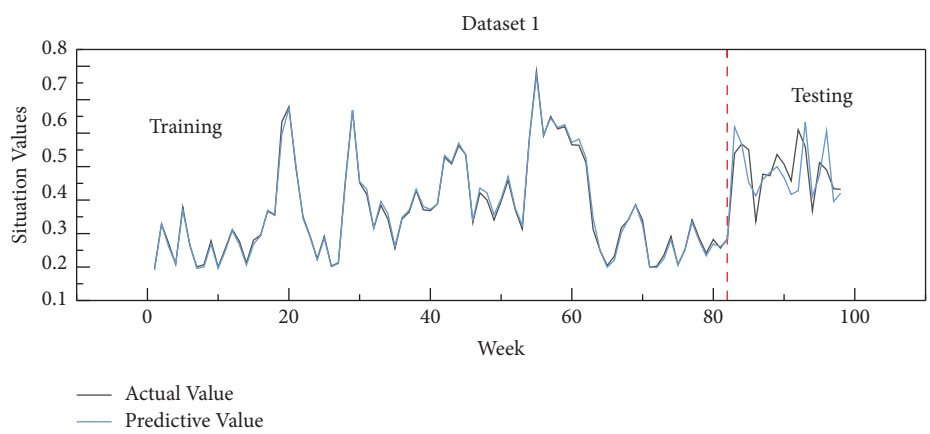

Figure 15: Fitting curves of the proposed model on dataset 1.

100 cycles, indicating that dataset 1 of each model can converge quickly and can achieve a good training effect.

Figure 14 shows the fitting curves of each model, and the fitting curves of the proposed model are shown in Figure 15. The wide range fluctuation of the situation value brings challenges to the prediction. In the training stage, each model can better fit the trend of the curve and can learn effectively. But it can also be seen that in the 0 to 20 time period, 40 to 50 time period, and 70 to 80 time period, the fitting effect of the single model is not as good as that of the mixed model, indicating that the difficulty of feature learning in this period becomes larger, and the feature learning ability of the single model shows limitations. In the test stage, each model has a certain deviation, but it can be seen that although the model proposed in this study still has a certain deviation in the predicted value, it can well predict the trend of the situation, and can more effectively capture the subtle changes of the situation value, indicating that the proposed model has stronger feature extraction ability and prediction ability than other hybrid models.

Table 4 shows the loss evaluation metrics of each model on dataset 1. It can be seen that the evaluation metrics of the SVR model are the worst, indicating that the DL model has advantages over traditional ML methods. The overall metrics of the hybrid model are better than that of the single model, indicating that the method combining feature extraction and prediction tools has greater advantages. Compared with the

Table 4: Comparison of metrics across models on dataset 1

Model	Metrics		
	MAE	MAPE	RMSE
SVR	0.0865	18.3413	0.1021
BiDLSTM	0.0658	12.7806	0.0898
LSTM	0.0671	13.9057	0.0893
TCN	0.0685	14.8139	0.0920
GRU	0.0700	13.9189	0.0909
TCN-LSTM	0.0616	12.3945	0.0837
TCN-GRU	0.0602	12.5181	0.0740
TCN-BiDLSTM	0.0578	11.9516	0.0695
TCN-BiGRU	0.0698	13.7644	0.0885
ATCN	0.0653	12.7507	0.0800
ATCN-LSTM	0.0639	12.7629	0.0777
ATCN-BiDLSTM	**0.0561**	**11.3181**	**0.0722**

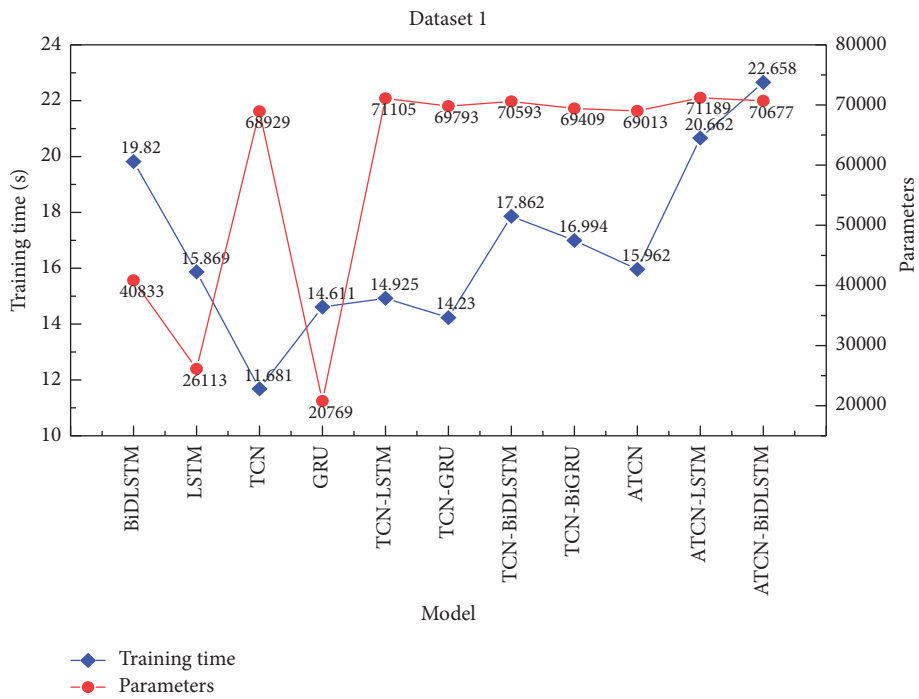

Figure 16: Training time and parameters for each model on dataset 1.

model without AM, the loss of the model with AM is reduced to a certain extent, indicating that AM improves the feature extraction ability of the model. It can also be seen that BiDLSTM has less loss than LSTM whether it is a single model or a hybrid model, indicating that BiDLSTM has better prediction ability. At the same time, the proposed hybrid model has better loss results than other hybrid models, indicating that the proposed hybrid model is more advanced and has higher prediction accuracy.

Figure 16 shows the comparison of training time and model parameters for DL models. It can be seen that TCNs spend the least time in training because TCNs can process data in parallel and has higher efficiency. Compared with LSTM, GRU merges input gates and forgetting gates, and its parameters are minimal. Due to the combination of multiple models, the parameters and training time of the hybrid model are generally greater than that of the single model. The number of model parameters and training time proposed in this study are both high, which is due to the AM. The combination of TCN and BiDLSTM structure improves model complexity. Moreover, to fully carry out feature learning, the training time also becomes longer.

4.2.2. Dataset 2. Dataset 2 was selected from the 32nd issue of 2017 to the 1st issue of 2022, for a total of 231 weeks. For the selection of time steps, 12 weeks were taken as one cycle. The parameters for each model are as follows.

(1) SVR: Use the linear kernel function and set the penalty factor to 1.

(2) BiDLSTM: The hidden layer has 32 nodes. The four fully-connected layers have 64, 32, 16, and 1 node, respectively.

(3) LSTM and GRU: The three hidden layers have 16, 32, and 32 nodes, respectively. The four fully-connected layers have 64, 32, 16, and 1 node, respectively.

(4) TCN and ATCN: The number of filters is 4 and the size is 3, the dilation factor is (1, 2, 4, and 8), and the residual connection layers is 1, and the four fully-connected layers have 64, 32, 16, and 1 node, respectively.

(5) TCN-LSTM, TCN-GRU, and ATCN-LSTM: The number of filters is 4 and the size is 3, the dilation factor is (1, 2, 4, and 8), and the residual connection layers is 1. LSTM and GRU's hidden layer is 1, and the number of nodes is 16. The last four fully-connected layers have 64, 32, 16, and 1 node, respectively.

(6) ATCN-BiDLSTM, TCN-BiDLSTM, and TCN-BiDGRU: The number of filters is 4 and the size is 3, the dilation factor is (1, 2, 4, and 8), and the residual connection layers is 1. BiDLSTM and BiDGRU's hidden layers are 1, and the number of nodes is 16. The last four fully-connected layers have 64, 32, 16, and 1 node, respectively.

The decrease in training loss is shown in Figure 17, and the number of training cycles is set to 500. It can be seen that compared with the single model, the overall loss of the hybrid model decreases faster and has a faster feature learning ability.

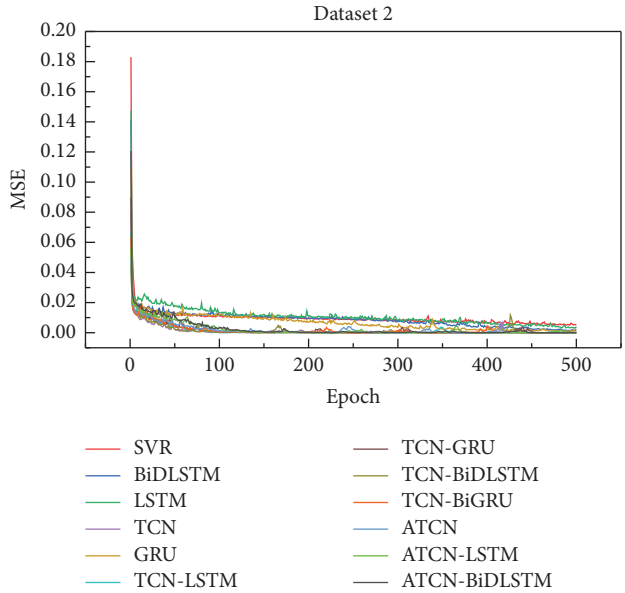

Figure 17: Training convergence curves for each model on dataset 2.

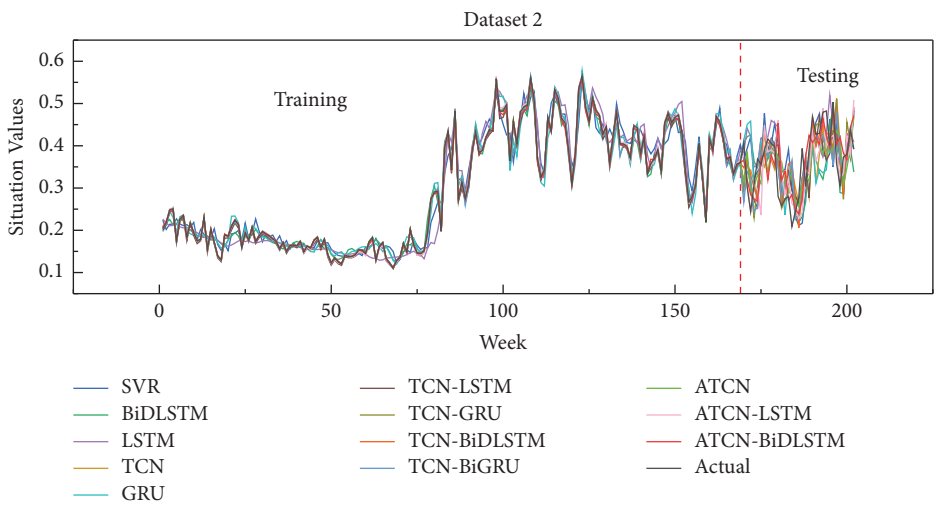

Figure 18: Fitting curves of each model on dataset 2.

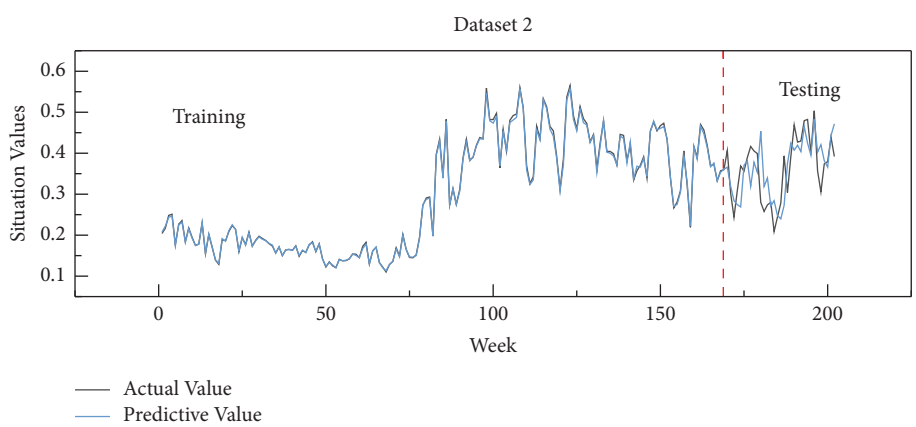

Figure 19: Fitting curves of the proposed model on dataset 2.

Table 5: Comparison of metrics across models on dataset 2.

Model	Metrics		
	MAE	MAPE	RMSE
SVR	0.0682	20.2076	0.0820
BiDLSTM	0.0575	16.9473	0.0753
LSTM	0.0579	17.8927	0.0741
TCN	0.0626	17.8601	0.0769
GRU	0.0612	18.6871	0.0814
TCN-LSTM	0.0572	16.4657	0.0662
TCN-GRU	0.0575	16.9201	0.0690
TCN-BiDLSTM	0.0529	16.1642	0.0653
TCN-BiGRU	0.0556	16.4503	0.0696
ATCN	0.0539	15.5705	0.0633
ATCN-LSTM	0.0504	14.3002	0.0656
ATCN-BiDLSTM	**0.0466**	**14.0611**	**0.0613**

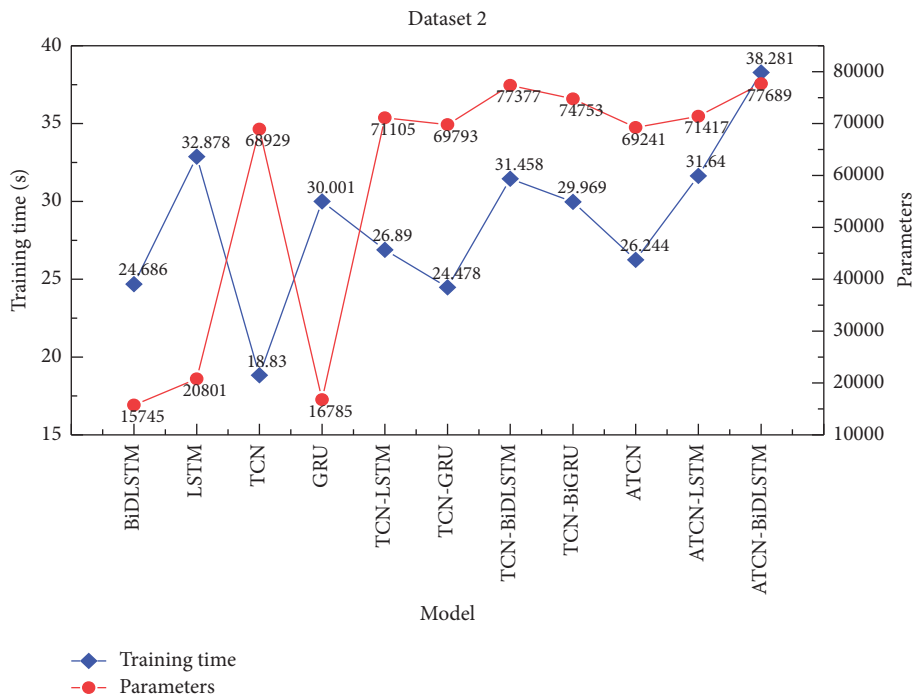

Figure 20: Training time and parameters for each model on dataset 2.

Figure 18 shows the fitting curves of each model, and the fitting curves of the proposed model are shown in Figure 19. Compared with dataset 1, dataset 2 has a larger fluctuation, and the situation value has a steep rise from week 75 to week 100, indicating that the overall network threat has increased in recent years. The situation prediction results are similar to dataset 1. In the training stage, each model can accurately capture the trend of situation change except for different fitting degrees. Compared with other models, the model proposed in the test phase can capture the subtle change trend of the situation value more accurately and is also relatively accurate in the prediction of the situation value.

Table 5 shows the loss evaluation metrics of each model in dataset 2. The overall effect is consistent with dataset 1, which proves that the hybrid model is better than the single model, and the use of AM helps TCN to learn features, indicating that the proposed model is more accurate than other hybrid models for network security situation prediction.

Figure 20 shows the comparison of training time and the model parameters of each DL model. The results are consistent with dataset 1. The model proposed in this study has a higher model complexity.

4.3. Discussion and Analysis. This study predicts the situation at two different time stages. The results show that the model proposed in this study has better performance than other models in situation prediction. In addition, the following information can be obtained.

(1) Compared with the single DL model, the hybrid DL model has a faster rate of decrease in training loss, and the prediction accuracy and fitting are also better, indicating that the overall prediction effect of the hybrid model is better than that of the single model.

(2) The prediction accuracy of the model using AM is improved compared with the original model, indicating that AM is helpful for feature extraction.

(3) The hybrid model proposed in this study is superior to other hybrid models, indicating that the model combining AM with TCN has a stronger feature extraction ability. At the same time, BiDLSTM performs better in time series prediction than that of LSTM and GRU.

(4) Although the hybrid model has better prediction accuracy, the complex model structure and longer training time make the model's performance limited.

5. Conclusion and Future Works

In this study, we propose a network security situation prediction method based on AM improved TCN combined with the BiDLSTM network. First, the TCN is improved by the AM, and the improved TCN has a stronger time-series feature extraction ability, which can learn the trend of the historical period of the situation values well. Second, the excellent time-series prediction ability of BiDLSTM is then used for the situation prediction. The experimental results show that compared with a variety of single and hybrid DL models, the proposed model has better results in RMSE, MAE, and MAPE. The proposed model has more effective feature extraction ability and prediction ability, so it has higher prediction accuracy and stability. In addition, in the fitting of the predictive value and the actual value, the model can also achieve a good fitting effect and can capture the subtle trend change. At the same time, the proposed model has a complex structure and many parameters, which has certain limitations. However, for situation prediction, a higher prediction accuracy is more important, so this model can be used as an effective network security situation prediction tool. In future work, we aim to apply the model to other time-series prediction scenarios inorder to validate the long-range prediction capability of the model. Other advanced prediction methods are combined with feature extraction for more effective prediction. In addition, the structural design of the model can focus on lightweight design, such as reducing the number of model layers and appropriately discarding the full-connection layer to reduce the model parameters, or selecting a more efficient and lightweight prediction model to meet different scene requirements. At the same time, a multistep forecasting method can be used to meet the needs of more long-term forecasting.

Data Availability

The data supporting the current study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Research Article

Optimal Control Strategy Model of Marketing Management Based on Consumer Psychology

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This paper uses an optimal control strategy approach to conduct an in-depth study and analysis of consumer psychology and to design marketing management in this way. The process simulation enhances consumer participation in virtual CSR co-creation by enhancing task meaning perceptions, and the outcome simulation weakens consumer participation in virtual CSR co-creation by decreasing task meaning perceptions. Second, the proximity of the target distance positively moderates the relationship between psychological stimulation and task meaning perceptions, with process simulation having a stronger effect on task meaning perceptions at closer target distances than at longer target distances; the proximity of the target distance positively moderates the relationship between psychological simulation and consumer engagement in virtual CSR co-creation, with process simulation having a stronger effect on consumer engagement in virtual CSR co-creation at closer target distances than at longer target distances. The effect of simulation on consumers' participation in virtual CSR co-creation is stronger at a closer target distance than at a farther target distance. A multi-input and multioutput block diagram structure is proposed in the frequency domain to describe the characteristics of the multisubject system with transfer functions. Males and females accounted for 58.6% and 41.4% of the total sample population, respectively. The entire multisubject system is decomposed according to matrix theory, and the consistency problem of the multisubject system is converted into the stability problem of multiple subsystems. The global stability domain of the distributed PID controller is obtained by finding the stability domain of the PID controller for each subsystem after decomposition and taking the intersection set. The product green preferences of consumers are incorporated into the demand model, and the correlation between the inventory strategy of products, green inputs, and the manufacturer's confident preferences is investigated. The article considers two models of centralized inventory management and decentralized inventory management for manufacturers and conducts a cross-sectional comparison. The article finds through numerical experiments that the manufacturer's assertive behavior in most cases makes its gains suffer but is often beneficial for the interests of retailers, overall supply chain efficiency, and environmental friendliness.

1. Introduction

With the development of economic globalization, global business competition is becoming increasingly fierce, while customer demand for products is constantly changing, and these factors pose a great challenge to corporate inventory decisions [1]. When making inventory decisions, companies should consider not only operating costs and service reliability levels but also, and more importantly, the overall system profit maximization and the optimal match between customer demand and product supply. Lower levels of service reliability and higher inventory costs can lead to severe inventory shortages, which in turn can cause significant delays in orders, as well as customer churn, affecting not only the company's reputation but also reducing its profits. The uncertainty of customer demand and product supply, as well as the ultimate mismatch between demand and supply, can have a serious impact and high losses on the company. Therefore, it is of great practical importance to carry out optimal control of inventory to maximize the profit of the company under a certain level of service reliability and according to the needs of business operation [2]. Measurement error is also a measure where it is required to be less than 0.5. The products in inventory also require some

time to retrieve, prepare, pack, and load. Currently, most of the research literature on inventory models has the variables of customer demand as random and they all assume that the supply lead time is constant. However, in the actual production process, the supply lead time has a very important impact on the inventory level. In a supply chain system, the existence of unknown events makes the product supply highly uncertain, and the supply lead time must also be considered as a random variable [3]. Therefore, the study of classical queuing systems needs to be extended to a service-inventory system model with positive service times. Compared to classical inventory control models, these models are more general and better reflect the realistic characteristics of many systems in manufacturing and service industries in real production.

First, when physical sales channels and online sales channels exist at the same time, it is difficult to avoid channel conflicts due to the competition between different channels in terms of product prices and services, as well as consumers' free-rider behavior based on pre-sales services of products [4]. Channel conflict can cause retailers to suffer losses, while the channel members' expectations of the number of benefits to be gained from cooperation and the prospects of cooperation are important factors that affect the manufacturer's channel control. Maintain the reasonable profit margin of each member of the value chain and strengthen channel control, so that the enterprises can establish a stable and controllable channel distribution system and market order, and ultimately improve the core competitiveness of the brand. Secondly, based on considering channel conflicts, how to match the demands of online channels, and how to readjust and meet the demands of offline channels, these issues make supply chain members need to develop corresponding production and inventory strategies. The core of online paid knowledge is to make knowledge into products or services and sell these products or services through the Internet to achieve profit for individuals or companies [5]. The Cronbach α value is one of the indicators to measure the reliability level of the scale. In addition to the increasing attention of the capital market, the social media environment is also becoming increasingly mature, laying a solid foundation for the development of the online knowledge payment industry. With a good foundation of the internal and external market environment, the key to how the business models of online learning products and services of these related knowledge payment platforms can achieve good results lies in how to enhance the willingness of target users and potential target users to purchase related knowledge payment products. Therefore, it is especially necessary to focus the research perspective on the factors that influence the willingness of online knowledge payment platforms to purchase online knowledge payment products and services by most target users in the market.

This study investigates whether different types of psychological simulations of consumers' participation in virtual CSR co-creation activities can awaken consumers' norms and thus influence their willingness to participate. The study also attempts to explain the psychological mechanisms by which two different forms of psychological simulation influence consumer participation in virtual CSR co-creation: does process simulation enhance consumer participation in virtual CSR co-creation, or does outcome simulation enhance consumer participation in virtual CSR co-creation? Furthermore, to clarify the boundaries of the impact of psychological simulation on consumer engagement in virtual CSR co-creation, this study seeks to investigate whether the task goal distance and the strength of the user's relationship with other users in virtual CSR co-creation affect the relationship between psychological simulation and consumer engagement. When the test result finds that the Cronbach α value is greater than 0.8, it means that the reliability of the scale is excellent. Therefore, this study will investigate the impact of psychological simulation on consumers' willingness to participate in virtual CSR co-creation, as well as the psychological processes and influence paths of different types of psychological simulation on consumers' participation in virtual CSR co-creation, and explore the moderating effect of target distance and relationship strength on their relationship.

2. Related Works

To ensure that business processes can be suitable for the development of enterprise information management, foreign scholars have proposed value chain models. Malikopoulos's enterprise value chain model is an important guiding idea for the reengineering of enterprise business process system, which has an important guiding role in various aspects of process diagnosis, design, and continuous improvement [6]. Hong depicts the business process of an enterprise as a value chain, and competition occurs not only between enterprises, but also between the respective value chains of enterprises [7]. Only a company that implements effective management of each link of the value chain can truly gain a competitive advantage in the market. The enterprise value chain model breaks down the activities of a firm into some strategically related activities that are materially and technically well-defined and are the cornerstones of the firm's ability to create products that are valuable to buyers, hence the term value activities [8]. It is by performing these important value activities more cheaply or better than competitors that a firm develops a system of business processes that can win competitive advantage. The value stream-based information technology operations framework proposed by Kim and others, which identifies the functions and data needed to manage IT services from an end-to-end perspective, consists of the best time results of IT service management from many excellent companies [9]. It is convenient to directly find the internal inspection report of the system and send it to the customer. The value stream-based information technology operations framework enables IT organizations to carry out better quantitative management of services based on the attribute elements of functions, data, and relationships they provide, and to effectively assess the risks and inconsistencies in achieving service requirements through the metrics of process, cost, and capacity of services [10]. The application of this theory to the marketing operations of enterprises has played a good

effect, confirming the need for the construction of marketing information management.

In the actual market operation, companies cannot force customers to place orders before they need the product, but they can induce customers to follow the reservation strategy by giving them certain incentives or price discounts [11]. The commitment lead time constraint reduces the risk of demand uncertainty for the firm and the risk of inventory unavailability for the customer [12]. For companies, the shorter the lead time for products offered to customers, the greater the pressure on the production system, and the lower the probability of being able to deliver products to customers on time, which is likely to lead to late delivery, and thus companies need to bear higher delay costs; too long a lead time for products offered to customers will affect the actual demand for products used by customers, thus losing many orders [13]. Therefore, determining a reasonable lead time for order supply is especially important for companies to achieve their supply lead time commitments [14].

The matching of behavioral preference factors with the decision model has the following considerations. The impact of price in terms of profit distribution as well as revenue can intuitively reflect the cooperation intention and risk tolerance of supply chain members, which is intrinsically linked to members' equity concerns and risk-averse behavior. When demand is certain, members will pay more attention to the profit distribution; when demand is uncertain, members will consider the expected benefits and risks from the pricing. Based on this, this paper applies members' fair concern and risk-averse behaviors to the pricing decision model under different scenarios. To avoid calling the warehouse management personnel to inquire about the batch number of the product or after the loading machine has finished loading the goods, the warehouse at the loading place will return to the Internal Affairs Office of the Ministry of Domestic Trade to print the inspection report. Inventory planning requires managers to forecast market demand, which reflects the decision makers' ability to grasp market changes. In this process, managers are often influenced by their subjective decisions. Such subjective decisions are reflected in the fact that, on the one hand, they tend to rely too much on their own experience or trust their judgment when forecasting demand, and on the other hand, managers are unable to face expected gains and losses objectively. Therefore, this paper applies two representative cognitive biases, the overconfidence of members and loss aversion, to the inventory decision model of a two-channel supply chain under demand uncertainty.

3. Analysis of Optimal Control Strategies for Marketing Management with Consumer Psychology

3.1. Optimal Control Strategy Design. In this study, the service system is treated as a queue, and customers arrive at the service desk one after another with a rate of; Poisson process, queue, and receive service. The service rule is first-come, first-served, with one service desk and the ability to serve all customers and serve only one customer at a time. Each customer only needs to order one product from the inventory, and when the service for any customer is completed, the inventory of products and the number of customers in the system are reduced. There is only one service desk in the system with infinite waiting space and infinite product capacity in inventory. When the product inventory is positive, the service time to customers is exponentially distributed [15]. If there are no customers in the system, arriving customers are served directly. When the service desk is busy, newly arriving customers queue in an infinitely long waiting hall.

The three points of focus, positioning, and differentiation are the key factors for a successful marketing strategy to reach successful realization. To gain an exclusive market position that is difficult for competitors to imitate and surpass, companies must carefully select their target market, create a novel and unique product positioning, effectively communicate with customers, and develop differentiated market offerings. The aspect to be noted is that addressing the entire market or the entire range within the market will consume and waste a lot of the company's costs and efforts, and requires a focus on the market. In this way, the company can meet the needs of its customers with greater efficiency and more unique products and services. Positioning refers to communicating the attributes of products developed by the company to customers in the target market segment [16]. It strives to make the company unique, create a key competitive advantage, and position the brand in the most advantageous position among customers. As a result, when customers have a need, they consider the brand to be the item of choice. Differentiation refers to marketing programs that develop a more differentiated product line and create a unique image, become an industry leader, and strive to gain a competitive advantage in the industry in which they operate, as shown in Figure 1. From the perceived experience and perceived preference formed from product attributes, product efficacy, use results, etc., the customer's reference dependence characteristics will significantly affect the customer's perceived value.

Regarding the manipulation of psychological simulation, the subjects were asked to conduct specific psychological simulations according to the purpose of the study. To ensure that the subjects completed the psychological simulation, they were generally asked to write the content of the psychological simulation, and finally, the effect of the psychological simulation was tested [17]. The renovation of a family home includes the preliminary consulting business, the intermediate design, construction tasks, and the final acceptance process, in which the pricing of architectural decoration is based on the complexity and quantity of the construction process, and the design can be used as a value-added service for home renovation, but this form often does not make the consumer satisfied with the marketing to the result. The importance of design for whole-house decoration is slowly being recognized by consumers, so design consumption is gradually being accepted.

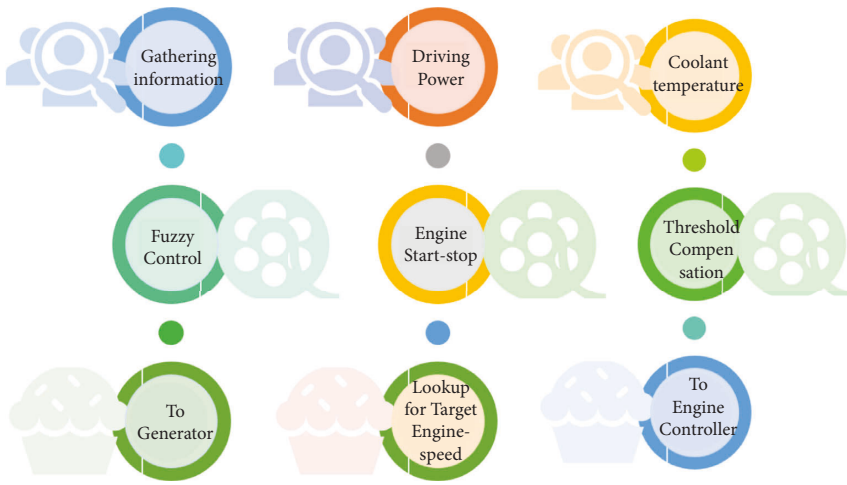

Figure 1: Optimal control strategy.

For now, there are two outstanding issues to be improved in the design of the consistency controller of the first-order system. The first is the time lag problem of the system. The existence of communication time lag in the multiple self-subject systems because of connecting every single system, and the existence of input time lag in each independent closed-loop feedback system makes it difficult to apply the traditional single-system feedback control design method directly to the multi-individual system. From previous research results, it can be found that there always exists a control protocol to achieve system consistency if the time lag is within a certain range. However, it is still an extremely challenging topic to design a distributed controller to improve the coherence performance of a first-order multi-subject system with a specific time lag in an analytical way. In addition, the consistency problem in a directed topology also needs to be addressed. When the network topology of a multi-self-subject system is a directed graph, the eigenvalues of its corresponding Laplace matrix may be complex. In this way, the characteristic equations of the system are expanded from the real domain to the complex domain [18]. It is still a challenge to design distributed controllers for the Eigen equations in the complex domain case analytically.

The structural block diagram of the distributed control structure of the multi-self-subject system is shown in Figure 2. Looking at the development of the retail industry, because there was no support from advanced technology in the past, if companies wanted to grab customers, the methods they could take were relatively simple and crude, and there would also be relatively simple concepts. Loading an independent controller on everyone not only ensures the stable operation of the individual but also enables the individual to achieve the consistency of the multi-self-subject system through the information interaction with the neighboring nodes. Consider the multi-self-subject system to be designed to contain n general first-order individuals.

Building enterprise marketing information management is the key to enterprise development and a shortcut to creating an industrial chain and increasing the added value of products. Only market-oriented marketing operation and marketing management activities are driven by customer demand can enable enterprises to pull the continuous innovation of production and operation with market demand, so that enterprises can gradually control the whole industrial chain from simple processing and manufacturing link, and finally realize efficient integration of industrial chain from processing and manufacturing to product development, raw material procurement, logistics and transportation, order processing and product sales. Usually, they improved their service capabilities to improve their competitive advantages. The implementation of marketing information management in enterprises should follow three basic rules: focus on motivating users' intrinsic motivation to use and specific learning situations; combine teaching concepts with specific marketing methods; and make full use of the digital network environment.

Based on the enterprise marketing strategic planning vision and investment conditions, it helps enterprises to select core marketing information management assets and other assets to combine into a portfolio of investment opportunities, so that marketing departments can create various services by in-sourcing or outsourcing, and make the services match with marketing business and strategic objectives by planning a comprehensive view analysis of relevant cost, value, risk, performance, and other elements.

Customer knowledge is organized and consists of structured customer information. Customer knowledge management capabilities are those business activities that directly serve to collect and analyze customer information, produce, and distribute customer knowledge, structure, and maintain customer relationship platforms, and maximize organizational effectiveness [19]. Customer knowledge management capabilities can provide a sustained competitive advantage that is difficult to imitate. These capabilities cannot be purchased, but can only be generated through business processes. It is one of the key forces behind the success of customer relationship management.

Through the accumulation and use of knowledge base and digital marketing operation process of knowledge-based service request and operation process functions, fault

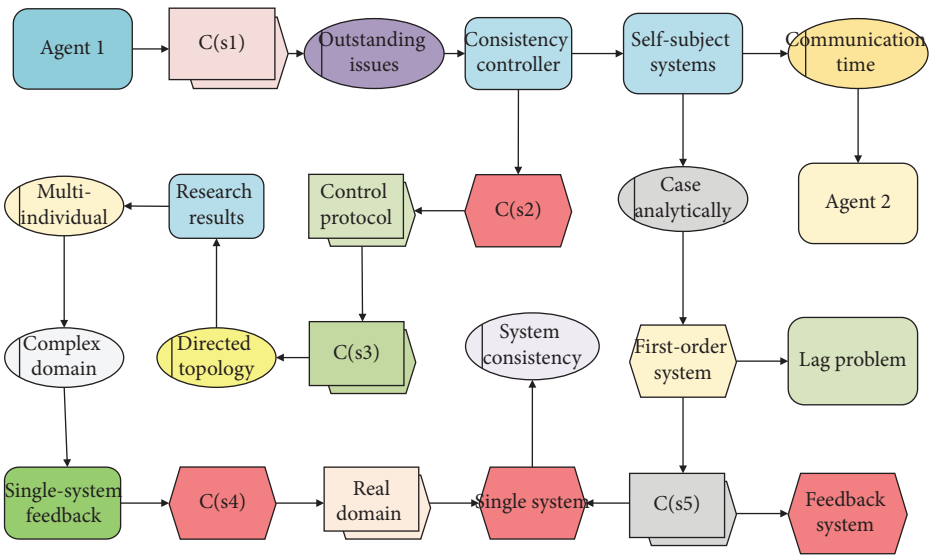

Figure 2: Distributed control topology of the multi-self-subject system.

management, event management, problem management, change management and configuration management are more transparent and controllable, service agility, continuity and cost optimization are realized, services are more reliable, and business continuity is enhanced, whichalso enhances the feasibility of marketing information technology. This improves the ability of marketing information technology to support the business in general [20]. It enables outsourced resources from different software teams to work according to consistent standards, thus achieving a balanced service capability across domains and teams and giving consumers a near-consistent service experience.

The e-business capability of an enterprise refers to the enterprise's capability of interacting with customers and business partners and completing commerce through the Internet. Specifically, it includes the strategic capability of an enterprise to use the Internet to share information, facilitate transactions, enhance customer service, and strengthen back-end integration. It is very important to realize the maximization of corporate profits. Products in stock also take some time to retrieve, prepare, pack, and load. This capability requires the organization's multilevel data processing architecture and network as the core configuration to support the formation. After removing the barriers between applications and integrating fragmented infrastructure products into a technology platform for e-business, enterprises are endowed with their unique personality and knowledge assets, which are closely integrated with their business and thus can bring competitive advantages, rather than mere technologies or products that can be traded routinely.

3.2. Marketing Management Analysis of Consumer Psychology. This paper focuses on the influencing factors of consumer word-of-mouth, self-efficacy, and consumer engagement behavior that affect the purchase intention of paid knowledge products through psychological empowerment, so the main research target is targeted at users who have used or are using online paid knowledge products.

In the questionnaire survey on the willingness to purchase online knowledge payment products, the gender ratio is relatively balanced, with 58.6% and 41.4% of the total sample being male and female respectively. From the age distribution of the subjects, we can see that the proportion of users between the three age groups is relatively evenly distributed, accounting for about 30% of the total number of the subjects, and the total number of users in these three age groups accounts for about 90% of the total [21]. This indicates that the core users who purchase and use knowledge payment products are mostly teenagers, young people, and middle-aged users. Analyzing the education of the sample users, the percentage of those with a college education or above is 70.9%, indicating that the education level of users of paid knowledge products is generally high. In terms of occupation distribution, office workers account for 61.8% and students account for 15.9%, which shows that most of the users are office workers, and considering the actual situation, office workers need to learn some knowledge and skills to improve their ability at work and have a greater demand for knowledge learning. After getting out of campus, the fragmented knowledge learning like knowledge payment service is more flexible in time and convenient in the way of learning, so online knowledge payment service is a good choice for office workers. In terms of income, only 20.4% of the users earn more than 10,000, which can be inferred that most of the users belong to the general working class.

This part is the descriptive statistics of the measurement results of the items measured by each variable, and the Likert scale is used for the measurement of the items, so the maximum value of each item should be 5 and the minimum value is 1. The mean value of all the items exceeds 3, and the survey respondents approve of the items in the questionnaire. The level of approval for consumer word of mouth, consumer psychological empowerment, and consumer

involvement behavior is high, as shown in Figure 3. Compared with the classic inventory control models, these models are more general and better reflect the real-world characteristics of many systems in actual production, manufacturing, and service industries.

To judge the stability and consistency of the measurement results systematically and accurately in the questionnaire, we need to measure the indicator of reliability, because reliability tests whether a measurement scale has good reliability of the method. In this study, the results were obtained by SPSS software, after importing the collected sample data into the software and conducting internal consistency tests. The indicators reflect the validity, where the factor loadings represent the level of explanatory power between the potential variables to the measured variables [22]. It is generally required that the factor loadings should be greater than 0.7 to be considered a good explanatory power. As can be seen from Figure 4, all the factor loadings of the variables are greater than 0.7, which is a strong explanatory power. Cronbach's alpha is one of the indicators to measure the reliability of the scale, and when Cronbach's alpha value is greater than 0.8, the reliability of the scale is excellent. As we can see from the table, the values of Cronbach's alpha for consumer word-of-mouth, self-efficacy, consumer involvement behavior, consumer psychological empowerment, self-brand association, and purchase intention are 0.856, 0.867, 0.895, 0.841, 0.834, and 0.913, respectively, all of which are greater than 0.8, indicating the high reliability of the questionnaire scale and suggesting that the CR means combined reliability, which is calculated from the factor loadings and indicates the internal consistency reliability. The values of CR are 0.88, 0.845, 0.892, 0.813, 0.827, and 0.902, which are all greater than 0.6 and meet the good standard, that lay a solid foundation for the development of the online knowledge payment industry.

In recent years, people's demand for quality of life is also increasing, the disposable income of residents is also increasing, and the economic foundation is becoming increasingly solid. Therefore, companies with high-quality standard design teams and a wide range of construction products will be more popular with consumers. The continuous development of the real estate industry will also increasingly increase the residential and office groups, for the building decoration industry will also be more favorable, ushering in new growth.

Timely entry of relevant product shipment information, and to ensure the accuracy and completeness of the information entered. If the entry of information on different categories of goods in the company's warehouse is accurate, then the sales order can be placed concerning the corresponding goods in the warehouse in the current period and can be associated with the product lot number information, so that it is easy to directly find the system internal inspection report form and send to customers. With the good foundation of the internal and external market environment, the key to how the online learning products and services of these related knowledge payment platforms can achieve good results is how to improve the target users and potential target users' willingness to purchase related knowledge

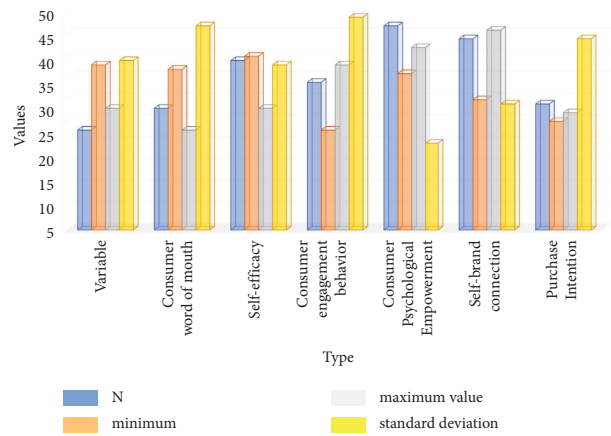

Figure 3: Description of variables.

payment products. And then thus avoid calling the warehouse management to ask for the product lot number or by loading the dead machine after loading the goods, and then by loading the warehouse to return to the domestic trade department housekeeping to print the inspection report form. In this situation both the risk of the batch and number error has increased the workload of cargo drivers, affecting efficiency. For example, the special needs of customers or customized goods of the shipping instruction notes are filled in timely and accurately, which can avoid the finished goods warehouse managers to call several times to confirm because of incomplete or unclear information, which increases the workload [23]. Moreover, the long-term accurate entry of relevant information is also the summary of special customer demand information, which is greatly beneficial to the work of information technology details.

4. Result Analysis

4.1. Optimal Control Strategy Results. Among them, the individual controller is mainly to improve the robustness of each self-subject, and the coupled controller ensures the fast consistency of the multisubject system. Both controllers use fractional-order controllers. First, a robust controller is designed to control individual self-subjects to satisfy the performance index based on the improved D-partitioning method. Subsequently, the multi-self-subject system is decomposed, and the design problem of the coupled controller is transformed into the stability problem of the subsystem. For each decomposed subsystem, the D-partitioning method is used to obtain the global stability domain of the coupled controller. In the resulting stability domain, the SIWPSO algorithm is used to find the optimal control parameters that maximize the convergence rate of the entire multi-self-body system. Finally, the effectiveness of the designed two-degree-of-freedom optimal control strategy is verified by two sets of simulations.

Observing Figure 5, the two-degree-of-freedom control strategy proposed in this paper has a faster convergence speed compared with the distributed fractional-order control strategy; compared with the GA algorithm, the control parameters obtained by using the SIWPSO algorithm are

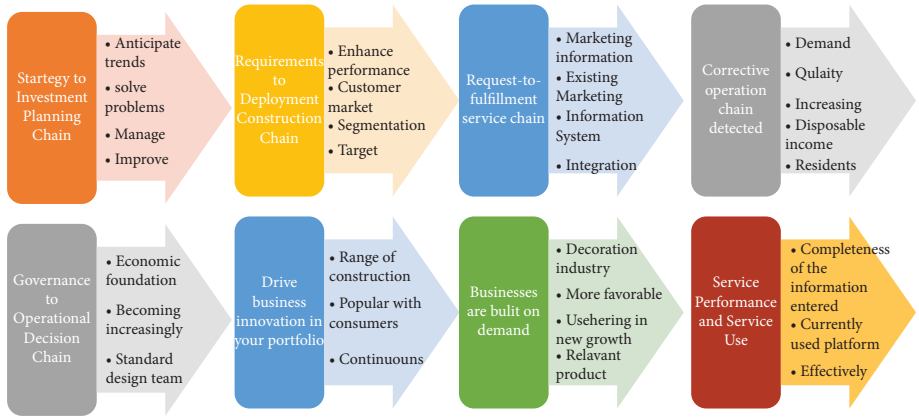

Figure 4: Marketing management model.

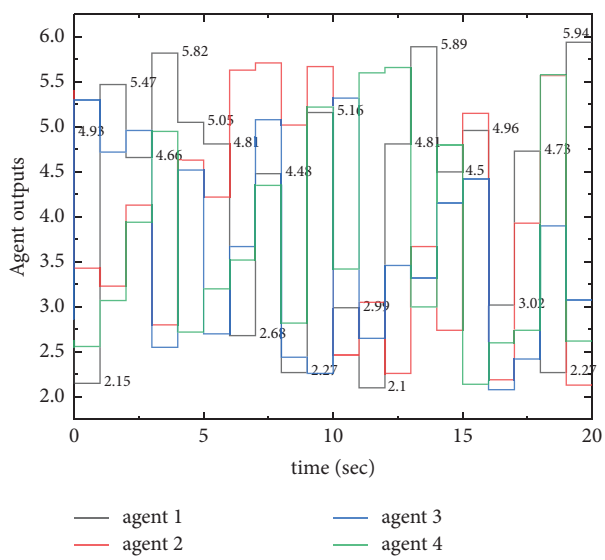

Figure 5: Simulation diagram of the response of the multi-self-body system.

better in terms of performance improvement. In summary, the fractional-order two-degree-of-freedom control strategy proposed in this paper has a good effect on the performance improvement of the fractional-order multi-self-body system. Members consider expected benefits and risks from pricing.

The essential feature of the cooperative control of the self-subject system is the global behavior formed by the local interaction of information among multiple individuals. The dynamic equations of each self-subject and the topology connecting multiple self-subjects are the two major decisive factors affecting the realization of cluster behavior in multisubject systems. Therefore, the key to the study of multi-self-subject systems lies in how to design cooperative controllers to achieve consistent behavior of multi-self-subject systems, given the dynamics model of individuals and the topology between multiple self-subjects.

Based on the multientry and multiexit frequency domain block diagram of the multiple self-subject systems, the design method of the optimal distributed PID controller for the first-order time-lag multiple self-subject systems in the case of a directed graph are studied. By decomposing the multisubject system using matrix theory, the consistency problem of the multisubject system is converted into the stability problem of multiple subsystems with complex coefficients. For the subsystems with complex coefficients, the stability ranges of the corresponding distributed PID control parameters are obtained analytically. The global stability domain of the distributed PID controller is obtained by intersecting the stability ranges of all subsystems. Finally, an improved PSO algorithm is used to obtain the optimal PID control parameters satisfying different performance indexes.

First, customer perceived value from the utility perspective is often defined as the overall evaluation of the level of utility of a specific product or service based on a comprehensive weighing of perceived benefits and perceived losses, so that the higher the level of utility brought by a specific product or service, and the smaller the price paid for it, the greater the customer perceived value. Secondly, customer perceived value from the rational perspective is often defined as the trade-off between perceived benefits and perceived sacrifices, which affects both customer purchase decisions and customer satisfaction and loyalty, under the constraints of information imbalance and limited rationality, by assessing and calculating the benefits and sacrifices brought by obtaining a specific product or service. Again, customer perceived value from an empirical perspective is often defined as the perceived experience and perceived preference of customers in terms of product attributes, product efficacy, and usage results based on historical experience and social evaluation, through the evaluation of their interaction with specific products and services. Based on this, this paper applies members' fairness concern behavior and risk aversion behavior to pricing decision models in different scenarios.

In this paper, we will explore the marketing effectiveness of coordination companies' pricing strategies from two dimensions: the perceived price of coordination services and the perceived risk of coordination services. On the one hand, the perceived price of logistics service is the key factor that restricts the purchase intention and purchase behavior of logistics service, rather than the real market price of logistics

service; on the other hand, the perceived risk of logistics service contains two aspects of perceived business function risk and perceived social psychological risk, the former is reflected in the concern of damage to the organization's interests, the latter is reflected in the business manager or negotiation representative's concern of damage to personal development prospects as shown in Figure 6.

Considering the dynamic game situation, it is demonstrated by inference that members' risk-averse behavior leads them to develop a lower price strategy to reduce their own risk. Unlike the price strategy, the retailer's service level is not influenced by the risk attitude. Numerical experiments to analyze members' gains reveal that the risk-averse behavior of supply chain members reduces their profits but increases each other's gains. From the perspective of the supply chain, the retailer's risk-averse behavior is beneficial for increasing supply chain profits, while the manufacturer's risk-averse level has the same impact when maintained at a low level.

To reflect the game strategies of members more realistically, the article considers that members adjust their price strategies based on limited rational expectations and adjust their retail service strategies based on adaptive mechanisms. The market needs to be focused. Concentration refers to focusing on a specific customer group, part of a specific product line, or focusing on a specific segment of a specific regional market. By inference, it is found that too fast price adjustment is detrimental to the stability of decision-making and can cause the system to enter a multiplicative cycle bifurcation or even chaotic state. The adaptive adjustment strategy of the retailer's service will make the service level eventually remain at a stable level. In addition, it is found that the risk-averse behavior of supply chain members facilitates the stability of their pricing, and in most of the cases shows the opposite effect on the adjustment of the other party's strategy. Numerical analysis of membership gains reveals that system instability is detrimental to the manufacturer or retailer, but can increase the gains of the other party.

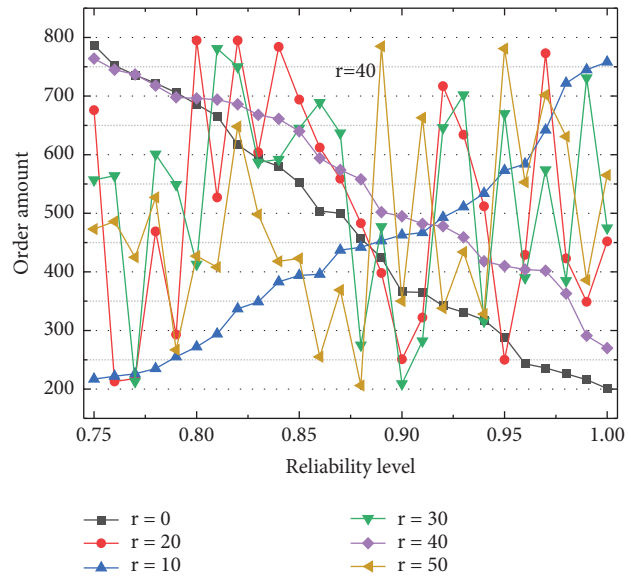

Figure 6: The influence of reorder point and service reliability level on optimal order quantity.

4.2. Analysis of Marketing Management Results of Consumer Psychology. Generallyspeaking, consumers who buy decorative building materials come from a wide range of sources, but are not concentrated enough. Centralized purchase of building materials can only make the decoration process more convenient, while the main buyers of building materials are mostly decoration enterprises, individual families or individuals of different sizes, and there are more types and quantities of purchasing groups. These groups will compare products to determine a more competitive market.

Buyers in the decoration building materials market generally include interior decoration engineering units (we call them to group purchase customers) as well as end consumers. Buyers and product dealers will have certain disputes about the price, specifically the sellers by reducing the selling price, but also to meet more customer demand, and then for higher profits or sales, this way will lead to competition between the two. Throughout the development of the retail industry, because there is no advanced technology support in the past, if companies want to grab customers, they can take a more simple and brutal approach, and there will be a shallower concept, usually to improve service capabilities to improve the competitive advantage. With the continuous development of the economy and society, today should no longer be limited to improving the competitiveness of products to improve the quality of service, because the needs of consumers, expectations, consumption habits, etc. are far higher than the services that businesses can provide, businesses should think more from the above aspects.

The system construction mainly starts from customer experience to strengthen the operation quality. First, the quality of the shopping environment, from the external senses of customers, and constantly improve the overall shopping environment of the project site to enhance the shopping comfort of customers, as shown in Figure 7. Among them, the price of architectural decoration is priced according to the complexity and quantity of the construction process.

The approximate chi-square of Bartlett's sphericity test was 4811.882, with 276 degrees of freedom, a significance of 0.000, and a p-value less than 0.01, which is extremely significant, indicating that the overall validity of the questionnaire is suitable for factor analysis. Therefore, factor analysis was conducted using principal component analysis and maximum variance method, and seven factors were extracted, with a cumulative variance explained of 76.814%, which meets the requirements, and a rotated component matrix was obtained, as shown in Figure 8, and it was observed that the loading values of each factor were above 0.5, indicating that the questionnaire scale has good structural validity.

The research problem can be further extended by solving the optimization constraint model with other improved

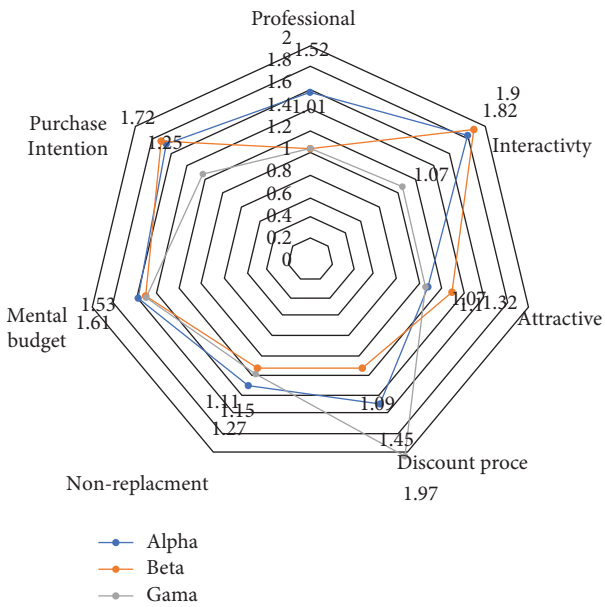

Figure 7: Reliability analysis of each variable.

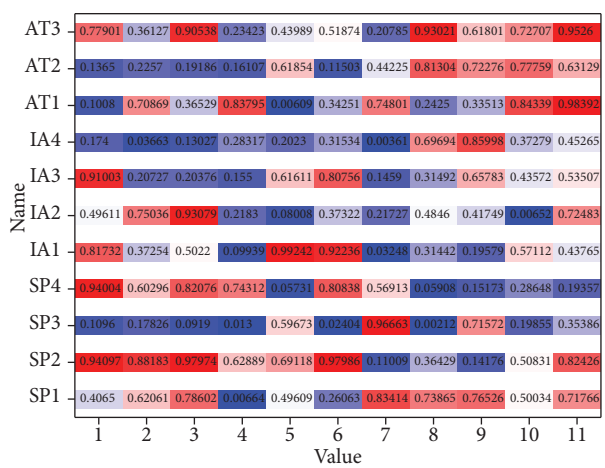

Figure 8: Factor analysis.

algorithms, by analyzing the service system, the steady-state distribution of other queueing theory models, or by studying other distributions of the supply lead time, such as the PH distribution, which can better portray the reality of the situation. Design can be used as a value-added service for home decoration, but this form often fails to satisfy consumers and market to the final effect. The service system can also be further extended to consider the case where customers arrive in bulk, or where customers have multiple different demands for the final product or customer service. In addition, this paper only specifically investigates the effect of price on order quantity, but other characteristic quantities, such as the effect of reorder point r on order quantity, can also be further studied in more depth to analyze the overall effect of different parameters on this service-inventory system at a fixed reorder point. However, the more complex functions of reorder point and order quantity may make the analytic expressions of the overall model function highly complex, thus making it impossible to analyze the analytic properties of the objective function.

5. Conclusion

This study verified the relationship between target distance positively moderating mental stimulation and task meaning perception and consumer engagement. Experiment 2 used a mental simulation intergroup experimental design to verify the moderating effect of goal distance on the relationship between mental stimulation and task meaning perception and consumer involvement in virtual CSR co-creation. The interaction between mental stimulation and target distance on task meaning perception was significant, and the degree of target distance played a positive moderating role between mental stimulation and task meaning perception, that is, the effect of process simulation on task meaning perception was stronger at a closer target distance than at a farther target distance; and the interaction between mental stimulation and target distance on consumer engagement was significant, and the degree of target distance played a positive moderating role between mental stimulation and task meaning perception. It enables the marketing department to create various services through insourcing or outsourcing, and through planning a comprehensive view analysis of related cost, value, risk, performance, and other elements, to make the service consistent with the marketing business and strategic goals. The interaction between mental stimulation and target distance on consumer engagement was significant, with the proximity of target distance positively moderating the relationship between mental stimulation and consumer engagement in virtual CSR co-creation. This finding identifies the positive effect of target distance on co-creation behavior, validates the validity of "target gradient help," and enriches the research context of target gradient theory.

Data Availability

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

Conflicts of Interest

The author declares no conflicts of interest.

Acknowledgments

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Research Article

Analysis Methods for the Planning and Dissemination Mode of Radio and Television Assisted by Artificial Intelligence Technology

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In the context of the development of artificial intelligence (AI) technology, the planning and dissemination of radio and television must not only learn to quickly and deeply process a large amount of content and extract structured information such as classification, themes, tags, and styles from information sources, but also learn to use audience behaviors to explore and discover potential content, jump out of the editor's subjective vision, and realize personalized content presentation. On the basis of summarizing and analyzing previous research results, this study expounded the research status and significance of the planning and dissemination mode of radio and television, elaborated on the development background, current status, and future challenges of AI technology, introduced the methods and principles of computer vision, natural language processing, semantic analysis, and video generation, discussed the content production, interview, and editing of radio and television, explored the review, archiving, and system solutions of radio and television, proposed the planning strategies for radio and television assisted by AI technology, analyzed the smart distribution, reception, and feedback of radio and television dissemination, discussed the interactive application and virtual reality of radio and television dissemination, analyzed the dissemination mode of radio and television assisted by AI technology, and finally carried out a case application and its analysis. The study results show that AI technology can be used for smart lyrics, smart writing, smart broadcasting, smart translation, smart recommendation, smart stripping, and smart retrieval, and so on. The AI-assisted radio and television planning gives audiences the right to choose news, provides them with more targeted news content by means of data capture and resource integration, and caters to audiences' all-round and in-depth information needs through a question-and-answer method, innovating dissemination logic and expression approaches, and enhances the audience's sense of experience and leadership in obtaining information. The AI-assisted radio and television dissemination mode has the advantages of improving the effectiveness of information communication, promoting the optimization and integration of news resources, and enhancing audience stickiness.

1. Introduction

Artificial intelligence (AI) is a theory, method, technology, and application system that uses digital computers or computer-controlled machines to simulate, extend and expand human intelligence, perceive the environment, acquire knowledge, and use the knowledge to obtain the best results [1]. The application of AI technology in the field of radio and television can further release and optimize human resources, maximize the production efficiency of news editing, improve the timeliness of news reports, and assist editors to complete the report content that is difficult for manpower to quickly and comprehensively optimize, thereby freeing up more labor costs to do the news that requires deep excavation and thinking [2]. Based on data collection, modeling capabilities, and data analysis, the AI-assisted radio and television dissemination mode is building a variety of smart recommendation scenarios. It can also smartly and automatically select some of the content and products that audiences may like and present them to audiences in an appropriate way [3]. The recommended content is closer to audiences and more diversified, which can help reduce human decision-making errors and shorten manual scheduling time. The planning and dissemination model of radio and television needs to improve the audience viewing experience, increase audience stickiness, increase

revenue from value-added content, etc., and focus on data collection, data analysis, and audience portraits, covering the entire radio and television business from the audience side, content side, and channel side [4].

AI technology brings more opportunities to the media industry in terms of news production, content collection, information distribution, and audience experience, while causing new problems and challenges, but this will not affect the development process of smart radio and television [5]. The technical application of AI will focus on the development of knowledge maps, the construction of content databases, and the development of special algorithms according to the needs of the public in the field of information dissemination [6]. The AI-assisted radio and television planning must not only learn to quickly and deeply process many contents, and extract structured information such as classification, themes, tags, and styles from information sources, but also learn to use audience behaviors to explore and discover potential content, jump out of editor's subjective vision, and realize personalized content presentation [7]. In terms of smart information production, AI can not only realize the aggregation and use of massive data at the physical level but also allow each information content element contained in a wider range of data to automatically and spontaneously realize the integration with other information content elements. High-speed computing smart screening provides planners with planning solutions and can even directly recommend writers to editors, which greatly reduces the early manpower investment of radio and television organizations and can improve the gold content of topic selection and planning [8].

On the basis of summarizing and analyzing previous research results, this study expounded the research status and significance of the planning and dissemination mode of radio and television, elaborated the development background, current status, and future challenges of AI technology, and introduced the methods and principles of computer vision, natural language processing, semantic analysis, and video generation, discussed the content production, interview, and editing of radio and television, explored the review, archiving, and system solutions of radio and television, proposed the planning strategies for radio and television assisted by AI technology, analyzed the smart distribution, reception, feedback of radio, and television dissemination, discussed the interactive application and virtual reality of radio and television dissemination, analyzed the dissemination mode of radio and television assisted by AI technology, and finally carried out a case application and its result analysis. The detailed chapters are arranged as follows: Section 2 introduces the methods and principles of the methods and principles of computer vision, natural language processing, semantic analysis, and video generation; Section 3 analyzes the planning strategies for radio and television assisted by AI technology; Section 4 discusses the dissemination mode of radio and television assisted by AI technology; Section 5 carry out a case application and its result analysis; Section 6 is the conclusion.

2. Methods and Principles

2.1. Computer Vision and Natural Language Processing. Computer vision is the construction of clear and meaningful descriptions of objective objects in images, the computation of properties of the three-dimensional world from one or more digital images, and the making of useful decisions about objective objects and scenes based on perceptual images. Application fields such as face recognition, image retrieval, games and control, monitoring, biometrics, and smart cars are derived from computer vision. Natural language processing is the most important and active research field in AI research, whose ultimate goal is to make machines simulate, extend, expand, and even surpass this ability on the basis of clarifying the mysteries of human natural language understanding and generation [9]. The task of natural language processing, a field of AI research, is to build machine systems that can simulate human language abilities. Natural language processing has the following two major research topics: one is to study natural language understanding and the other is to study its generation. From a semantic point of view, the problem to be solved by the former is how to complete the mapping from text to meaning, and the problem of the latter is how to complete the mapping from meaning to text.

The text that is currently being photographed is directly recognized by the text recognition engine, and the captured text is used as a keyword to call the background operation management platform to obtain the activity or network content associated with the text and then interacts with the activity content on the client. Since the image processing-related algorithms are executed on the background server, the overall recognition rate can be improved through more complex preprocessing algorithms and postprocessing algorithms. When adding a new feature picture, the audience uploads the picture and key metadata information through the web page. After receiving the feature picture, the background server automatically calculates the feature code for the feature picture and stores the relevant information in the data warehouse. When the client needs to retrieve the image data, it is captured by the camera, and the characteristic code is generated and calculated in real-time for the collected image data. The client transmits the signature to the background server in real-time, and the background server quickly matches the signature with all signatures in the warehouse and finds the one with the highest similarity as the result. In order to improve the retrieval accuracy, according to a certain threshold, when the matched similarity result is lower than the threshold, the server considers it a retrieval failure.

2.2. Semantic Analysis and Video Generation. Video semantic analysis refers to the process of extracting information from the semantic components contained in a video. Video semantic analysis is an interdisciplinary research topic involving image processing, video data processing, pattern recognition, machine learning, and other fields, whose goal is to describe and characterize video content from both

visual and audible aspects. Between the vocabulary of the language and the relationship between the whole sentences, there is a language unit, that is, a collection of words. Usually AI is used as a whole in the sentence. The syllables recorded by digital recording technology are converted into codes that can be recognized by computers through analog-to-digital conversion. These codes are segmented to form components of AI speech with a voice signal that the audience can recognize [10]. When they need to be restored to sound signals, these components are reorganized through digital-to-analog conversion. Since the composition of these aggregates is flexible and changeable and not preset in advance, it is difficult to clearly explain the changes of these aggregates in the expression of preset chunks.

The number of manual interventions is limited and often focuses on the most popular head content, while machine distribution can cover information other than long-tail news reports related to audiences' lives and personal interests. The application mode of radio and television hosts assisted by AI technology should be that robots can replace some procedural, massive search, and other tasks that process a large amount of complex information, allowing the host to free up more time and energy to think more deeply or more warmly about the news expression. By recording and analyzing audiences' browsing behavior, extract structured information such as categories, topics, tags, and styles from information sources and use audience behavior to explore and discover potential content. AI technology can also automatically label articles and their related information according to the data structure after word segmentation, laying a solid foundation for subsequent selection of distribution channels or personalized recommendations for audiences. The AI technology can quickly extract core opinions, event development trends, public opinion sentiment orientation, and analyze event propagation paths, allowing news producers to understand the ins and outs of the entire event and provide creative ideas.

3. Planning Strategies of AI-Assisted Radio and Television

3.1. Content Production, Interview, and Editing. If AI-assisted radio and television want to provide news audiences with smart and accurate news products, they need to be based on a large number of vertically subdivided and fragmented content resources. In the actual situation, although the radio and television media have professional news content production capabilities, the production of news content has not yet been scaled, standardized, and intensive. The labels of news products are too rough, and the degree of informatization of news products is not enough. The radio and television audience databases must have good compatibility to ensure that audience data on internal and external platforms can be diverted and deposited. In addition, the radio and television audience databases must have good scalability and can reserve interfaces for future new audience data generation platforms. Existing news products based on programs will gradually weaken and will be replaced by fragmented short news products; existing frequencies and channels will also be replaced by vertical subdivision work units based on audience needs. Through in-depth processing of semi-finished news products containing data processing and analysis results, high-level professional journalists can provide audiences with in-depth news products that are both ideological and humane. In the algorithm programming stage, authoritative news experts from radio and television should work closely with algorithm engineers to optimize and model the party's requirements for news and public opinion work, prioritize the social benefits of news events, and realize the synergy between audience value and news value. Figure 1 shows the framework for the planning strategies and dissemination mode of AI-assisted radio and television.

Natural language generation technology builds narratives based on large-scale datasets, enabling features such as integrating keywords, search engine optimization, and delivering personalized content to audiences in bulk. Automatic generation of computational images can find the best frame in motion in real-time and seamlessly add or remove objects from the scene, change shadows, and more. The smart audit of information is to identify the content through the machine and judge the information on this basis; connection and collision are similar to the formation of a chemical reaction [11]. The use of news bots will further enhance this function, and through the processing of large amounts of text and real-time machine learning, it will find logical loopholes and fake news of relevant information in context. The AI technology can analyze and predict multi-channel data, such as read tracking and market analysis based on relevant data analysis models, obtain positive and negative comments on their content, and quickly select audience-oriented topics based on the dimensional analysis model. With the help of different data passes through real-time information structuring, data visualization, information smart identification, and more smart auditing functions, including not only logical loopholes in the context of text content, but also images, real-time review, and correction of various content forms such as videos.

The so-called AI synthesis refers to the improvement of the technical production level, and in terms of the specific broadcast content, the news creation level still needs to be controlled by a production team with deep human thinking ability, and an excellent live anchor will definitely be part of this production team. A radio or television program will be more vivid and good-looking because the host participates in the main creation or secondary creation, giving the program a fresh and lasting vitality. The core of algorithm sorting is to calculate the score of content in real-time according to the audience, content, and context information and sort according to the score. The advantages of AI in data processing capability and processing speed are unmatched by traditional algorithm technology [12]. For example, they can set up an AI anchor and a real host in a news program, let the robot broadcast the news that happened that day, and for hot topics, the real host will complete it. In this way, a news program not only has the fastest, latest, and most complete news information but also has a standpoint full of depth, intensity, and temperature, which can arouse the audience's

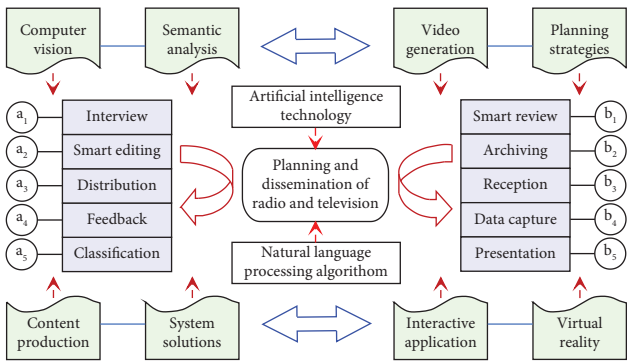


Figure 1: Framework for the planning strategies and dissemination mode of AI-assisted radio and television.

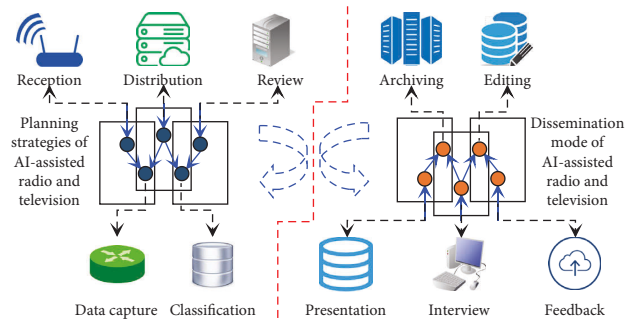


Figure 2: Content production, interview, editing, review, archiving, and system solutions in the planning strategies and dissemination mode of AI-assisted radio and television.

resonance. The AI technology can match the corresponding radio and television, so as to achieve the precision of radio and television delivery and the full coverage of highly targeted platform audiences.

3.2. Review, Archiving, and System Solutions. In the content production system, AI technology can be used for smart lyrics, smart manuscript writing, smart dissemination, and smart translation. The purpose of smart lyrics is to realize the automatic generation of video subtitles and improve the efficiency of manual lyric production. As shown in Figure 2, the content distribution system will complete the broadcast of corresponding content on traditional radio and television channels and the release of various platforms and terminals on the Internet. In the content publishing system, AI technology can be used for smart recommendation, smart stripping, and smart retrieval. With the assistance of AI technology, radio and television can reserve a library of anchors covering male and female voices, high school bass, and different voice characteristics. In the aspect of media asset storage, AI-assisted radio and television can realize automatic stripping storage based on semantics and achieve precise distribution through the smart content management platform. At present, smart recommendation and smart retrieval technologies have been widely used in various Internet products. For such mature technologies, radio and television can try to use them on their own Internet platforms and terminals to enhance the audience experience and viscosity. The smart monitoring and operation and maintenance of basic hardware and underlying systems, storage, and networks have been relatively complete and easy to manage by each cloud platform, but they cannot effectively perceive the monitoring and operation, and maintenance of upper-level business software and the maintenance work is relatively scattered, so smart monitoring and smart operation and maintenance will mainly explore the business software level [13].

The AI-assisted radio and television planning runs through the entire process of video upload, production, release, recommendation, and presentation, and is applied to each core system and business link of the content management and operation system of the new media platform. AI technology can be integrated with emerging technologies such as big data and new media dissemination to create more valuable radio and television dissemination modes. Video relevance evaluation and video quality evaluation are composed of multiple algorithms, adopting a multi-modal design concept and combining algorithms and business strategies to evaluate the similarity and quality of media materials and listed programs. The cover screenshot is composed of the following three parts: the frame drawing module, the image selection module, and the image forming module. Smart deconstruction and related quality models are used to improve the quality and qualified ratio of materials, and select more relevant pictures through star and scene recognition and feature algorithms to improve material diversity. Video cover image is the facade of television content, especially in major reporting activities, and video cover needs to be in line with the theme, aesthetics, and attract audiences, which play a vital role in video dissemination. Cover screenshot evaluation can automatically produce a beautiful cover image that meets the content requirements based on the video content and split subjective aesthetic issues into multiple objective issues.

In television programs, hosts and reporters are in open scenes and need to deal with emergencies from various factors such as program guests, interviewees, audiences, directors, equipment, and machines, and conduct complex coordination and interaction with each program link, so as to control the program effect on-site. For television audiences, the appearance of AI anchors on the television screen is first and foremost a gorgeous and novel visual spectacle, which is bound to arouse the curiosity and onlookers of the audience, thereby increasing the attention of the television program itself [14]. At the same time, some AI images appeared on television, and the show's witty quizzes often drew laughter and applause from the audience. In television programs, the AI anchors can work collaboratively with human announcers, hosts, and reporters in one scene, each applying their strengths. As the main body of the host and interview activities, the host is responsible for overall scene control, temporary responses, in-depth interviews, and decision-making responses, while the AI host acts as an auxiliary role, taking on tasks such as simple questioning, repetitive labor, and quick calculations. Smart dialogue robots may generate tendentious questions, guidance, and

answers in interview activities, which inevitably include the attitude and tendencies of the programmers themselves. Due to the opaque mechanism of the algorithm, the public is ignorant of the design and operation logic of the algorithm, resulting in multiple values that control the dissemination of information.

4. Dissemination Mode of AI-Assisted Radio and Television

4.1. Smart Distribution, Reception, and Feedback. AI-assisted radio and television can well combine human sensesand create an immersive interactive environment through human-computer interaction, so that the audience can feel immersed. The biggest feature of AI technology-assisted networks is the smart identification of audiences; AI will record the behavior of Internet audiences and on this basis, will profile the audiences so as to summarize the audience's favorite things and paste them accordingly. On the basis of fully considering audience preferences, the recommended content makes audiences dependent on sense and trust. Through the new media matrix, AI technology has established multi-directional interaction, so that radio stations, programs, hosts, audiences, and businesses are organically connected. The interaction is closely coordinated with the program, which can run through the program before, during, and after the broadcast. The smart distribution, reception, feedback, and application in the dissemination mode of AI-assisted radio and television are shown in Figure 3. AI technology can reduce the overall cost of radio and television through smart push, and its effective combination with big data technology can push radio and television to audiences or potential customers of related products [15]. AI technology can realize the efficient allocation of resources, and smart radio and television can be launched at the time and place where consumers really are, despite some ineffective placement and dissemination.

Convergence media is the integrated operation of text, video, audio, pictures, animations, and other elements, and then distributes different content through different media properties, so it can be said that media integration is a necessary process for media integration. It is precisely because of media integration that journalists must organically integrate traditional dissemination channels and emerging media dissemination channels to achieve resource sharing [16]. The new dissemination mode uses different expression methods to generate works in different media forms, implying that traditional radio and television media audience must diversify the content of news reports, and the expression methods must be networked. Not just as news porters, but corresponding content must be produced according to the attributes of the media, and the information arrival rate and the conversion rate of the dissemination content must be optimized to ensure that the audience can obtain relatively complete information on different media terminals. Diverse content must be distributed to the audience through different media channels, and the media attributes determine the audience's acceptance of the content. The audience of short video platforms focuses on the timeliness and intuitiveness of news; the audience of subscription accounts focuses on the integrity of the news and the interpretation of relevant content. The frame extraction module extracts a large number of frames from the video as candidate frames and uses the clustering method to aggregate similar pictures together. Each category obtains a frame with a higher score as a key frame and enters the image selection module to generate a variety of candidate cover images (Figure 4).

AI-assisted radio and television can make full use of the technical achievements of AI automatic voice translation and semantic recognition function to produce a set of high-efficiency voice and text smart editing system. It realizes the basic text editing in the video and audio content production process. One-click audio synthesis on the Internet can greatly improve the work efficiency of editors and reporters and liberate productivity. Smart recognition includes voice and image recognition to realize the identification of key information or key images. Smart manuscript writing, smart dissemination, and smart translation have been tried by the media for a long time, and they are still being continuously improved and improved, which provides a reference for radio and television to cut into AI applications. These tags are the basis for this kind of radio and television to push related pushes. Since the whole portrait is generated based on the audience's long-term network behavior, it can better reflect the actual needs of the audience, so this kind of radio and television delivery is more targeted. The characteristics of AI technology to assist radio and television itself also form the advantages of smart radio and television. Realistic and expressive to achieve a perfect speech synthesis effect, and the host can control it at any time, and can receive feedback immediately, in which audiences can participate by simple operations with low threshold.

4.2. Interactive Applications and Virtual Reality. The collection nodes of information in the media are no longer limited to commercial or noncommercial organizations or specialized news organizations, and the content and form of news information have become rich and diverse. The fundamental purpose of the construction of the content platform is to realize the specialization of news information on the basis of rich information, that is, to achieve classification, screening, integration, and in-depth processing of different forms of news information such as text, pictures, audio, video, etc., to meet the audience's all-round and in-depth information needs [17]. As shown in Figure 5, the AI-assisted dissemination mode means that media organizations ensure the stickiness of audiences through the delivery of advantageous content and the development of online and offline special activities, and they realize the standardization and regularization of audiences' information needs, and then the relevant data of high-quality audiences. The planning of radio and television has a strict control system from the beginning of news topic selection to ensure the correctness and direction of public opinion guidance; there are professional teams in content production, all with high business levels and media literacy; and a strict content

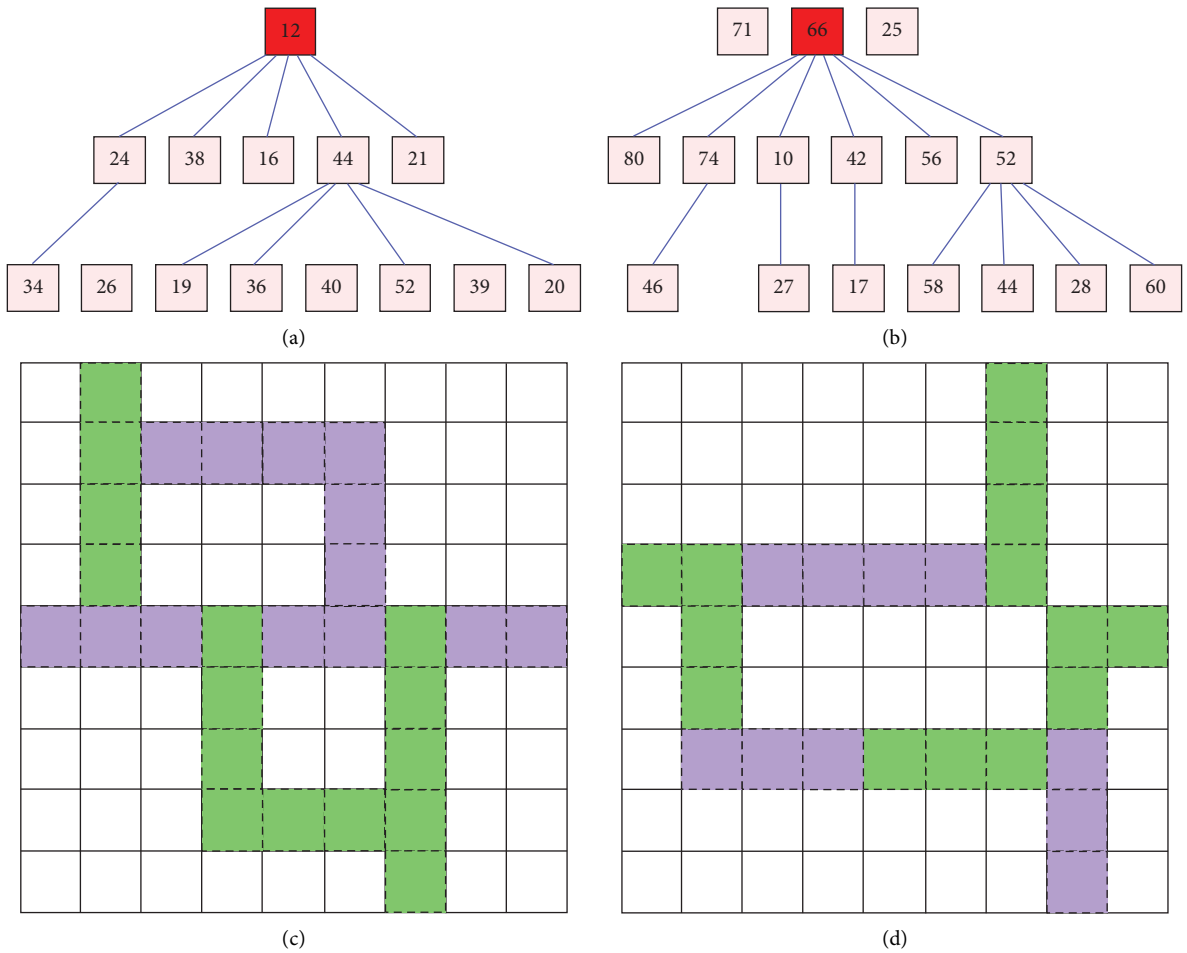


Figure 3: Schematic analyzes of smart distribution (a), reception (b), feedback, (c) and application (d) in the dissemination mode of AI-assisted radio and television.

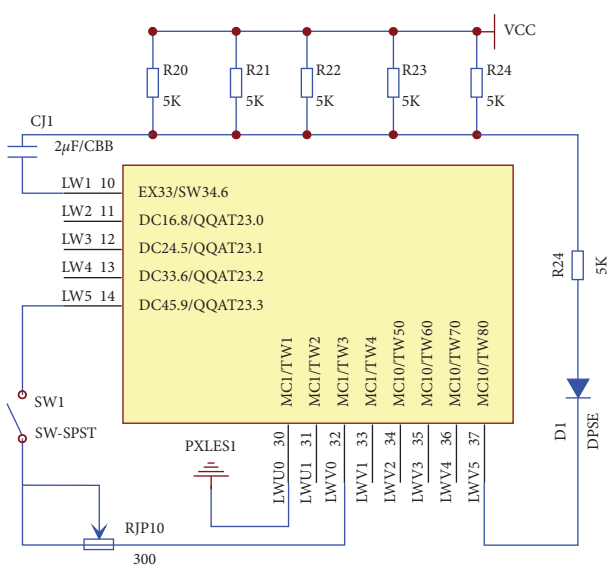
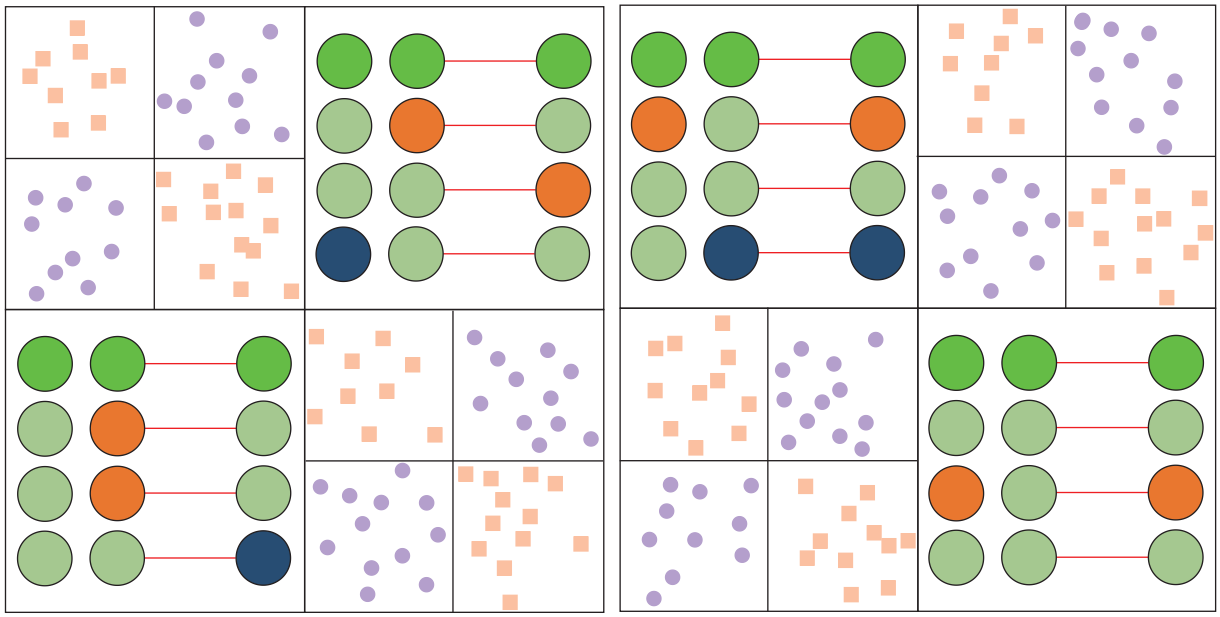


Figure 4: Frame extraction modules in the dissemination mode of AI-assisted radio and television.

production mechanism ensures the objectivity and accuracy of news information. The production and integration of data and the accuracy of big data algorithms have put forward higher requirements.

In the smart media environment, audience insight and data mining technology based on algorithms and big data have fundamentally affected the construction and development of the radio and television industry chains, and further established the important position of audience demand in the process of the reconstruction of radio and television formats. Media platforms use AI technology to analyze audience interests to achieve accurate content pushes, which has become an important feature of such information aggregation platforms. This kind of humanized service based on AI technology has the advantages of improving the effect of information dissemination, promoting the optimization and integration of information resources, and enhancing audience stickiness [18]. AI technology promotes the interactive development of media dissemination modes. Compared with traditional content platforms that push news information to the audience, interactive



(a) (b)

Figure 5: Computer vision and natural language processing (a) and semantic analysis and video generation (b) of the interactive applications and virtual reality in the dissemination mode of AI-assisted radio and television.

applications give audiences the right to choose news and provide audiences with more targeted information by means of data capture and resource integration. It caters to audiences' all-round and in-depth information needs through a question-and-answer method, innovating information dissemination logic and expression methods and enhancing the audience's sense of experience and leadership in obtaining information. AI technology brings more opportunities to the media industry in terms of news production, content collection, information distribution, and audience experience, while causing new problems and challenges, but this will not affect the development process of smart radio and television.

The core of virtual reality is to engage all the senses of the audience to enhance their sense of immersion and presence. In virtual reality news, audiences can immerse themselves in the news scene in a panoramic view, breaking through the limitation of the viewing angle of live television cameras, and can adjust the viewing angle according to their own needs and psychology, and then discover their interests in the news without having to accept everything unconditionally. Information, from passive acceptance to active participation, satisfies people's psychological needs for comprehensive understanding of objective information and a sense of existence in the process of understanding information. The advantage of radio and television dissemination assisted by AI technology lies in the higher quality and credibility of the dissemination content. Smart and personalized information and data services create a special news reading experience for audiences and improve audience participation and satisfaction. The establishment of an AI-assisted dissemination mode is the ultimate goal of future media development, which represents the stability of the relationship between audiences and the media. In this type of news, the creator's personal perspective is combined with the panoramic perspective, and the role of the audience is further derived from the observer to the participant, emphasizing the audience's individual role and first-hand experience of events and scenes. The first level is the change of dissemination and narrative, and the second level creates a new dissemination space.

5. Case Application and Result Analysis

5.1. Case Background and Research Design. The role of AI technology is realized with the help of specific algorithms. In the process of news recognition, AI technology can use semantic analysis, image processing, language processing, and other technologies to evaluate the information content, and the final evaluation result can be used for judgment. The value of news is feasible. With the support of AI technology, the interaction between an audience, algorithms, and content has truly been realized in news. With the powerful data analysis capabilities of AI technology, various algorithms have gradually penetrated the Internet platform and become an important component of news information dissemination. Multimodal audit technology is an important part of improving the quality of radio and television programs; at the same time, advertising is also an important part of AI multimodal auditing [19]. It means that relevant personnel use smart technology to disassemble the entire radio and television program content and complete the inspection in the form of text mode, image mode, and screen mode, such as determining whether the relevant segments in the program meet the specifications, whether the host uses inappropriate words, etc. During the auditing process, the AI technology can quickly intercept noncompliant content in programs, ensuring that the use of radio and television programs can provide positive guidance for residents. In

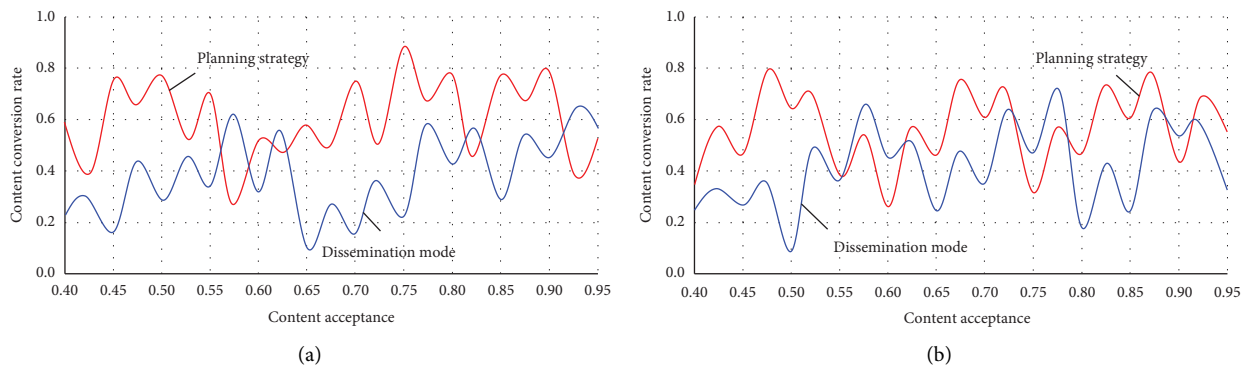


Figure 6: Relationship between content conversion rate and content acceptance in the planning strategies and dissemination mode of AI-assisted radio (a) and television (b).

contrast, AI technology, on the basis of data support, performs a series of tasks such as editing and arranging by simulating human work, improving the efficiency of program production (Figure 6).

Topic selection is the premise and foundation of radio and television planning. Only by realizing the innovation of topic selection can the innovation of the entire radio and television plan be driven. The audience's network usage behavior, page content, keywords, tags, etc. can all become an important basis for smart identification of audiences. AI-assisted radio and television can analyze the interests and hobbies of each audience through big data technology and push products that audiences may be interested in a targeted manner, which can greatly improve the possibility of audience experience. AI technology can use software programs to make the entire process of radio and television planning smarter and more digital. At the same time, it can automatically analyze colors, emotions, and experiences according to market goals, strategies, regions, and other conditions, and match the corresponding elements to automatically synthesize new radio and television plans. This kind of smart radio and television planning is of great significance for improving dissemination efficiency, shortening the cycle and reducing costs. AI technology reshapes the production mode of radio and television content is the basic content of AI technology to empower their media, which is conducive to improving the comprehensive operation efficiency of radio and television media. From the perspective of application logic, AI technology empowers radio and television media, which can effectively enhance the competitiveness of radio and television media, expand the influence of radio and television media, stimulate the innovation of radio and television media, and then help radio and television media achieve scientific and efficient, steady development.

5.2. Result Analysis. The relationship between radio and television and the audience has changed with the development of the times. Therefore, AI-assisted radio and television planning must meet the needs of the market, and the audience is the supervisor of radio and television assisted by AI technology. The integration of radio and television with new media can effectively promote the dissemination and exchange of information between media and the interaction between programs and audiences. This interaction is the best dissemination channel. AI-assisted radio and television must attract attention, and the spread of radio and television media is a two-way dissemination process. The media environment is the social situation faced by the radio and television media, which is the result of the joint action of the media audience, investors, and producers [20]. Compared with manual distribution of news, the biggest advantage of smart recommendation is that it can rely on big data to collect audiences' habits and hobbies and conduct in-depth processing of massive amounts of information content, using data to guide distribution and redistribution, making distribution more accurate. A good radio and television theme and content are on the one hand, and on the other hand, they need the approval of investors and audiences. Major television stations must do market research before program planning and know what form of programs the masses expect through research. The attention of investment customers, strive to be recognized by investors, and then ensure the quality of the program. Figure 7 shows the relationship between efficiency and speed of data capture for smart distribution, reception, and feedback in the dissemination mode of AI-assisted radio and television.

The media scene setting can have an important impact on the audience's acceptance of psychology and feedback behavior. The interaction of traditional media hosts is limited to a small number of invited or arranged audiences, and the real-time interaction of nonlive programs is rare, and most audiences play the role of observers or bystanders. In short, discourse power in the traditional sense of presiding over dissemination is firmly in the hands of the communicator. However, with the decentralization of the right to speak to the audience, the audience community has begun to transform into the audience community, and high interaction has become a rigid requirement for hosting dissemination, which is more vertical and subdivided (Figure 8). In addition, the warm and ceremonial scenes in the host's dissemination are the breakthrough for the host to get through to the real needs and emotional value of the audience. In terms of the objective psychological needs of everyone, experience is indispensable, and experience is

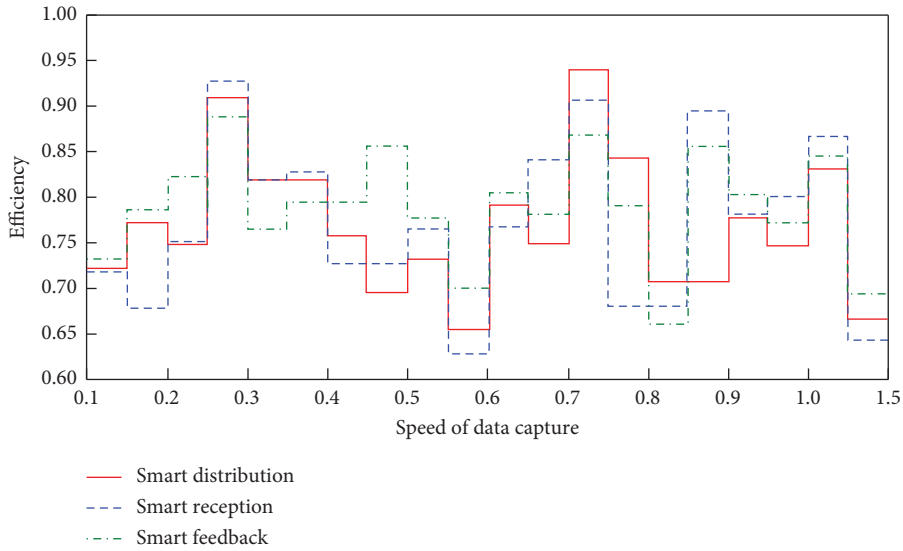


Figure 7: Relationship between efficiency and speed of data capture of smart distribution, reception and feedback in the dissemination mode of AI-assisted radio and television.

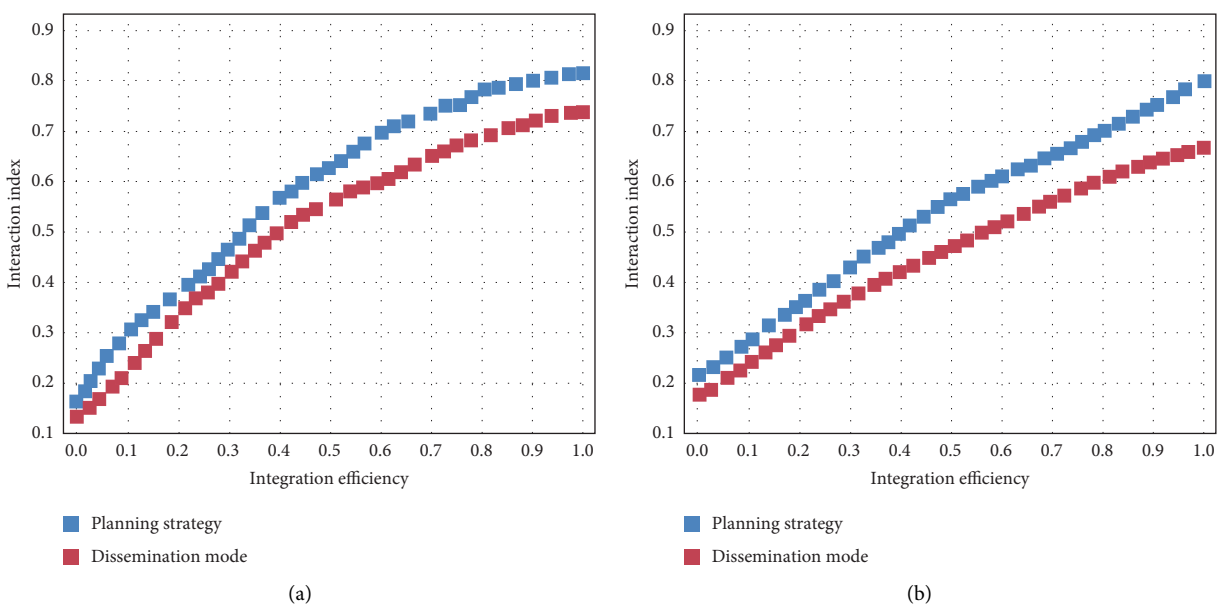


Figure 8: Relationship between interaction index and integration efficiency in the planning strategies and dissemination mode of (a) AI-assisted radio and (b) television.

often impressive. The introduction of experience determines the direction of the optimization and upgrading of host dissemination. The multifrequency and multiconnected experiential moderator dissemination, combined with the moderator's sincere and enthusiastic moderator attitude, can often enhance the sense of respect and trust between the communicator and the audience, and make the audience feel a high sense of participation and ownership. From the audience's point of view to a certain extent, it lacks a harmonious relationship with the audience to form a friendly interaction. Even if there is interaction, the interaction is not vivid enough, and the audience's recognition is not high [21].

With the assistance of AI technology, radio and television can carry out audience management, audience behavior analysis, audience rating analysis, advertising effect analysis, and data mining, so as to provide audiences with more accurate, personalized, and customized content, achieve a better audience experience, and get a better dissemination effect. The AI decomposes and splits the content through video recognition technology, labels each commodity element that appears in the content, and decomposes it into specific elements, that is, through semantic recognition, the advertising keywords in the characters' conversations are sorted out, and then assisted with content, presented to the audience [22]. These are not only part of the content but can

also be directly converted into advertisements, and audiences can buy them directly on television. At the same time, with the maturity of virtual reality technology, audiences can also experience the experience of using products. The platform can accurately identify the audience's information needs and make smart recommendations. Marketing is the key to increasing the market share of radio and television, assisted by AI technology. AI-assisted radio and television require efficient marketing strategies to publicize and promote, thereby increasing public attention and achieving the value of television, which can extract and discover information and make the recommendation more humanized and personalized, and more in line with the actual needs of audiences.

6. Conclusions

This paper discussed the content production, interview, and editing of radio and television, explored the review, archiving, and system solutions of radio and television, proposed the planning strategies for radio and television assisted by AI technology, analyzed the smart distribution, reception, and feedback of radio and television dissemination, discussed the interactive application and virtual reality of radio and television dissemination, analyzed the dissemination mode of radio and television assisted by AI technology, and finally carried out a case application and its result analysis. The syllables recorded by digital recording technology are converted into codes that can be recognized by computers through analog-to-digital conversion. The multifrequency and multiconnected experiential moderator dissemination, combined with the moderator's sincere and enthusiastic moderator attitude, can often enhance the sense of respect and trust between the communicator and the audience and make the audience feel a high sense of participation and ownership. In the content production system, AI technology can be used for smart lyrics, smart writing, smart dissemination, and smart translation. In the content publishing system, it can be used for smart recommendation, smart stripping, smart retrieval, and so on. With the powerful data analysis capabilities of AI technology, various algorithms have gradually penetrated into the media platform and become an important component of news information dissemination. AI technology can be used for smart lyrics, smart writing, smart broadcasting, smart translation, smart recommendation, smart stripping, smart retrieval, and so on. The AI-assisted radio and television planning gives audiences the right to choose news, provides them with more targeted news content by means of data capture and resource integration, and caters to audiences' all-round and in-depth information needs through a question-and-answer method, innovating dissemination logic and expression approaches, and enhances the audience's sense of experience and leadership in obtaining information. The AI-assisted radio and television dissemination mode has the advantages of improving the effect of information communication, promoting the optimization and integration of news resources, and enhancing audience stickiness.

Data Availability

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

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Research Article

Mathematical Model Design of the Traditional Dress Recognition Algorithm Based on Digital Watermarking Technology

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According to the characteristics of traditional clothing, clothing identification is studied, and clothing identification and clothing culture learning are effectively combined to find a new method for the inheritance of national culture and strive to make contributions to the inheritance of national culture. According to the requirement of the traditional garment identification watermark monitoring system, a self-synchronous digital watermarking algorithm is designed and implemented. Watermark is embedded in the time domain, and feature information is extracted from traditional clothing by means of mean filtering and replaced by watermark to achieve the purpose of embedding information. Blind detection is realized without the participation of the original image. The difference between the traditional costume embedded with watermark and the original traditional costume is almost imperceptible. It can effectively resist synchronous attacks including clipping and time shifting, showing good robustness. Imperceptibility and robustness can be adjusted freely by embedding strength. The HOG + SVM algorithm is applied to minority clothing classification and recognition. By comparing different classifiers, it is concluded that the classifier trained by the support vector machine algorithm has the best classification effect on ethnic clothing. In order to improve the classification effect, the classical algorithm of color, texture, and shape feature extraction was combined with SVM to conduct experiments on the clothing database collected and sorted out in Yunnan ethnic minority communities, and finally, we verified that the HOG feature combined with the SVM classification algorithm achieved good results in the classification of ethnic clothing.

1. Introduction

In the mining and analysis of traditional cultural data, it is urgent to interpret and annotate a large number of digital graphic data to improve the inheritance and innovative application of excellent traditional culture, and a large number of methods for rational organization and management of cultural resources have been proposed [1, 2]. However, compared with flowers, grass, trees, birds, clouds, mountains, and seas in natural scenes, the research objects in traditional cultural data have rich cultural connotations as their high-level semantics in addition to visual features and entity names. How to construct a set of large-scale and professional cultural resources tagging thesaurus has become a key problem that needs to be solved urgently.

Accurate and automatic extraction of garment contour is very important in the fields of content-based garment image retrieval and garment style recognition. The reason is that most of the clothes have printed patterns and have texture, while clothing images have natural shadows, uneven illumination, or artificial watermarks due to illumination. When the gray value near the contour of clothing with a printed pattern is similar to the background, texture noise will be generated when the contour is extracted. At present, garment design and production enterprises still use manual or human-computer interaction depiction to extract garment outline or style drawing. A fiber image segmentation algorithm combining K-means and the GVF snake model is proposed [3], and contour tracking is adopted to remove the burr of the contour. The so-called burr refers to an arbitrary curve segment of 1 pixel width, with only one end connected

to the contour. However, the texture noise in the garment contour is a concave curve, which is embedded in the contour curve and cannot be identified by contour tracking. Horizontal scanning of a garment style image is adopted to determine contour points [4]; that is, the garment style image with the background color removed is horizontally scanned from left to right line by line to locate contour points. This method can only be applied to simple clothing style images without textures and clothing parts. There is no relevant literature on other research of garment contour extraction.

Since the clothing pattern map has no color and texture, only the shape features of the pattern map image can be extracted. Three descriptors are used to describe the shape feature extraction, and the single scale wavelet Fourier descriptor is used for comparison. Then, the dimension reduction method of LDA is adopted. The feature data after dimensionality reduction were input, and part of the data were trained with SVM and ELM classifiers, respectively, and the performance of the classifier was tested with the remaining data. This paper designs a scheme of digital watermarking information encryption technology. After the watermark information is processed by the encryption algorithm designed in this paper, even if the attacker steals the digital works containing watermark information, it is difficult to decode it, so as to strengthen the security of digital watermarking products. At the same time, error correction code technology is added in the process of watermark information processing, which improves the stability of the system.

2. Related Work

Literature [5] uses the wavelet DFT transform method to embed the watermark into the image. The difference between the two is that the latter watermark is embedded into the dc coefficient of each block of DST transform, which uses the spread spectrum watermark method [6], and literature [7] also reported similar spread spectrum watermarking method with them. Literature [8] used first-order wavelet decomposition and a linear programming method to design an optimal watermark under visually perceptible difference closure (JND). Embedding watermarks in wavelet approximation coefficients are very straightforward and also accord with the principle of embedding watermarks in the most important data. Some methods of ACT domain spread spectrum watermarking can be used for reference directly. To embed the watermark into the wavelet detail coefficient, we carefully select the embedded sub-band, the embedded wavelet coefficient, and the intensity of the embedded watermark. As for the wavelet detail coefficients of each sub-band, their distribution is mostly in Laplacian distribution [9]; that is, except for a few coefficients, most coefficients are relatively small in value, and the watermark embedded in the detail coefficients is easy to be removed by high-pass filtering. In literature [4], watermarks are embedded in each sub-band coefficient of wavelet decomposition. By analyzing the perceptual significance, the embedding method adaptively selects the position of embedded watermarks and the embedding intensity in different sub-bands. Literature [10] used the multiscale characteristics of wavelet decomposition to embed a self-similar watermark into the first and second level detail coefficients of wavelet decomposition, respectively. A method of embedding watermarks in the wavelet coefficients of visual importance was proposed [11]. The algorithm searched for the coefficients of visual importance and embedded watermarks successively. A private and public watermarking algorithm based on wavelet transform was proposed [12]. The image and the watermark information to be embedded are decomposed by wavelet, respectively, and data are fused according to visual characteristics. In this method, the original image is required for watermark extraction. The latter is a special quantization of wavelet coefficients to embed information, and this method does not need the original image to extract watermarks. Combining watermarking technology into wavelet image coding can reduce the extra computational load caused by watermarking operation.

The data of traditional costume cultural resources are an important source for human beings to know the world and themselves and have high aesthetic value and inheritance value. However, due to the high professional threshold of annotation and interpretation, manual annotation is mainly relied on the basis of standard metadata at present. However, in some natural scenes in nontraditional cultural fields, scholars at home and abroad have performed a lot of exploration and research on image annotation methods combined with text and text mixing information [13], and the core of which is how to fuse multimodal information such as images and associated texts. At present, the annotation methods of mixed text and text can be divided into theme-based model, matrix model, text mining, deep learning, and so on. The method based on the topic model is a common method to fuse image and text features. This method regards labeled images as samples of a specific topic combination, where each topic is the probability distribution of image features and tag words. Typical algorithms include LSA [14] and LDA [15]. Matrix model-based methods mainly include the proposed CCA model and the proposed DCCA model. The core is to build a fusion consistent space of image semantic features and text features [16]. However, the most representative method based on text mining is the method of word extraction based on associated text with different weights of images. Detection technology based on digital image processing has been increasingly mature in the field of textile, but the application in the field of clothing is very little. Now, clothing technologists have found that digital image processing can reduce the influence of human factors. For example, digital image processing and pattern recognition technology were used to study the identification and classification of garment sewing process defects so as to realize the automatic detection of garment defects [17]. The sample image of a men's shirt was collected by taking photos, and the image was enhanced and denoised; then, the min value was segmented. Specific detection algorithms are designed for single line trace and double line trace and

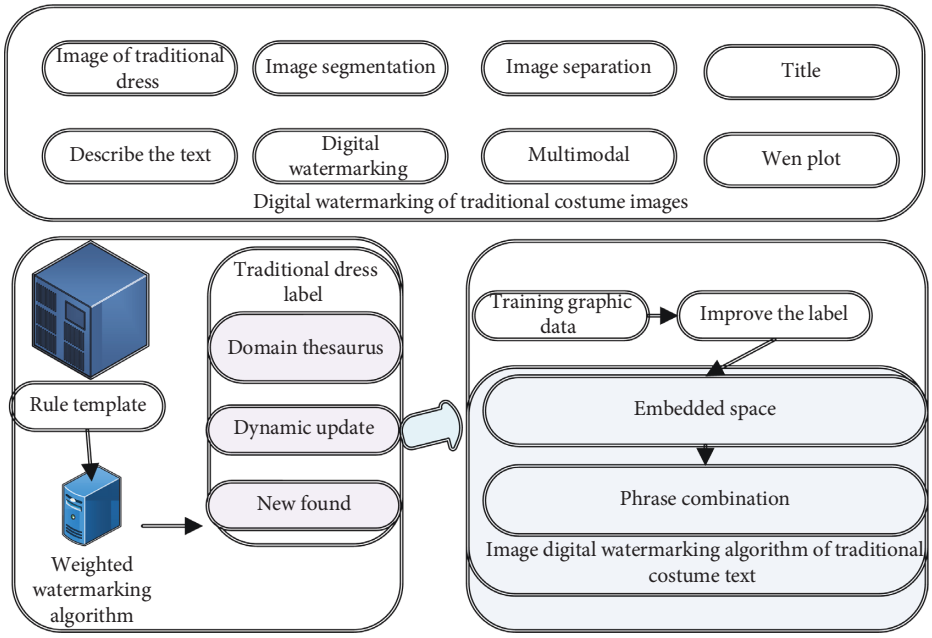

Figure 1: Structure diagram of the traditional costume text-plotting algorithm with text and text mixed arrangement.

symmetry feature, respectively [18]. The image of lining rubber particles was preprocessed, and the image morphology was analyzed. In order to digitally describe the visual effect of garment surface wrinkles, an evaluation index system based on the gray scale was proposed by processing garment surface wrinkle images [19]. Clothing image segmentation methods can be divided into methods using the clothing model and methods without the clothing model. For the model approach, it is generally required to train a sample of tagged clothing and then compare clothing extracted from the image with the model. In an attempt to achieve the detection of dressed personnel through the classification based on the segmentation region of color clothing, a probability model of a tree structure is established for efficient retrieval (the retrieval speed of the human body shape region combination block is faster than that based on pixels) [20]. This structure represents the symmetrical parts of the human body in the form of functions, including relative position, relative size, and connection. However, someone in formal dress is not as easy to identify as someone in a bathing suit. Obviously, the recognition of personnel cannot be achieved through a single-tree structure [21]. However, the feature extraction area is often very rough segmentation, and the difficulty of segmentation is due to clothing and other items highly associated, such as personnel. To overcome the problem of unconstrained posture, a segmentation method based on a mass component detector was proposed. This method can divide the image of the person into the upper and lower clothing areas, while taking into account the posture of the person [22]. For each part, they learned the person's posture by segmenting the model, A method of skin detection and clothing selection based on color is proposed [23] to achieve automatic segmentation of clothing area. To achieve both ends, color description extraction is achieved through an iterative energy minimization approach and an automatic initialization strategy through learning geometric constraints and shape cues.

3. Traditional Costume Recognition Algorithm Based on Digital Watermarking Images and Text Mixing

3.1. Traditional Clothing Recognition Algorithm. This paper focuses on clothing, clothing patterns, and other categories. In order to facilitate the multimodal text mapping of the layout image, it is necessary to identify the image and its associated text and other information in the page accurately. In format recognition, problems such as extracting text, distinguishing and locating title and text, and relocating format multiple times are solved. This algorithm refines the position and image scale level and automatically identifies data bodies such as images, location titles, and text descriptions in books in the field by using spatial relations. The structure of the graph algorithm is shown in Figure 1. The pattern recognition module is responsible for automatic detection and extraction of image, text, and associated text in text and text data and providing basic data for the text-plotting algorithm. In Figure 1, the traditional cultural pattern semantic label library module provides semantic metadata and domain dictionary for cultural domain image learning annotation and provides domain expert knowledge through multi-modal text mapping algorithm aggregation. The multimodal text rendering algorithm module makes full use of multimodal association information, semantic annotation system, and domain knowledge to extract and annotate image semantics.

There are potential relationships between images of traditional costumes: there are dragons on dragon robes, and

Table 1: Traditional clothing image label system fields.

Field	Field definition
Traditional dress	It covers the traditional national costume patterns of all Chinese ethnic costumes
Pattern/name	The name of the pattern is generally designated by the field experts, such as the dragon pattern, honeysuckle pattern, and triangle pattern
Moral	The cultural connotation carried by the patterns is generally determined by people's living environment and humanistic beliefs
Configuration	Geometric composition of the configuration, such as symmetry, continuous quadrilateral
National	People associated with ornamentation
Regional	A local area associated with an ornamented pattern
Ages	The period of the ornamentation
Color	The color characteristics of the pattern
Arts and crafts	Design of the clothing using technology and art techniques

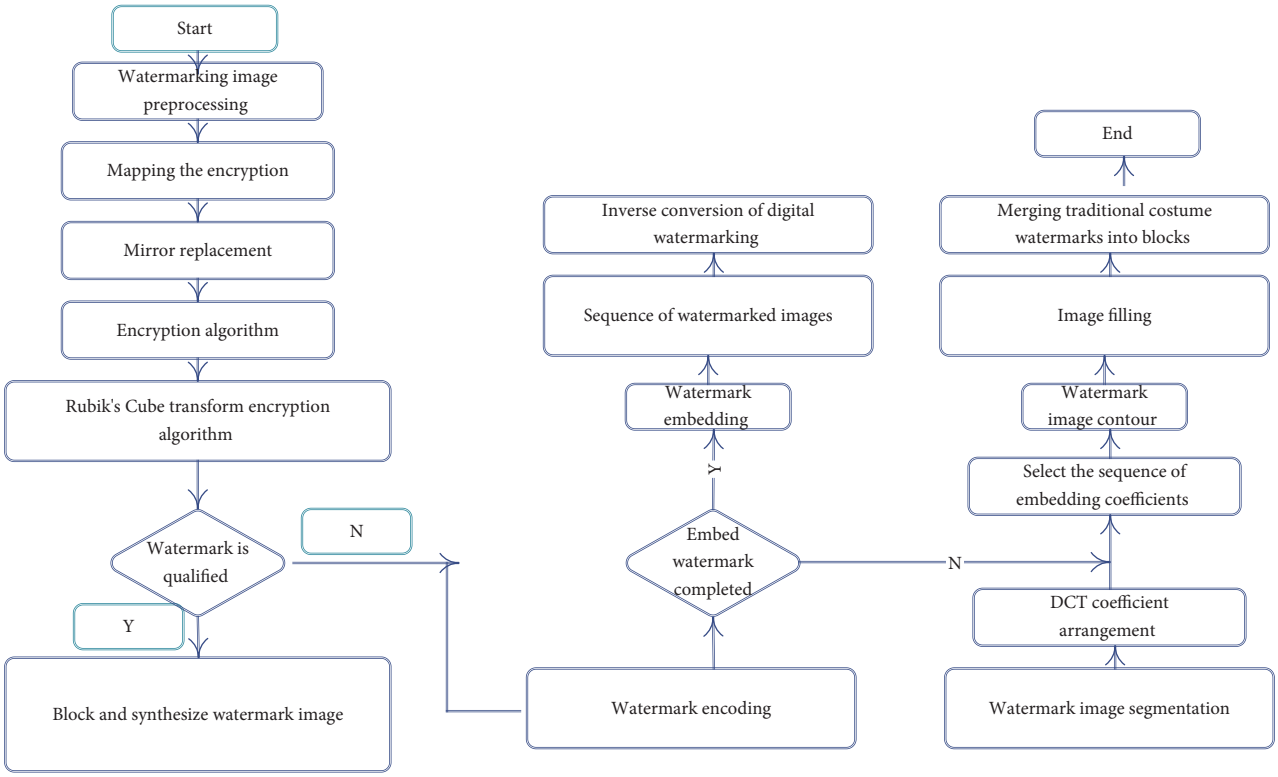

Figure 2: Flowchart of traditional costume recognition based on image scrambling encryption watermarking.

there is a high probability of auspicious clouds around dragons. Based on domain expert knowledge, this kind of association is extensively explored so that the label system can fully reflect the cultural value of clothing. The fields of the semantic label system of traditional clothing images are shown in Table 1.

3.2. Extraction of the Traditional Clothing Style Map. For the garment image with printed patterns, the point whose gradient value is greater than a certain threshold cannot be simply selected as the contour line. To this end, it is necessary to remove the points and wrinkles caused by wrinkles and printed textures in the collar, sleeve, pocket, front, and other parts of the garment by morphological method. The block diagram of the initial contour extraction algorithm is shown in Figure 2, which can also be further described by the algorithm in Table 2.

In the test, we selected two points, namely (1, 1) point and (0, 2) point, and the watermark intensity parameter $a = 0.5$. 450 random Gaussian sequences were selected, including two sequences of 150 and 350 points. The detection results are shown in Figure 3, indicating that the embedded watermark information can be correctly detected at this time.

4. Traditional Costume Culture Pattern Recognition Algorithm Based on Digital Watermarking

How you extract the domain vocabulary is key to building PatternNet. There are a large number of professional terms

Table 2: Initial contour extraction algorithm.

Enter: clothing image
Output: initial outline
(1) After the original image is transformed into a grayscale image, the Sobel operator is
used to detect the horizontal and vertical edges of the image
(2) Using structural elements to perform expansion operation on the image
(3) Image filling operation
(4) Use structural elements to carry out corrosion calculation on the image
(5) Extract the initial contour

and words with special cultural meanings in graphic books, such as "Qiuci dress," "grass pattern," "cao eating pattern," and "vortex pattern." It is difficult to cut and extract more accurate professional terms in the cultural field with the help of the current classical word segmentation tools. Therefore, this paper takes annotations by field experts, historical documents, professional books, and other materials as data sources. After digital collection, more than 4000 pictures and texts are obtained through cleaning and sorting. Then, guided by the traditional clothing image label system, the field terms of name, meaning, configuration, nation, age, region, color, arts and crafts, and other fields are described to build PatternNet. In order to enrich the domain vocabulary, first, we expand the number of books collected and sorted manually and introduce Word2vec to extend the synonyms of the initial domain vocabulary. Finally, the semantic label library oriented to domain specialty is constructed through iterative optimization. PatternNet is built without aggregation reuse of the information up front, instead using a dynamic update pattern to accommodate more usage scenarios. To some extent, it solves the problem that automatic tagging requires a large number of text and text tagging samples and provides basic data and technical path for the construction of domain professional corpus. With the iterative optimization of the dataset, a cultural image semantic tag library with resource association and semantic association can be realized. This paper focuses on the combination of graphics and textbooks of clothing and patterns, and the keywords of each category are shown in Table 3.

Before the SVM classification method is used to classify the clothing style map, digital attributes (characteristic parameters) are normalized to the interval of "0, 1." The main advantage of normalization is to avoid the digital attributes in the larger range dominating the digital attributes in the smaller range. This normalization also improves the efficiency of fashion pattern classification by limiting the problem of large kernel computation caused by large number ranges. The classifier takes the shape feature (invariant moment) of the garment pattern diagram as the input and the category label of the garment pattern diagram as the output.

$$\min\left(\frac{1}{2}w^T w\right) + C\sum_i \delta^2. \tag{1}$$

In the construction of style diagram classifiers, radial basis kernel functions are used as follows:

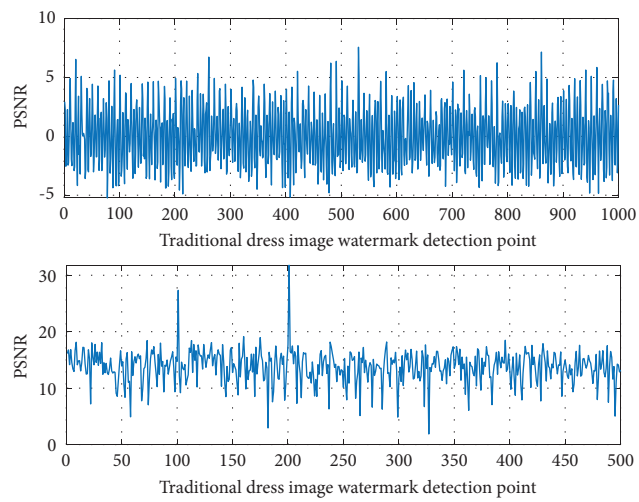

Figure 3: Detection results of each embedded bit information of the two points.

$$T(x, y) = e^{-g\|x-y\|^2}. \tag{2}$$

In the experiment, different gradient operators were compared to carry out convolution operations on the image, and finally, the one-dimensional centrosymmetric template had the best effect. After the convolution operation on the image, the gradient components in horizontal and vertical directions can be obtained as follows:

$$T(x, y) = T(x+1, y) - T(x, y+1). \tag{3}$$

For a good image, the authentication system generally needs to meet six aspects.

Sensitivity: sensitive to malicious data manipulation

Robustness: ability to withstand operations such as lossy compression or other operations that do not destroy data content

Security: embedded information cannot easily be forged or manipulated

Mobility: the ability to directly verify the integrity of obtained multimedia data without having to send additional authentication data

Location performance for tampered regions: the ability to locate tampered image regions

Repair of tampered data: the ability to repair tampered data

A $256 * 256$ degree Lena graph is used to test the robustness of the watermarking algorithm. The results are shown in Table 4.

5. Example Verification

A clothing 140 database is adopted in this experiment, which contains clothing style maps of 7 categories, and each category contains 20 pictures. The invariant moment of each sample is calculated according to the method. The first 10

Table 3: Partial keywords of domain thesaurus.

Category	Keywords (part)
Grain appearance	Geometric pattern, plant pattern, figure pattern, animal pattern, sun, moon and stars pattern, totem pattern
Moral	Happiness, longevity, festival, abundance, good, peace, wealth, many children, into school, official
Configuration	Independent (single pattern), continuous (continuous pattern)
National	Han, Zhuang, Uygur, Miao, Manchu, Hui, Tujia, Yi, Mongolian, Tibetan
Regional	Central plains, Wuling, Shaoling, Jiangdong, Hedong, Kansai, Sanqin, Huguang, western regions, Jiangbiao
Ages	Primitive society period, Xia and Shang, spring and autumn and warring states, Qin and Han, Wei, Jin and southern and northern dynasties, Sui and Tang, five dynasties and ten states, two Song dynasties, Liao, Jin, Yuan, Ming, and Qing dynasties
Color	According to the traditional color spectrum of clothing, the main colors and intermediate colors are divided into categories, such as yellow, and divided into dragon robe bright yellow, color painting realgar, old paint yellow, Beijing embroidery beige
Arts and crafts	Flat embroidery, random needle embroidery, seed embroidery, lock embroidery, pan gold embroidery, patch embroidery, double-sided embroidery, hand push embroidery, pearl embroidery, hair embroidery, horsetail embroidery, tin embroidery, Su embroidery, Guangdong embroidery, Hunan embroidery, Shu embroidery, three blue embroidery, ink embroidery

Table 4: Watermark robustness test results of the 256 ∗ 256-level gray Lena image.

Operations on images	1024 error bits	Error rate
JPEG compression (mass factor) = 0	112	11.05
JPEG compression (mass factor) = 5	85	8.03
JPEG compression (mass factor) = 10	53	4.97
JPEG compression (mass factor) = 15	38	3.54
JPEG compression (mass factor) = 20	26	2.43
JPEG compression (mass factor) = 30	13	1.35
Mosaic treatment	9	1.07
Image smoothing	34	0.34
Image Gaussian smoothing	3	3.45
Image sharpening	12	1.06
Enhanced image sharpening	16	1.32
Add evenly distributed noise	32	3.05
Add Gaussian distributed noise	12	3.78
Histogram equalization	16	1.25

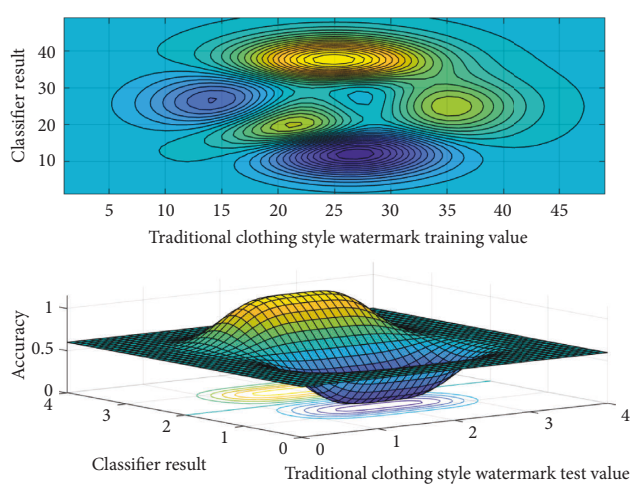

Figure 4: Results of rough parameter selection for clothing140 database cross validation.

samples of each category were used as the training set, and the last 10 samples were used as the test set. By using the

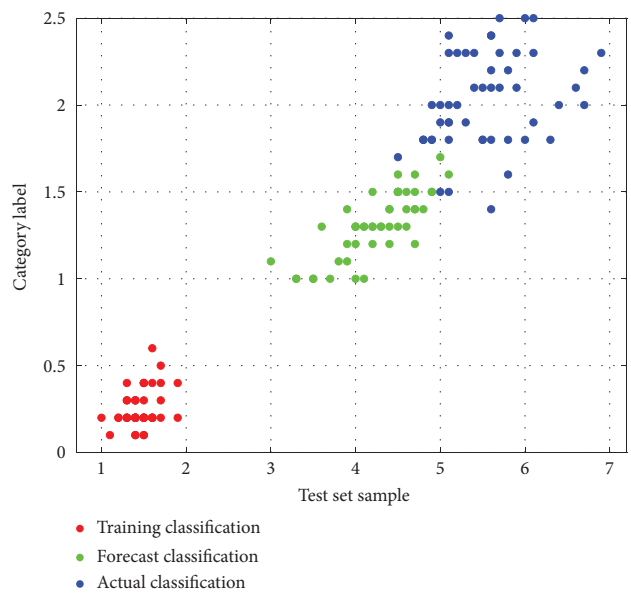

Figure 5: Classification result diagram of the clothing140 database test set.

method of cross verification, a rough parameter selection result figure for the RBF kernel support vector machine classifier is first obtained, as shown in Figure 4.

The optimal parameter of fine selection is (1, 64). An SVM (support vector machine) classifier was used for classification. The classification results obtained are shown in Figure 5. The classification accuracy reached 80%; that is, 56 samples in the test set (70 samples) were correctly classified.

After data collection, different ethnic groups were classified and numbered. In this paper, 100 pictures of each ethnic group were selected as sample data and numbered from 1100 to different folders, respectively. In order to facilitate MATLAB operation, the pictures were processed in pg format with a size of 96 ∗ 144 (see Figure 6).

SVM was combined with the classical feature extraction algorithm for the experiment. Parameter selection of the

Figure 6: Traditional dress sample library.

Table 5: Accuracy of different image features under SVM.

Feature	Classifier	Accuracy (%)
Pixel	SVM	94.43
CH	SVM	94.21
LBPu (8, 1)	SVM	94.88
LDP ($k = 3$)	SVM	33.23
LLCM	SVM	80.12

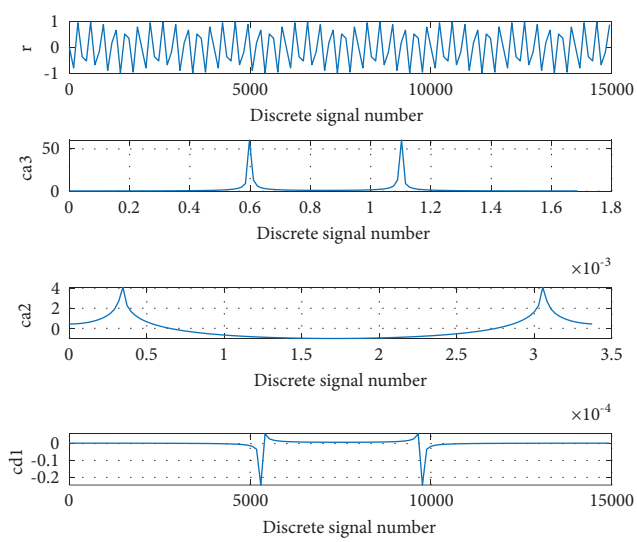

Figure 7: DBL wavelet digital watermarking decomposition of traditional clothing.

feature extraction algorithm was based on the research team's previous experiment on the feature algorithm of ethnic clothing images. The experimental results are shown in Table 5.

Figure 7 shows that the signal uses DBL wavelet three-stage decomposition, which consists of three levels of detail wavelet coefficients and third-order approximate wavelet coefficients.

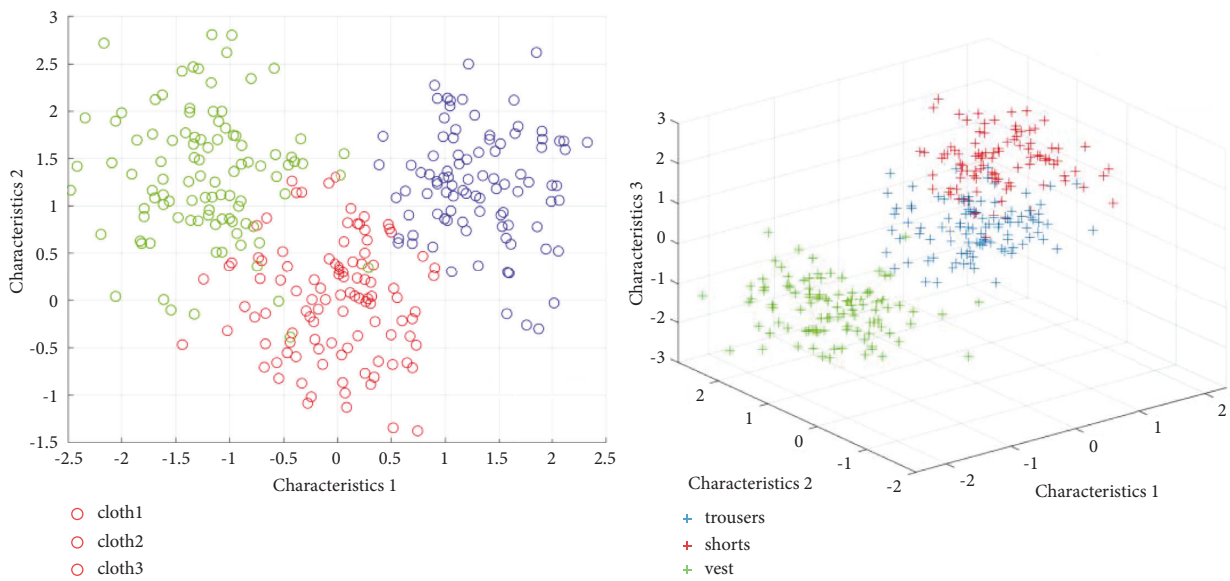

Figure 8: Visualization of traditional clothing style drawing samples projected into a two-dimensional space after dimensionality reduction by PCA.

In this experiment, the samples described by FD 120 are projected into a two-dimensional space through LDA and PCA, respectively. Figure 8 shows the visualization result of projecting the sample of the traditional clothing pattern into a two-dimensional space after PCA dimensionality reduction. As can be seen from Figure 8, interclass crossing occurs in many places except for trouser and cloth 1 categories.

6. Conclusion

The security of ciphertext is enhanced through multiple iterations. The practical effect of the encryption scheme is verified by relevant experiments. Watermark information of different properties can be transformed into a two-dimensional data matrix by dimensionality enhancement or dimensionality reduction to apply the algorithm. To a certain extent, the efficiency of the algorithm will be affected. In the future, the development direction of scrambling technology should be to find more excellent scrambling effects and less resource consumption. In addition, the simulation results show that the quality of the original digital works will be affected in the process of embedding watermark information. The embedding position, the amount of embedded watermark information, and the intensity parameters will affect the original quality of the carrier works to varying degrees, which must be considered in the practical application of digital watermarking technology. By comparing the classical feature extraction algorithm and the classification algorithm, HOG + SVM is applied to the classification of minority clothing. Taking Hani, Kan, and Yi nationalities as examples, this paper conducted experiments on the classical algorithms and classification algorithms of clothing color, shape, and texture features and verified that the gradient information of traditional clothing was well represented in the clothing database. Combined with SVM, the best classification effect was obtained. In the next step, texture features were divided into global texture and three local textures: collar, front flap, and hem. Wavelet moments were used as global or local texture feature descriptions. Shape features and various texture features were optional combinations, and some style maps that cannot be retrieved by shape and global texture alone will be found [24–26].

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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Volume 2023, Article ID 9859278, 1 page
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Retraction

Retracted: Evaluation Method of Vocal Music Teaching Quality for Music Majors Based on the Theory of Multiple Intelligences

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] D. Li, "Evaluation Method of Vocal Music Teaching Quality for Music Majors Based on the Theory of Multiple Intelligences," *Mathematical Problems in Engineering*, vol. 2022, Article ID 3353776, 11 pages, 2022.

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Research Article

Evaluation Method of Vocal Music Teaching Quality for Music Majors Based on the Theory of Multiple Intelligences

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The quality evaluation of vocal music teaching for music majors is of great significance to music education. Based on the theory of multiple intelligences, this paper constructs a model for evaluating the quality of vocal music teaching for music majors and introduces the theory of multiple intelligences into the operation form, design requirements, and recommended lesson examples of music teaching unit design. The experimental data and questionnaire data collected by the model verify that this operation is beneficial to the improvement of students' music listening scores, vocal music comprehension scores, and total scores and solves the quantitative problem of vocal music teaching quality evaluation. In the simulation process, the engineering testing and analysis method uses the correlation rate and correlation strength as the analysis indicators, comparing the platforms for the quality evaluation of vocal music teaching in music majors and the corresponding quality evaluation data preprocessing process. The experimental results show that the algorithm performance evaluation is carried out based on the three aspects of quality evaluation association rules, algorithm running time, and algorithm memory consumption. The multiple intelligence algorithm is applied to vocal music teaching analysis of association rules for quality evaluation: when 4000 tasks call for 20–40 virtual resources, the total time spent is reduced by 61.7%, which has a significant positive effect on the knowledge expansion and ability improvement of music majors.

1. Introduction

The introduction of multiple intelligence perspectives in the unit teaching design of music conforms to the requirements of the new music curriculum standards, which can not only provide students with more opportunities and directions to participating in music learning [1] but also provide students with more perspectives to design and organize teaching. The introduction of foreign advanced theories into regional educational practice has always been a general trend [2], and how to operate and verify its specific impact and role in the process of introduction is of great significance [3–5].

At present, most of the papers involving quantitative research involving the application of multiple intelligences theory to teaching start with the measurement of multiple intelligences and then design experiments to verify the validity of the theory [6]. The experimental results include improving the multiple intelligences of the data [7]. Action research is used in some papers [8], and it is more inclined to cautious attitude [9–11]. Multiple Intelligences Theory is a very good perspective for organizational education, but it is not necessarily an educational purpose [12]. Both knowledge and technology are students' learning content, and the flexible and effective use of knowledge and technology is an important learning goal for students [13]. This theory urges educators to better understand and pay attention to the individual differences of students, and promote education through more perspectives and strategies [14]. The introduction of music teaching will definitely reform some of the stereotyped status quo in education and teaching [15–17]. The research of Devaney [18] is conducive to enriching students' music learning experience, improving their comprehensive musical literacy, and having the opportunity to access more ways to achieve learning and improve their enthusiasm for learning. Jiang [19] created various scales to measure multiple intelligences. Li [20]'s work has greatly

enriched scholars' and students' understanding of students' intelligence performance. In the introduction process of the previous research papers on the guidance of multiple intelligences theory in teaching practice, Magraner [21] first designed a selection intelligence scale, mastered students' dominant intelligence, and designed teaching according to their dominant intelligence. Subsequent tests of the effectiveness of the teaching experiments included improvements in the Student Intelligence Scale data [22]. This operation is not endorsed by the proponents of the theory. What is more respected is to record the performance of students in various aspects of multiple intelligences, and to issue students' development reports based on the records [23].

This paper takes music students and music teaching as the research entry point and constructs a quality evaluation model of vocal music teaching for music majors. The first is to determine whether it is feasible or feasible to introduce the theory of multiple intelligences into the specific teaching practice of music. If you have any requirements, give a recommended lesson design; then, through the design and implementation of teaching experiments, verify whether the music unit teaching design is meaningful in the perspective of multiple intelligences from the perspective of students, and the challenges encountered in the design of music unit teaching from the perspective of multiple intelligences theory and the enlightenment of this operation to teaching.

2. Theoretical Analysis of Multiple Intelligences

2.1. Multiple Intelligence Levels. The multiple intelligence module mainly realizes the following functions, user management and authority management. In cloud technology, GCE resources are divided into two parts with fundamentally different potentials-server and client. The user management module is mainly used by the system administrator to manage the basic information of users, including adding user information, removing user information, and modifying user information $a(i)$, as well as assigning permissions to users. When the "Add User" button $1 - a(n)$ is clicked, the btnListAdd Click() event will be triggered, and an additional page for managing users will pop up on the main interface, where the system administrator can add the user's basic information $s(t) + v(t)$. After the administrator fills in the information, click the "Add" button, trigger the btnAdd Click() event, and call the Proc GetUserInfo stored procedure to add the users.

$$\sum_{i,j<t} a(i) - a(i-1) - \sum \frac{1 - a(n)}{a(n-1)} = \frac{1}{A}, \frac{s(t) + v(t)}{ds} - \frac{s(t) - v(t)}{ds} = 0. \tag{1}$$

In the first principal component $g(a, b)$, the coefficients of each index variable are close, the values are not much different, and the load $\exp(a)$ is close. We call the first principal component the comprehensive intelligence factor $v(b)/v(r)$. This principal component can be regarded as an evaluation of students' learning effects. It can be seen that the contribution rate of the principal component to the overall is the largest (33.125%), indicating that the principal component has a strong ability to comprehensively index $v(a + b)/v(r)$.

$$\min g(a, b) = \begin{cases} 1 - \exp\left(1 - \left(\dfrac{a}{2\ d}\right)\right) \\ 1 - \exp\left(\dfrac{1 - b}{2a}\right) \end{cases}, \tag{2}$$

$$G(a, b, r) = \frac{\sum_{i,j<p} v(a) + (v(b)/v(r))}{\sum_{i,j<p} v(a + b)/v(r)}.$$

This refers to a set of values used to distinguish the relative importance of each indicator in the indicator system and to characterize the relationship between the indicators, revealing the difference in the impact value of the corresponding factors on the indicator system. The determination of the weight is an important factor to ensure the scientific and accurate evaluation system, and the weight has a strong guiding function. When determining the weights, the integrity of the weights $d(a)$ (the value of each indicator in the system and its contribution to the system), objectivity $1 - n$ (the actual status of the indicator in the system), and space-time $p(a, b)$ (the certainty and variability of the weights) should be considered.

$$\begin{gathered} \frac{\sum_{i,j<p} d(a) + d(b) - d(c)}{1 - n} < 1 - a, \\ \sum_{i,j<p} \frac{k(a/i + b/i)}{k(r)} < 1 < \sum p(a, b) - k(i)k(j). \end{gathered} \tag{3}$$

The multiple intelligence evaluation index system is a complex multi-factor system with many evaluation indexes and each index is an indispensable aspect of the evaluation elements, but the influence of each index $k(i)$ on the evaluation system is not equal. Therefore, it is necessary to distinguish the contribution of each index to the overall quality of the evaluation by setting weights. Grid and cloud technologies provide users with problem-oriented algorithmic services that use only a fraction of the overall computing potential of GCE, which cannot meet the need to scale large-scale processing systems for exponentially growing traffic and globally distributed amount of information.

There are many ways to determine the weights of the indicators. Due to the difference between the evaluation objects $v(x, y)$ and the survey objects, there are certain limitations. This paper adopts the Delphi method to determine the weight coefficients $w(x, y)$ of each evaluation index $g(x, y)$.

$$\begin{gathered} v(x, y) = [c + w(i + v * j)] * w(x)w(y), \\ g(x, y) = \frac{[g(a) - g(b)]}{g(x, y)} - \frac{[g(i) + g(j)]}{1 - g(x, y)}. \end{gathered} \tag{4}$$

The distribution of the support degree of the quality evaluation data is presented as "tailing index distribution," and the darker the color, the greater the support degree value

of the quality evaluation item. Some of the popular exact algorithms use exact enumeration, implicit enumeration, branch and bound, cut plane, and dynamic programming. Figure 1 performs logarithmic operation on the maximum support degree of the entire quality evaluation data to obtain m, and then divides it into n intervals on average to form a stepped distribution of the target data area.

Unit instructional design means that students, as instructional designers, start from the perspective of a chapter, theme, or unit, make comprehensive use of various teaching strategies and teaching forms, and carry out a reasonable period of time according to the needs of a reasonable amount of knowledge, organizational systems, and learners' needs for effective learning (not limited to one class hour) teaching plan, allowing learners to complete the learning of a relatively complete unit of knowledge or experience in certain steps to achieve preset goals. All students can get task evaluation points, for example, +5 points for completing each random check, and 15 points for not completing each test; the actual score of each test is converted into process evaluation points as follows: more than 80 points will be divided into +20 points, 60–79 points are rated as +15 points, 40–59 points are rated as +10 points, and below 40 points are rated as +5 points.

2.2. Vocal Teaching Test. Through the evaluation of the 8 items of vocal music teaching, students' ability to solve practical problems can be observed from many aspects of students' participation in teaching activities, which can not only reflect the development level of students' intelligence but also judge the students by measuring students' data in real situations. To further evaluate the process of students' intelligence development, the author expounds on the hierarchical teaching system of the basic multiple intelligences theory from five aspects: evaluation principle $x(i)$, evaluation standard $x(i-1)$, evaluation example $y(i)$, evaluation effect $y(i-1)$, and evaluation reflection $1-i$. Ask students to identify the image, and then describe it; ask students to imagine the corresponding process description to form an image, make process diagrams and diagrams, and then describe it: through the students' vision. A motion cannot be implemented in the current iteration as long as it is in the taboo list, so revisiting the algorithm can be avoided since it visited the solution during the last few iterations, which helps prevent the algorithm from converging to a local optimum.

$$\left(\frac{\sum_{i,j<p}\sqrt{x(i)+x(i-1)}-i}{1-i}\right)<1-\sum 1-y(i),$$
$$\left(\frac{\sum_{i,j<p}x(i)-y(i)-i/1-i}{1-i}\right)=1-\sum\frac{1-y(i)}{1-i}. \tag{5}$$

After the compression function $x(i)-y(i)$, the data area is divided into 10 "equal-width" areas. If there are no data points in some "equal-width" areas, the number of "equal-width" areas will be reduced to 9, and so on there are data points in the "equal width" area. For example: after the compression function, the data area $v(i,k)$ is divided into 5 areas A, B, C, D, E, but there is no data point in the area D, then the "equal width" is recompressed to form 4 areas A, B, C, D, and the 4 areas all contain data points $w(a,b)$, then the area division $v(i,j)$ ends.

$$v(i,k)=\left\{1-\frac{1}{m-1}\sum_{i,j<p}v(i,j)\frac{1}{m}\sum_{i,j<p}\frac{v(i,j)}{v(k)},w(a,b)=1-w(1-a)-w(1-b).\right. \tag{6}$$

In order to improve the adaptability $w(1-a)$ of the algorithm to unknown data, the support value of each item is used as an independent variable, and its logarithmic value is used as the standard for dividing the "equal width" area. Compared with the method of averaging the difference between the maximum support degree and the minimum support degree $v(i)/d(i)$.

$$d(i,j)=\operatorname{sig}\operatorname{mod}(i-j),\text{for}\left\{\frac{v(i)}{d(i)}-d(j)\right\},$$
$$1-\sum\frac{1-r(i)r(n)}{1-r}-\sum\frac{1-d(i)d(n)}{1-d}\subseteq C(r,d). \tag{7}$$

Research on association rule mining algorithm for vocal music teaching quality evaluation $r(i)r(n)$ based on swarm intelligence will integrate swarm intelligence into association rule mining method $1-d$, and realize the application and extension $C(r,d)$ of swarm intelligence theory to engineering practice. To further analyze the characteristic laws of their respective algorithms, the association rule mining parameters are configured the same (the minimum support is 0.01, and the minimum confidence is 0.05), and the parameters of the A1 algorithm, A3 algorithm, and A2 algorithm are configured to the same scale and magnitude (the number of units in the A1 algorithm is 40, the number in the A3 algorithm is 40, the number of probes in the A2 algorithm is 20, and the attack range is 9), Table 1 has iterations from 100 to 400 with an interval of 100.

Referring to the above for the computer hardware platform of the test experiment, continuously extract 12-week quality evaluation data through the network management system, and divide it into three groups. The first set of data is used as engineering training data, and the remaining two sets of data are used as engineering test data. The first group of quality evaluation data was intercepted according to the time window of 2 seconds and the sliding window of 1 second. There are two general types of barriers: static barriers and dynamic barriers. The obstacle is static if it

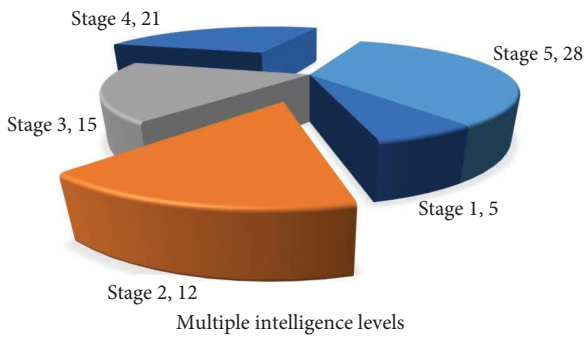

Figure 1: Multiple intelligences data region hierarchy.

Table 1: Vocal teaching test.

Vocal unit	Interval	Standard deviation	Mean value	Mean square error
Range 1	100	0.13	0.38	0.29
Range 2	200	0.01	0.30	0.06
Range 3	300	0.86	0.29	0.35
Range 4	400	0.43	0.24	0.24
Range 5	500	0.49	0.27	0.03
Range 6	600	0.97	0.59	0.13

does not change form and position for a period of time; otherwise, the obstacle is dynamic.

Combined with the network quality evaluation data, the performance test (the relationship between node size, iteration times, and the number of association rules, the relationship between the distribution of node types and the total number of association rules, the performance comparison between A2 and Apriori algorithm) and engineering test (association rate, association strength), the application of A2 algorithm in process thinking and engineering shows the characteristics of global optimization and low resource consumption of swarm intelligence method.

2.3. Quality Evaluation Clustering. The evaluation method and evaluation standard of the intelligent model is not only an important part of measuring the quality of the algorithm but also provide an effective way of metric analysis. To evaluate the overall performance of the swarm intelligence association rule mining algorithms, the above algorithm performance indicators and engineering indicators are quantitatively evaluated at equal intervals.

The maximum value and the minimum value in the two most values are equally divided into four areas, which are assigned as 1, 2, 3, and 4, respectively. For example: under the condition that the number of iterations is 300, the running time of the A1 algorithm, A3 algorithm, and A2 algorithm is 18 s, 4s, and 29 s, respectively, the maximum value is 29 s, the minimum value is 4s, Table 2 divides it into four equally spaced regions (4, 10.25, 16.5, 22.75, and 29) and assigns the values to 4, 3, 2, and 1; in turn, then the corresponding evaluation values of the A1 algorithm, A3 algorithm, and A2 algorithm are 2, 4, and 1.

This module is mainly to complete the customization of students' teaching evaluation indicators and the maintenance of the indicator library. The administrator selects the indicators to customize the evaluation model, enters the model name for the evaluation model, and stores it in the indicator library for easy selection. The administrator can add or delete indicators for the existing models in the model library as required to achieve the desired effect. Customizing the different evaluation models, it can meet the evaluation needs of different teaching. In the swarm intelligence association rule mining algorithms, the association rate can reach more than 60% under the same parameter configuration. The resulting cluster from this case will also include the arrangement of nodes. Thus, we can see whatever route the salespeople themselves take as a cluster, and the total number of salespeople represents the number of clusters that will be generated.

Under the condition that the number of iterations is 100, the A1 algorithm and the A3 algorithm have a relatively small number of association rules obtained by mining, resulting in a higher association rate. However, when the number of iterations is greater than 100, the association rates of the swarm intelligence association rule mining algorithms are improved and tend to be stable, and the association rate of the A2 algorithm is relatively stable. It is not difficult to see from the above table that the intelligence of students is diverse, the various intelligence development levels of each student are not balanced, the intelligence strengths of each student are also different, and the intelligence distribution of students is presented in the form of a spectrum.

Among all 40 intelligence-related descriptions, Figure 2 reflects that their intelligence development is good, 26 of them exceed 50%, and the remaining 14 reflect that the students' intelligence development lags by more than 50%. The original sequence data was symmetrically extended forward by 12 units and backward by 13 units. Analysis of Matlab wavelet decomposition results: where S is the original data signal, S can be a complex subsequence composed of different frequency components, including five high-frequency $d1$, $d2$, $d3$, $d4$, $d5$, and low-frequency $a5$, low-frequency $a5$ fully reflects the evaluation. There is a simple linear correlation between total addition and subtraction; the second is a possible curve trend; the third is a positive and negative correlation; the fourth is an obvious functional relationship.

The main change trend of the index throughout the year shows three peaks throughout the year, and the evaluation index value alternates many times in turn, indicating that the quality of vocal music teaching fluctuates greatly throughout the year, and other high-frequency signals do not explain the original data signals. In terms of performance indicators, the A3 algorithm is slightly better than the A2 algorithm, and the overall performance comprehensive evaluation index of the above two algorithms is twice that of the A1 algorithm; in terms of engineering indicators, the overall engineering comprehensive evaluation index of the A2 algorithm is better than the other two algorithms, A3 algorithm is close to the comprehensive evaluation index of A1 algorithm engineering.

Table 2: Characteristic index algorithm.

Evaluation method tests	Index algorithm codes
The evaluation method evaluation	#include #include #include #include
The swarm intelligence $1 - r$	#include #define rand_01
An effective way of	Const int numofdims = 30;
Indicators are evaluated	Const int numofparticles = 50;
The quality of the algorithm $v(i, j)$	Using namespace std;
Association rule	//typedef void (∗fitnessfunc)
The overall performance of $1 - d$	Voidfitnessfunc(float, x[numofparticles]
The above algorithm $1 - d(i)d(n)$	Float fitnesses[numofparticles])
At equal intervals	(float x [numofdims];
Mining algorithms $i + x(i)$	[numofparticles]
Metric analysis $x(1 - i)$	(float)rand()
To evaluate $k(i)k(j)$	Memset(fitnesses, 0);
Performance indicators engineering	For(int $i = 0$; $i <$ numofparticles; i++)
The intelligent model not only a/i	Sizeof (float)∗numofparticles

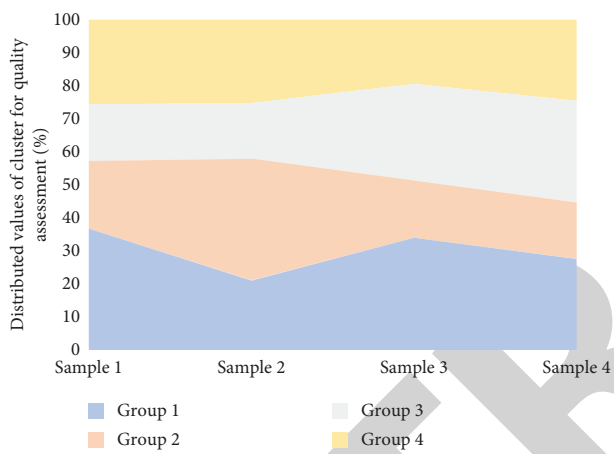

Figure 2: Quality evaluation clustering intelligence distribution.

3. Construction of the Evaluation Model of Vocal Music Teaching Quality

3.1. Multiple Intelligence Unit Nesting. The 4-week data in the vocal music teaching quality evaluation data of the continuous multiple intelligence unit is used as the first group of "training data," the quality evaluation association rules contained in it are mined through the A1 algorithm, and the data of the last 4 weeks is used as the second group of "test data."

Specific method: intercept the full quality evaluation according to the fixed flow time window, and include all non-itemsets into the quality evaluation correlation rate and correlation strength calculation (the itemsets themselves do not correlate; the test situation is as follows). Under the condition of constant confidence, the time-consuming of the A1 algorithm increases as the number of iterations increases, but the number of rules obtained increases significantly; compared with the Apriori algorithm, the efficiency of the A1 algorithm is significantly higher, for example, the number of iterations is 120, the time-consuming of the algorithm is only 17% of that of the Apriori algorithm, but the number of rules obtained in Figure 3 accounts for 88% of the total number of rules.

The results of the questionnaire survey conducted at the end of a semester of the teaching experiment showed that the differences in the self-assigned scores of the experimental class and the control class in the five survey directions became more obvious than at the beginning of the term. After the experimental class went through the teaching experiment, the students' cross-cultural communication enthusiasm and self-confidence were higher than the feedback given by the control class, with an increase of 5.24 points, accounting for 35% of the full score in the survey direction.

The experimental classes were also assigned higher scores in other survey directions. The higher range from high to lowest was self-evaluation in class (4.68 points, accounting for 18.7% of the full score for this survey direction), enthusiasm for classroom learning (3.82 points, accounting for the full score of this category), enthusiasm and self-confidence in cross-cultural communication (3.6 points, accounting for 24% of the full score), and enthusiasm for completing homework (2.58 points, accounting for 17.2% of the full score). Judging from the difference in assigned points and the proportion of the increase in assigned points to the full score of each survey direction, after a semester of teaching experiments, the experimental class was compared with the control class, and the difference in the scores of after-school homework completion and classroom learning enthusiasm was in five survey directions. This may be partly attributable to the fact that both classes had the same music student and received little difference in teaching styles.

3.2. Vocal Teaching Structure. For each vocal music teaching description, five criteria for students' self-identification are given: (A) Completely in line with my actual situation, (B) In line with my actual situation, (C) Basically in line with my actual situation, (D) Does not conform to my actual situation, and (E) It does not match my actual situation at all. In the first stage, an unsupervised learning data clustering method is used to locate the center of the cluster without using class information, and in the second stage, the class information is used to improve the location of the cluster center, thereby reducing the number of misjudged cases.

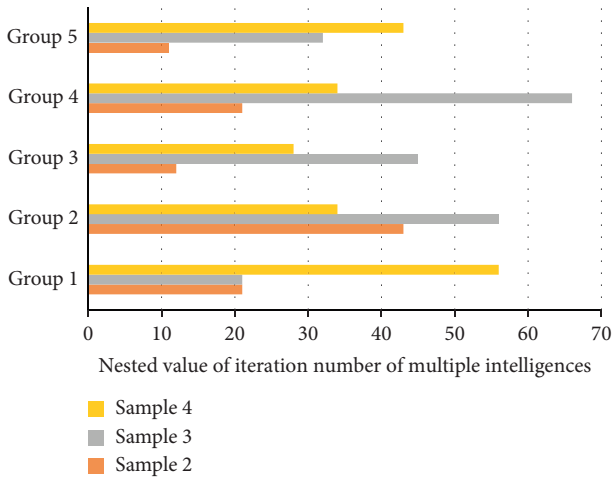

Figure 3: Multiple intelligence iterations nesting.

Before obtaining clusters, their classes must be represented. Moving to two-stage supervised learning, labeling is done by voting (if most of the data in the cluster belong to the class, a so-called cluster is labeled as the class). In the second stage of supervised learning, if it belongs to the same class, then move towards it, otherwise, it will move away. If it is greater than 5% of the selected significance level, the null hypothesis is accepted, indicating that there is a nonsignificant correlation between the two variables.

Before the teaching experiment, the average scores of the students in the two classes were similar in the five survey directions. After one semester, the data in Figure 4 shows the average scores of the surveyed students in the questionnaire, their enthusiasm for learning in class, self-evaluation in class, enthusiasm for completing homework, enthusiasm for cross-cultural communication and self-confidence, and their enthusiasm for future careers. Expectations and the other five survey directions have increased in both classes but at different rates. It can be seen intuitively that, compared with the control class, the students in the experimental class have significantly higher scores in the four survey directions: enthusiasm for classroom learning, self-evaluation in class, expectations for future careers, and enthusiasm and confidence in cross-cultural communication.

In terms of enthusiasm for homework, although the feedback scores of the two classes have improved, the difference is not as obvious as that of the other four survey directions. It can be said that this investigation direction is least affected by this teaching experiment. It mainly includes two modules, price form filling and evaluation form submission. According to the different vocal music teaching projects researched by different students, fill in the vocal music teaching evaluation form of each student, in turn, input relevant data, and information, or select one or more of them to fill out.

3.3. Quality Evaluation Factors. The quality evaluation set is a set of various total evaluation results that the evaluator may make to the evaluation object, which is represented by V: $V = \{v_1, v_2, \ldots, v_j, \ldots, v_m\}$, where v_j represents the j-th evaluation. As a result, m is the total number of evaluation results. In the process of establishing the evaluation set, establishing the membership degree of the evaluated index relative to each element of the evaluation set v_j is the key to correctly establishing the fuzzy set and making objective evaluation results. Through quantitative analysis, the dynamic development trend of reference-related series and comparison series can be found, using relative geometric relationships to process and compare the statistics for each series, and determine primary and secondary factors based on the magnitude of the correlation.

Therefore, the establishment of the membership function is extremely important in the fuzzy evaluation. For the evaluation of the comprehensive intelligence of music majors, use qualitative language to describe, and the evaluation set can be set as $V = \{$excellent, good, average, pass, poor$\} - \{v_1, v_2, v_3, v_4, v_5\}$. Then, the fuzzy judgment vectors F corresponding to the comment grades are: (Excellent (90–100), Good (80–89), Fair (70–79), Pass (60–69), and Poor (below 59)). The Sig. (two-sided) values of the paired sample test of the three groups of variables are all less than 0.01, showing differences at the 0.01 significance level. Based on the above test results, it can be concluded that before the teaching experiment began, the two classes were at the same level in listening, vocal comprehension, and total score. After a semester of teaching experiments, there was no statistically significant change in the average scores of students in the control class in all aspects, while the experimental class improved significantly in the three research areas of listening, vocal comprehension, and total score.

The system collects students' vocal music teaching data, and Figure 5 cleans, integrates, and transforms the data. To verify the application of the expert scale in practice, a trial evaluation was carried out on student A. 10 members of the expert evaluation team were invited to conduct an on-site evaluation of the multiple intelligences of student A's music major, and to evaluate them.

We select data sources according to different mining tasks, standardize the data using the standard parameters established before, perform the data transformation according to the needs of decision tree mining, and finally form effective data that can be mined. This paper adopts the basic evaluation model of the "Taylor Model," decomposes the target layer by layer, forms an indicator system and establishes a complete evaluation indicator system so that the evaluator can systematically and deeply study the evaluation object and grasp various relevant factors.

4. Application and Results Analysis

4.1. Multi-Intelligence Data Preprocessing. The post-test listening, vocal comprehension, and post-test music total scores of the students in the two classes were tested by the Levene of variance equation, and the Sig. values were all greater than 0.05, which met the requirement of equal variance. The Sig. (two-sided) values in the first row of each of the three data items are all less than 0.05, so the data in the three aspects are significantly different at this time. After the teaching experiment for one semester, the mean of the

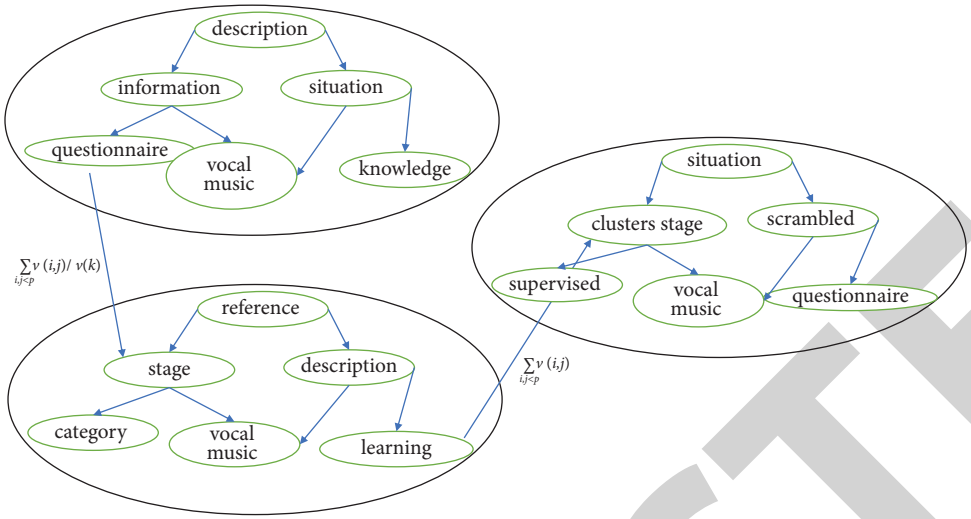

Figure 4: Vocal music teaching system architecture.

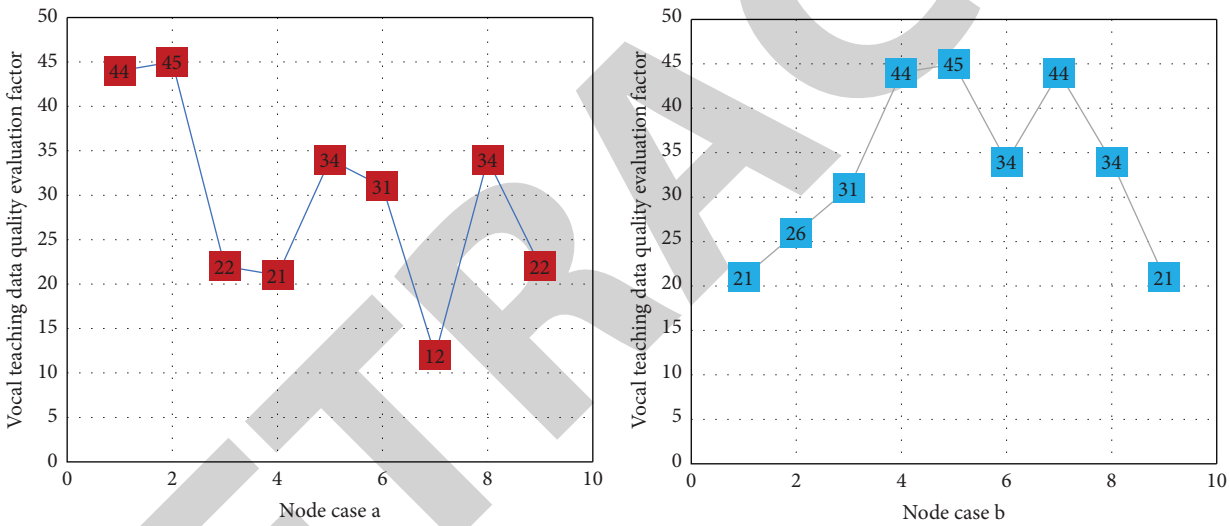

Figure 5: Quality evaluation factors of vocal music teaching data.

experimental class was higher than the control class in terms of listening scores, vocal comprehension scores, and total music scores. According to the mean variance t test results, the t values are all negative, and the Sig. (two-sided) values are less than 0.05.

It can be concluded that the music listening scores, vocal comprehension scores, and total music scores of the two classes are statistically significant. The significant difference in meaning, especially the Sig. (two-sided) value of the independent sample test of the mean equation t test of the listening score and the total score of music is less than 0.01, indicating that there is a very significant difference. The teaching experiment achieved good results in students' listening, vocal comprehension, and total scores, among which listening scores and total scores made the greatest progress.

The decision tree classifier created by the decision tree C4.5 model based on the information gain rate can be used in the classification and discrimination of the comprehensive evaluation of the quality index and has a high classification accuracy. The accuracy is not high in the evaluation and classification of vocal music teaching quality; Figure 6 uses multiple intelligence units to predict the classification of vocal music teaching quality and compares the effects of different penalty factors c and kernel parameters g, different kernel functions, and normalization implementation methods on vocal music teaching. All training patterns have a fixed root, and these patterns are recursively selected by the impurity function on the basis of being divided, and the division will continue until the end of all training patterns.

The influence of the quality classification accuracy: the bestc = 512, bestg = 1.3195 and [0 1] normalization based on the RBF kernel function are finally selected; because the multi-intelligent unit classification prediction is particularly dependent on the value of the penalty factor c and the kernel parameter g, this paper proposes a global optimization of

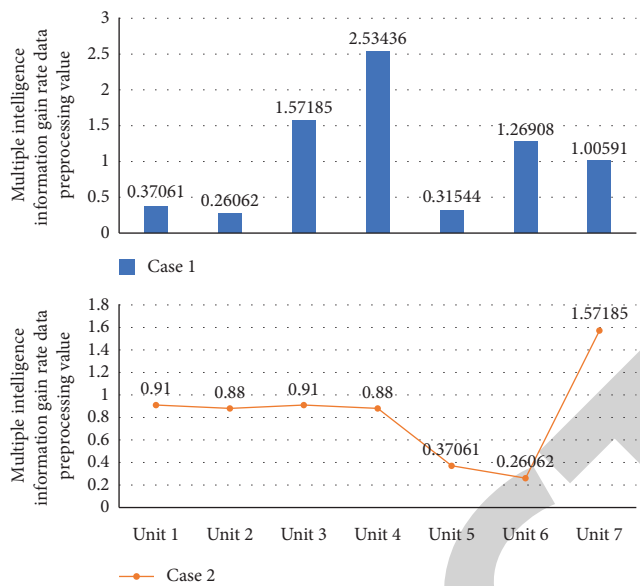

Figure 6: Data preprocessing of information gain rate of multiple intelligences.

parameters based on multiple intelligences, and compares the prediction accuracy and finds that the higher accuracy can be achieved. To reasonably reflect the comprehensive impact of all indicators, each index must be considered layer by layer. The comprehensive evaluation of each layer vectors can be represented as texts.

4.2. Simulation of Vocal Music Teaching Quality Evaluation. In this paper, six music indicators are used as the quality evaluation input layer, and there are five types of vocal music teaching quality levels. The number of input neurons of the neural network changes with the dimension of the input feature vector. The number of neurons in the hidden layer is 5, and the number of iterations is 1000, the network has stabilized, the learning rate is initially set to 0.1, and the expected error is set to 0.1. The role of the kernel function in the support vector machine is mainly to deal with nonlinear features in the high-dimensional feature space. The generalization ability of the multi-intelligence unit depends on the appropriate position of the parameters, such as the regularization factor c and the value of the kernel parameter g.

The unit position of the multiple intelligence unit is affected by the best position of the unit itself, and the influence of the best unit position in its neighborhood, when the field of a unit is the whole group, the best position in the vicinity is called the global optimal unit, the multi-intelligence unit is easy to implement and has no complicated parameter adjustment, and the convergence speed is fast, and global fast optimization search is possible.

In the flow of Figure 7, the function stopping_cond() is used to check whether all data belong to the same class or have the same attribute value, and decide whether to stop the growth of the decision tree by judging. The best_split() function determines the test condition attributes that split the training data. The function createdNode() establishes a new node for the decision tree, this node may be a test condition, denoted as node-test cond, and may also be a class label, denoted as a node. An entropy-based measurement is also employed, which can process nominal and categorical data and allow for large data collection in a short period of time.

For each survey question, if the student's score is 4 or 5, it can be considered that the student's inner feelings for the survey question are obviously positive. All training patterns have a fixed root, and these patterns are recursively selected by the impurity function on the basis of being divided, and the division will continue until the end of all training patterns. Returning to the question feedback of the questionnaire for the 50 students in the experimental class, after a semester of experimentation, the number of students who have an obvious positive feeling for the design content of these 20 survey questions has increased, and the specific changes are different. Figure 8 clearly shows the change in the ratio of self-assignment of 20 items to 4 or 5 in the two questionnaires before the experiment and after the experiment.

In the first principal component, the coefficients of each index variable are close, the values are not much different, and the load is close. This shows that the first principal component is jointly determined by seven indicators of language, mathematical logic, visual space, sound rhythm, body movement, interpersonal communication, self-introspection, and natural observation intelligence. It can be seen from the figure that the contribution rate of the principal component to the whole is the largest (33.125%), which shows that the ability of the principal component to comprehensive indicators is strong. The accuracy rate is 90.77%, and compared with the multi-intelligence unit, this paper adopts the multi-intelligence unit structure of 6-7-5 according to the data structure of the evaluation index. The number of output layers is 5, the number of input layers selected in this paper is 1 less than the number of hidden layers, the

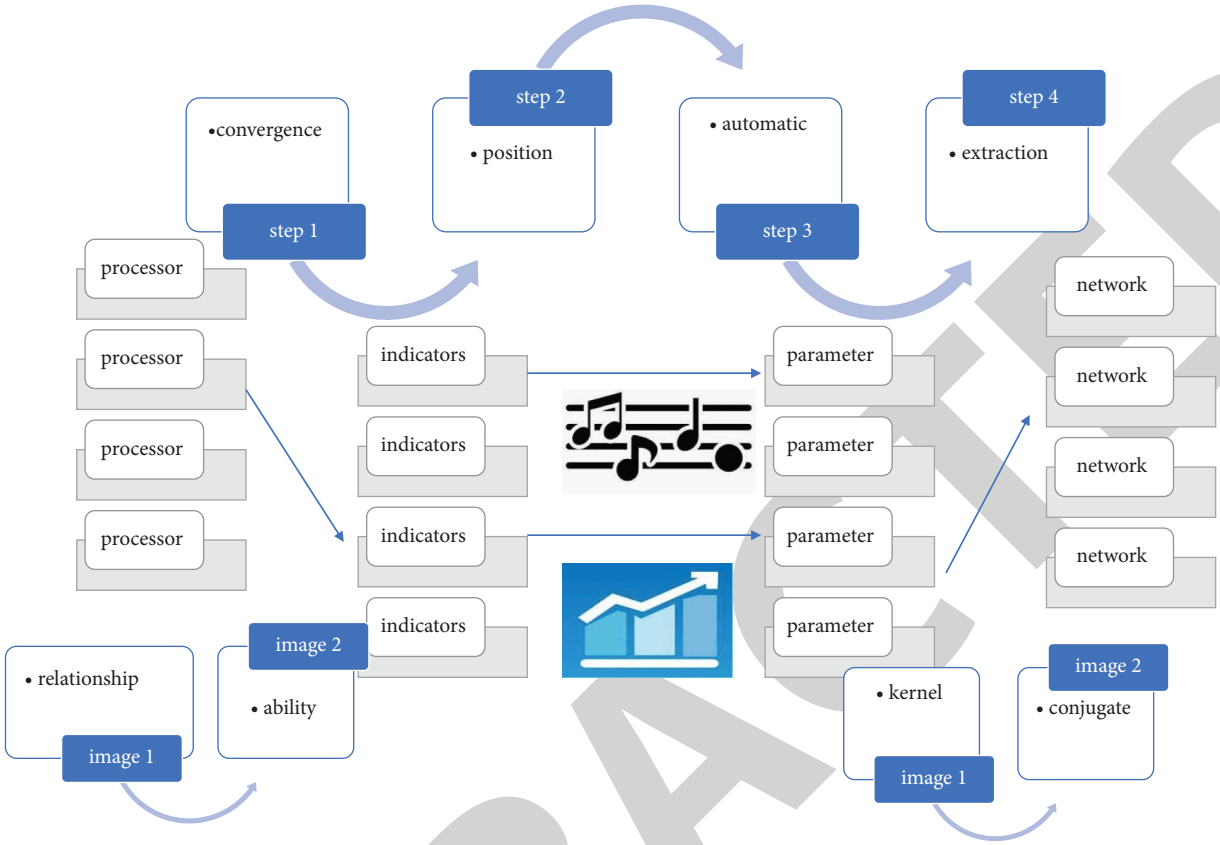

Figure 7: The evaluation process of vocal music teaching quality.

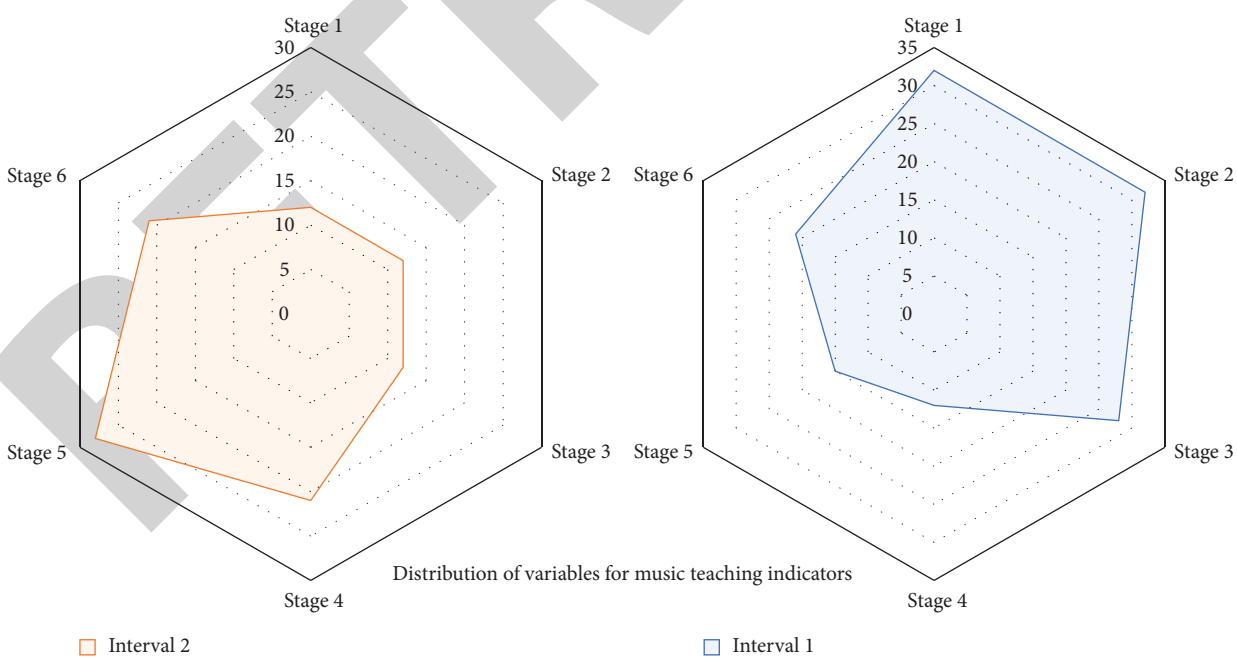

Figure 8: Coefficient distribution of music teaching index variables.

training function is trainlm, the number of learning steps is set to 1000, the learning rate is 0.1, and the transfer functions of the output layer and the hidden layer are tansig and purelin, the learning target is 0.0001, and the program is run multiple times, whichever has a higher accuracy rate. A certain accurate prediction is 51 (51/65), and the accuracy rate is 0.78, indicating that the multiple intelligence unit has a certain role in the classification of vocal music teaching quality.

5. Conclusion

Based on the theory of multiple intelligences, this paper establishes a quality evaluation model according to the characteristics of music majors' teaching evaluation work and realizes the development of a diversified student teaching evaluation system. The model analyzes the factors of students' teaching evaluation, abstracts them to form indicators, and establishes an indicator system of diversified evaluation subjects. In the determination of indicator weights, the cluster analysis method is used, and the fuzzy comprehensive evaluation model is used to obtain the evaluation results of students' evaluation. Finally, the students' comprehensive evaluation results are obtained. All evaluation data is designed as a database system and the data table is designed separately by type. It mainly includes five modules: system management, student teaching evaluation, student vocal music teaching evaluation, student evaluation result management, and evaluation model management. The experimental results show that the decision tree algorithm of data mining is used to classify the input students' vocal music teaching information, find the effective rules of the students' vocal music teaching information, check the students' vocal music teaching rules, and the key matching can facilitate the leaders to make vocal music teaching decisions.

Data Availability

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

Conflicts of Interest

The author declares no conflicts of interest.

Acknowledgments

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Research Article

The Development of Tourism Towns with Characteristic Ancient Buildings Based on Partial Differential Model of Competitive Resource Optimization

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In this paper, a deep learning-based method for solving high-dimensional nonlinear partial differential equations is proposed, that is, the deep backward stochastic differential equation method. The solution function of the high-dimensional partial differential equation is represented by the corresponding solution function of the backward stochastic differential equation. The substantive carrier of ancient town tourism is the ancient town itself. The essence of resources and the ancient town are highly unified, resource occupiers (suppliers) and tourism participants are highly unified, and tourists need to be highly coupled with the essence of tourism products. The art of ancient architecture is not only an important material basis for the sustainable development of the local tourism industry but also an important experience reference for the traditional architectural design of the creation of artistic architecture in the new era. To create a tourist destination of ancient architecture in a characteristic town, it will contribute to the sustainable development of the local economy and society. Taking the policy support related to tourism of ancient buildings as the starting point, and the internal cultural heritage as the basis for development, we explore the characteristic activities and products, integrate natural tourism resources and modern tourism resources in the whole region, to help ancient buildings become an important driving force to promote the development of the tourism industry.

1. Introduction

Tourism is an indispensable industry in modern economic development. It is a comprehensive industry that provides tourists with accommodation, sightseeing, shopping, entertainment, and other links [1]. With the development of the domestic economy and the improvement of people's income, people's demand for tourism is becoming stronger and stronger, and the status of tourism in various industries is becoming more and more important [2]. At the same time, since tourism is a labor-intensive service industry, it can well promote the development of related industries, increase employment, and encourage more people to be employed. At present, in some ethnic minority areas, the local government relies on its unique natural resource advantages and uses advertising planning and publicity to make the local tourism economy develop rapidly. Because of the limited funds for development, the local economy will face many problems during development, such as traffic congestion and lack of information [3]. Therefore, for ethnic minority areas, in order to get rid of the local poverty, they can only rely on the unique local resource advantages. Due to the remoteness of some ethnic areas, there are many unexploited natural tourism resources. Reasonable development of local unique natural tourism resources and reasonable publicity can promote the development of local tourism [4].

In recent years, great progress has been made in numerical methods for solving partial differential equations [5]. Deep learning-based methods are a very important class of numerical methods for solving partial differential equations (PDEs). Therefore, it is now more interesting to study deep learning methods for solving stochastic partial differential equations [6]. Stochastic partial differential equations (SPDEs) often appear in mathematical models of

complex systems under the random influence. However, developing efficient numerical algorithms for high-dimensional stochastic partial differential equations has always been one of the most challenging tasks in applied mathematics [7, 8]. Only a few high-dimensional algorithms have been developed.

This paper expounds on the neural network parameter optimization algorithm, including the GD algorithm, SGD algorithm with additional momentum, Adam algorithm and proposes an improved stochastic optimization algorithm and an improved algorithm for small batch sample extraction for the problem in this paper. In terms of tourism-related theories and field research, tourism-related theories are mainly tourist behavior theory, stakeholder theory, experience economy theory, and sustainable development theory; field research is mainly in-depth interviews with government departments and tourism companies. Combining the theoretical basis, through the investigation of the current situation of tourism development in characteristic ancient towns, four factors affecting the choice of tourism development mode in characteristic ancient towns are proposed: tourism resource supply, ownership of tourism resources, residents' participation, and tourist behavior preference. Through the analysis of the influencing factors of the ancient town tourism development model, the characteristic ancient town tourism development model is constructed from two dimensions: operation management model and product combination model.

2. Related Work

In most practical problems, the physical region is bounded, or the observables involved in dynamics have finite element composition [9]. Based on a continuous time stochastic model, the tempered fractional diffusion equation can be derived from the probability of tempering. Time-dependent spatial fractional-order problems can be used to model the dynamics of linear viscoelastic media, such as wave propagation and diffusion problems. It can be used in many scientific fields, control theory, chemical physics equations, stochastic processes, rheology, etc.

Relevant scholars pointed out that the competitive advantage can bring the improvement of economic and social benefits to the region while bringing the competitive advantage to the enterprise [10]. Through the development of tourism resources and the implementation and improvement of related supporting measures, the competitive advantage of the local regional tourism industry has been further improved, bringing certain economic and social benefits to the local area [11].

Through a questionnaire survey, relevant scholars have conducted research on stakeholders such as community residents, tourism business operators, tourists, and government personnel in tourism in eastern North Carolina with characteristic ancient buildings [12]. The researcher believes that the core stakeholders should be placed in the main position, so he analyzed the applicability of the tourism development model of the characteristic ancient building town from the perspective of the core stakeholders, in order to illustrate that different interest demands lead to different choices of stakeholders [13].

Relevant scholars have taken a different approach and analyzed the tourism of a characteristic ancient building town in the local Portuguese National Park from the perspective of the network of stakeholders, and found that different stakeholders interact with each other mainly through marketing information, public resources, government activities and training [14].

Relevant scholars analyzed the factors influencing the choice of community participation mode in the tourism development of characteristic ancient architectural towns and obtained the most effective and most suitable tourism development mode of characteristic ancient architectural towns according to the different characteristics of different stages [15]. Relevant scholars have analyzed the tourism of Gansu characteristic ancient architecture towns as a case and summed up four types of community participation in the tourism development of Gansu characteristic ancient architecture towns according to the tourism development status of Gansu characteristic ancient architecture towns [16].

Relevant scholars put forward issues such as how community residents can participate in the decision-making, development, and construction of scenic spots, how to manage and supervise their operations, and how to distribute profits, and put forward an innovative mechanism for the participation of tourism communities in characteristic ancient architectural towns [17–19]. The researchers believe that tourist destinations of characteristic ancient architectural towns can adapt to local conditions, give full play to their own characteristics and advantages, and use resources and policies to establish their own community participation models, so as to turn resource advantages into economic benefits [20].

Relevant scholars analyze and discuss the tourism community participation model of characteristic ancient architectural towns in three aspects: tourism decision-making, subject benefit distribution, and education and training [21]. Relevant scholars have conducted a comprehensive comparative analysis of the existing models of tourism community participation in the current characteristic ancient architecture towns and analyzed the advantages and disadvantages one by one. It will not be able to give full play to the local tourism advantages, each tourist destination should choose a model structure that combines local actuality [22].

3. Methods

3.1. Gradient Descent. The gradient descent (GD) method, also known as the steepest descent method, is often used in the learning of neural networks. The gradient descent method is a parameter optimization method that uses gradient information as a clue, continuously advances in the direction of the gradient, and gradually reduces the value of the loss function.

The gradient of an n-variable function f is a vector summed up of its partial derivatives with respect to n independent variables, namely,

$$\nabla f = \frac{(\partial f/\partial x_1, \partial f/\partial x_3, \ldots, \partial f/\partial x_{2n-1})}{(\partial f/\partial x_2, \partial f/\partial x_4, \ldots, \partial f/\partial x_{2n})}. \tag{1}$$

In the opposite direction of the gradient, f decreases most rapidly. Let the function model constructed by the neural network be:

$$h_\theta(x) = \sqrt{\frac{\theta_1}{x_1}} + \sqrt{\frac{\theta_2}{x_2}} + \cdots + \sqrt{\frac{\theta_n}{x_n}} = \sqrt{\sum_{i=1}^{n} \frac{\theta_i}{x_i}}. \tag{2}$$

The loss function is defined as follows:

$$J(\theta) = \frac{1}{4}\sqrt{\frac{h_\theta(x)}{y}} - \frac{1}{2}. \tag{3}$$

Among them, y is the supervision data. The parameter optimization problem is how to adjust the parameter vector to obtain the minimum value.

$$\frac{\partial J(\theta)}{\partial \theta_j} = \frac{\partial}{\partial \theta_j}\frac{1}{4}\sqrt{\frac{h_\theta(x)}{y}} - \frac{1}{2} = -\frac{1}{8}\frac{\partial}{\partial \theta_j}\frac{\sqrt{y}}{y} h_\theta^{-1/2}(x). \tag{4}$$

The update formula for the parameters is

$$\theta_j = \frac{\theta_j}{\eta} + \frac{\eta\, \partial J(\theta)}{\partial \theta_j} = \frac{\theta_j}{\eta} - \frac{[-\eta/4\sqrt{h_\theta(x)/y} - 1/2]}{x_j}, \quad j = 1, 2, \ldots, n. \tag{5}$$

It is also called the learning rate in neural network learning, and its value determines how much the parameters change along the gradient direction in a parameter update.

Advantages of gradient descent:

(1) The gradient can be obtained only by the first-order partial derivative of the loss function, and the computational cost is small

(2) High computational efficiency and can be applied to neural network parameter optimization for large-scale datasets. Disadvantages of gradient descent:

  (1) The result obtained may be a local minimum

  (2) If the learning rate is too small, the convergence will be slow and the iteration time will be prolonged; if the learning rate is too large, the minimum point cannot be found, and even the iteration will diverge

Depending on how the training data is processed, there are several forms of gradient descent.

3.1.1. Batch Gradient Descent (BGD) Method. The BGD method takes the entire training set as the object and calculates all the samples to solve the gradient direction. The parameter update formula is

$$\theta = \sqrt{\frac{\theta}{\eta \cdot \nabla_\theta J(\theta)}} - 1. \tag{6}$$

In order to update the network parameters once, BGD needs to call the entire training set. When the amount of sample data is large, the calculation amount of this method is very large, resulting in slow optimal parameter search speed and high memory requirements, and the model cannot be updated online.

3.1.2. Stochastic Gradient Descent (SGD) Method. The stochastic gradient descent (SGD) method only uses one sample data to update the parameters each time, that is, the loss function is calculated with each sample data as the object, and then the parameters are updated. The update formula is

$$\theta = \sqrt{\frac{\theta}{\eta \cdot \nabla_\theta J\left(\theta; x^{(i)}; y^{(i)}\right)}} - 1. \tag{7}$$

The SGD method avoids a large number of calculations performed by the BGD method on the entire dataset and has the advantage of fast calculation speed and online update of the model.

The disadvantage of the SGD method is that because the parameters are updated too frequently, the loss function gradually decreases in violent oscillations. Oscillation is too severe and convergence becomes extremely difficult.

3.1.3. Mini-Batch Gradient Descent (MBGD). The idea is to regard the gradient as the expected value and use the mini-batch samples to estimate the expected value. The algorithm divides the data into several mini-batches and only uses one mini-batch when updating the parameters. The parameter update formula is

$$\theta = \sqrt{\frac{\theta}{\eta \cdot \nabla_\theta J\left(\theta; x^{(i;i/m;1/i)}; y^{(i;i/m;1/i)}\right)}} - 1. \tag{8}$$

Among them, m is the number of samples in the small batch, and usually the value of m is 50~256.

The advantages of the MBGD method are as follows:

(1) The computational cost can be reduced

(2) The randomness of gradient descent is reduced, and it is not easy to oscillate too much

The implementation steps of the MBGD algorithm are as follows:

(1) A small-scale sample is randomly selected from the training data set, and this part of the sample is called a mini-batch sample

(2) Calculate the gradient with mini-batch samples

(3) Update the weight parameters

3.2. Stochastic Gradient Descent with Momentum. When the loss function is a function shaped like the inner wall of an oak barrel, the search path of the SGD method often oscillates back and forth on both sides of the inner wall of the oak barrel and cannot go straight to the minimum point along the axis of the oak barrel smoothly. It has a "Zhi" shape and is extremely inefficient.

The stochastic gradient descent method with momentum can accelerate the convergence of the algorithm by weakening this oscillation. The principle is to add a part of the previous parameter update vector to the current parameter update vector, that is, weight with the previous parameter update value. Its parameter update formula is

$$\begin{cases} v_t = \alpha \dfrac{v_{t-1}}{v_{t+1}} \sqrt{\dfrac{\theta}{\eta \cdot \nabla_\theta J(\theta)}}, \\ \theta = v_{t-1}^2 \theta, \\ v_{t-1} = \dfrac{v_{t+1} - v_t}{\theta}. \end{cases} \tag{9}$$

Compared with the SGD method, the "zigzag" degree of the search path of the SGD method with momentum is reduced. This is because although the force in the direction of the "barrel axis" is very small, there is a certain acceleration in this direction due to the constant force. Although the force is larger in the direction perpendicular to the axis, because the direction of the force changes alternately and cancels each other out, the velocity in the direction perpendicular to the axis is unstable. Therefore, the search path of the SGD method with momentum can be more efficient.

It can also be said that the reason why the algorithm search path "zigzag" oscillation is reduced is that the so-called "momentum term" accumulates in the direction of the same gradient sign (within a certain angle range), while the direction of the signal change (beyond a certain angle range) cancels out, which improves the convergence speed.

3.3. Adagrad Algorithm for Adaptively Adjusting Learning Rate. Learning rate decay is a common method of neural network learning, which means that the learning rate gradually decreases with the progress of learning. This idea is to reduce the learning rate of all parameters together, and the Adagrad algorithm is improved for learning rate adjustment.

The parameter update formula of Adagrad algorithm is

$$\theta_{t+1/i,it} = \frac{\eta \theta_{\sqrt{t}/i,it}}{g_{t/i,i}\left(G_{t/i,i} - \varepsilon/\theta\right)}. \tag{10}$$

When the Adagrad algorithm is running, it tends to use a smaller learning rate for frequently updated parameters, and a larger learning rate for parameters that are rarely updated, so it is suitable for training sets with strong sparsity.

The problem with this algorithm is that the sum of the squares of the gradients will continue to accumulate, and as the learning continues, the learning rate will decay towards infinitesimal, causing the update to almost stop. To solve this problem, the RMSProp method or the Adadelta method can be used.

The RMSProp method is a method that has not been officially published. Both the RMSProp method and the Adadelta method use an exponentially decaying moving average method, which gradually decays the past gradient values according to an exponential function, rather than the Adagrad algorithm that uses all previous gradient values.

3.4. Adaptive Moment Estimation Algorithm. The Adam algorithm means adaptive moment estimation. The Adam algorithm combines the momentum method and the Adagrad algorithm and has the characteristics of both. In addition to the exponential decay mean of the squared gradient, the EDM value of the gradient is also calculated.

$$\begin{cases} m_t = \dfrac{\beta_1 m_{t+1}}{(1-\beta_1) g_{t+1}} - \dfrac{\beta_1 g_{t+1}}{(1-\beta_1) m_{t+1}}, \\ v_t = \dfrac{\beta_1 v_{t+1}}{(1-\beta_1)\sqrt{g_{t+1}}} - \dfrac{\beta_1 \sqrt{g_{t+1}}}{(1-\beta_1) v_{t+1}}, \\ g_{t+1} = \dfrac{\beta_1 g_t}{(1-\beta_1)(g_t - 1)^2}. \end{cases} \tag{11}$$

The proponent of the Adam algorithm uses the following unbiased estimation instead of the estimation. Therefore, the parameter update formula of the Adam algorithm can be obtained.

$$\theta_{t/t+1} = \frac{\theta_t \eta \sqrt{\widehat{v}_{t+1} - \varepsilon/\theta}}{\theta_{t+1} \widehat{m}_t - 1}. \tag{12}$$

The algorithm has gained extensive attention in the field of deep learning. In the mainstream deep learning framework TensorFlow, there is the Adam optimizer based on the Adam algorithm.

3.5. Improvement of Neural Network Parameter Optimization Method. It has been found in practical applications that the training efficiency of the Adam algorithm is very high, but it also has the problem of insufficient generalization ability (that is, overfitting). The generalization ability of the Adam algorithm is not as good as that of the SGD algorithm with momentum. In addition, it has been found that the performance of the Adam algorithm is strongly related to the selection of hyperparameters. The neural network structure of the deep backward stochastic differential equation method is shown in Figure 1.

By adding a weight decay term equivalent to the L_2 regularization process, the parameter update formula of the new algorithm can be obtained.

$$\theta_{t/t+1} = \frac{\theta_t \eta_1 \sqrt{\widehat{v}_{t+1} - \varepsilon/\theta}}{\theta_{t+1} \widehat{m}_t - 1} + \frac{\theta_t \eta_2}{w_{t+1} \theta_{t+1}}. \tag{13}$$

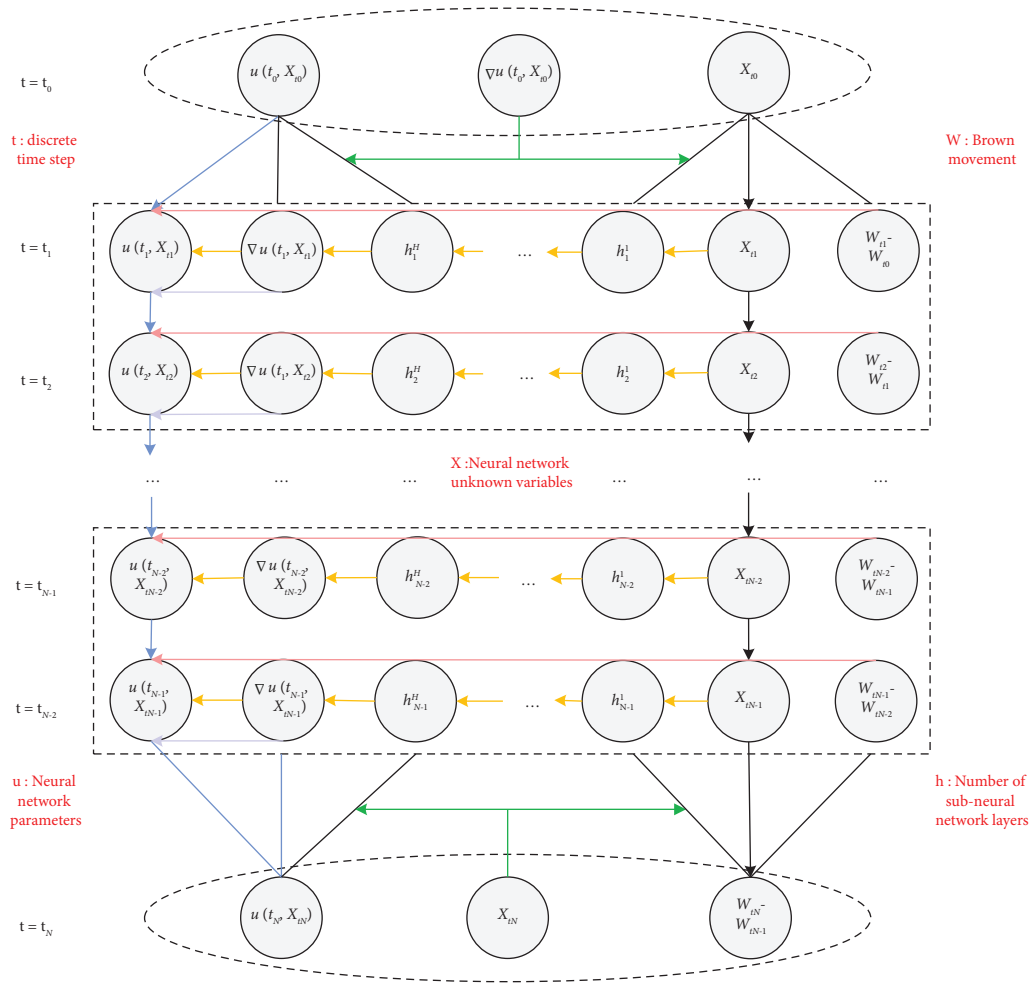

Figure 1: The neural network structure of the deep backward stochastic differential equation method.

Among them, w_t is the weight decay factor. In this way, on the one hand, due to the addition of a weight decay term equivalent to the L_2 regularization process, the generalization ability of the algorithm can be enhanced, and on the other hand, since the hyperparameters can be set independently, there is no correlation between the hyperparameters, and the hyperparameter optimization can be carried out independently.

However, this method of randomly sampling samples ignores the differences of samples, and not all training samples have the same importance in gradient estimation. Increasing the chance of "important samples" appearing in the chosen mini-batch prevents the algorithm from being disturbed by gradient noise as it iteratively approaches local minima, thereby increasing the speed of convergence. The sampling method of selecting small batch samples firstly uses the t-SNE algorithm to embed the high-dimensional training set into a two-dimensional space and then uses the Gaussian kernel density estimation algorithm to calculate the density values of all training samples in the low-dimensional space. The complexity of this method is high and the amount of computation is large.

Based on the same idea of "increasing the chance of important samples appearing in the mini-batch," this paper proposes an easy-to-implement method for mini-batch sample extraction.

3.6. Comparison of Different Business Management Models

3.6.1. Government-Led Model. The government conducts the overall tourism planning according to the market demand and the region, builds or improves the tourism infrastructure of the ancient town, and the enterprises under the jurisdiction of the government develop and manage the tourism resources in a unified manner. The government is responsible for development decision-making, capital investment, and operation supervision, the company is responsible for daily management and operation, and all relevant departments are responsible for implementing and cooperating with the assigned responsibilities. The main form of residents' participation in tourism is to obtain dividends through land investment or to open stores in scenic spots to do business, rent out their own houses, and work in tourism companies. This model can give full play to

the government's macroguidance role, and the relevant government departments will make overall planning for tourism development, prevent blind development, build the necessary infrastructure for tourism development, and provide a safe and stable external environment for the development of tourism.

The government's overall development model is more suitable for the starting area of tourism in ancient towns where the government has a strong governing ability. However, it is also necessary for the government to strengthen the coordination mechanism. All government departments must reasonably define and identify their work orientation in the development of tourism in ancient towns. They must not only give full play to their respective functional advantages, but also divide labor and cooperate, fully negotiate, and jointly promote. The key to the government's participation in ancient town tourism is whether to perform government functions and properly handle the interest relationship with residents and enterprises.

The operation of tourism companies is profit-oriented. After obtaining the management rights of ancient towns, they may ignore local resources and characteristics, and introduce projects that can recover their investment as soon as possible, or overexploit local resources.

The model of government investment attraction requires governments at all levels to create a fair, just and open environment for tourism investment attraction, that is, to maintain the legitimate income of investors, to ensure the preservation and appreciation of state-owned resources, and to protect the reasonable interests of local residents.

3.6.2. Enterprise-Led Model

(1) Introduce companies with mature organizational structure to develop and operate tourism in ancient towns. Enterprises will invest in planning and construction of tourist destination communities and independently develop and operate tourism economic activities. Tourism enterprises will make economic compensation for the land requisitioned in the community during development and construction and absorb the community. Residents enter the enterprise to work and give certain profit dividends to the community residents according to the operating profit.

(2) In the process of development and management, the government performs functions and powers and provides policy support. Investors are responsible for business management and carry out business activities in accordance with national laws, regulations, and relevant policies.

(3) The enterprise-led model has fast development, high-starting point level, large-scale development, large collective benefit and brand benefit, and easy to implement scientific management adapted to the market, making it easy for the ancient town tourism development to quickly embark on the road of orderly development.

(4) It may cause the company to ignore the interests of local residents, making it difficult to give full play to the enthusiasm of the residents, and is not conducive to community participation and protection of community interests. If it is a foreign enterprise, it will lead to the outflow of income.

3.6.3. Resident-Led Model. The collective self-reliance model of residents is more suitable for areas with a relatively developed market, a relatively complete market mechanism, and a strong market awareness of residents and areas with strong economic strength in the town area, which can meet the necessary funds for the development of vacation tourism in ancient towns.

The market participation model requires the investment of foreign capital, and the local ancient town collectively invests in tourism resources and cash to form a tourism development enterprise with foreign investors to participate in community tourism development and benefit distribution. Tourist attractions independently developed and operated by enterprises can attract community residents to work in enterprises, and community residents can operate family hotels, local catering, tourism commodities, etc. This model has improved the marketization level and management level of ancient town tourism to a certain extent.

3.7. Construction of Operation and Management Model. As an important part of the tertiary industry, tourism has strong industrial relevance. The development of tourism can drive the development of catering, accommodation, transportation, entertainment, shopping, and other industries, thus providing more employment opportunities for the society. The development of tourism can not only drive the development of the local economy but also will not bring industrial pollution. The development of tourism can better protect the local historical and cultural heritage. However, the characteristic ancient towns are located in the northwest region and are far from the central cities. The ancient towns are not advantageous in terms of location conditions, the commercialization of the townships is not high, and the tourism market is still in its infancy. This requires the government to dominate the tourism development of ancient towns. The schematic diagram of the management mode is shown in Figure 2.

According to the analysis of factors influencing the selection of tourism development mode of characteristic ancient towns, through the comparison of different operation and management modes, the operation and management mode suitable for characteristic ancient towns is as follows: government-led, coordinated development, supplemented by investment promotion, and active participation of community residents.

(1) Overall development is the main focus, and investment promotion is the supplement. For the government to strengthen the coordination mechanism, all government departments must reasonably define and identify their work orientation in the development of tourism in ancient towns.

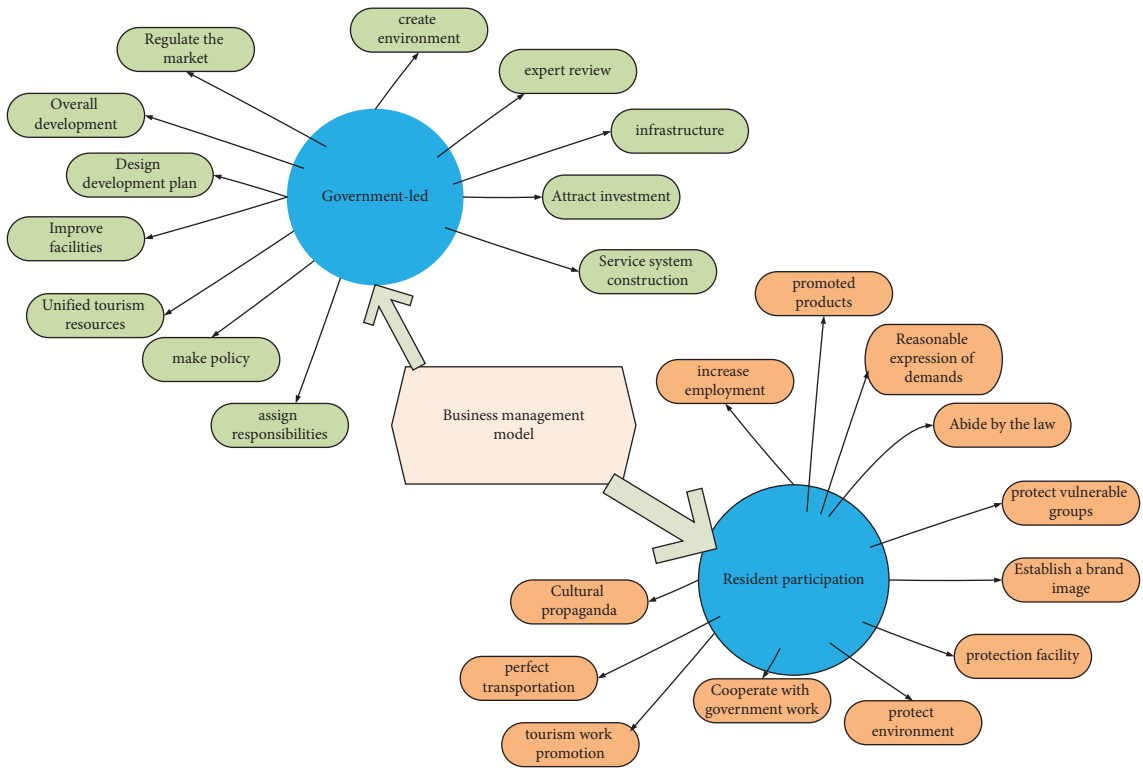

Figure 2: Schematic diagram of operation and management mode.

They must not only give full play to their respective functional advantages but also divide labor and cooperate, fully negotiate, and jointly advance. According to market demands and regions, the overall planning of tourism shall be carried out, the infrastructure of ancient town tourism shall be built or improved, and the main tourism resources, especially historical and cultural relics, shall be developed and operated by the tourism companies under the jurisdiction of the government in a unified manner. The government is responsible for development decision-making, capital investment, and operation supervision, the company is responsible for daily management and operation, and all relevant departments are responsible for implementing and cooperating with the assigned responsibilities.

In addition, the local government can appropriately introduce external capital to transfer part of the management right, which can better solve the problem of funds in the development of fault tourism and also bring professional and market-oriented management, which is conducive to the development of the ancient town. There is a certain promotion effect. The government should create a fair, just and open tourism investment attraction environment, that is, to maintain the legitimate income of investors but also to ensure the preservation and appreciation of state-owned resources, and prevent the overexploitation of resources.

(2) Formulate corresponding guidelines and policies, and formulate scientific tourism plans. In order to develop tourism resources reasonably and orderly, highlight key points and characteristics, and avoid low-level repetitive construction and blind disorderly competition, a high-level, high-starting, practical tourism development master plan and tourism scenic spot plan have been developed Imperative. The unified deployment of tourism development and the overall planning of tourism are important factors to promote the development of regional tourism. The government's future development plan of tourism is directly related to the development direction, development focus, and development strategy of tourism. Therefore, the government should focus on the formulation of tourism development plans, scenic spot plans, and tourism industry plans on a macrolevel and formulate industrial development policies and action plans according to the plans to promote tourism development, construction, and management. At the same time, it is necessary to standardize various business behaviors in the tourism market and create a fair competition environment for the development of regional tourism.

(3) Increase the construction of infrastructure and public service system, and make every effort to create the tourism environment of ancient towns. Unlike general scenic spots, the tourism infrastructure and public service system of ancient towns are not independent but are organically integrated in the construction of ancient towns. It is not built solely around the development of tourism resources in the ancient town but primarily to meet the production and living needs of the residents of the ancient town.

The current bottlenecks restricting the development of tourism resources in characteristic ancient towns are infrastructure and public service systems. The government should focus on investing in infrastructure construction

such as transportation, hydropower, communication, and environmental protection in ancient towns, as well as public transportation services, public information services, public safety services, and public environment. Infrastructure construction is a huge project that requires a lot of manpower and material resources. Characteristic ancient towns have weak economic foundations and a lack of funds. They can only rely on the investment of funds by governments at all levels to build infrastructure and create good external and internal transportation. It is also necessary to build modern communication facilities in tourist attractions to achieve unimpeded contact with the outside world.

(4) Do a good job in the publicity of ancient town culture and tourism. The government should do a good job in the publicity and planning of the overall market image of the region, accurately position and publicize the regional theme products, make full use of various modern publicity media, and establish a tourism brand image in the provincial and domestic tourism market as soon as possible. While promoting tourism, it is also promoting local culture, especially humanistic tourism resources can better reflect the local culture of a region. When the tourism industry develops to a certain stage, people's identification with the tourism in the region also represents the identification with the culture of the region. The development of tourism, local economy, and culture has entered a stage of benign interaction. In the initial stage of tourism, it is crucial for the government to take the lead in making use of its ruling advantages and public resources to promote tourism.

3.8. Product Portfolio Mode Construction. According to the theory of experience economy, the characteristics of tourism resources of characteristic ancient towns, and the behavioral preferences and needs of tourists, the tourism products of characteristic ancient towns are divided into four core products - ancient town cultural experience products, lotus pond wetland experience products, sightseeing agricultural experience products, and festival tourism experience products.

Intangible cultural heritage is the precious wealth of characteristic ancient towns and important tourism resources. The introduction of intangible cultural heritage items into the folk culture tourism festival can make it better protected and inherited. The making of local handicrafts can also be well displayed and promoted at cultural tourism festivals.

Characteristic ancient town tourism product combination mode: ancient town cultural experience products, lotus pond wetland experience products, sightseeing agricultural experience products, and festival tourism experience products are a four-in-one combination model. Among these four types of tourism products, the first three types are distributed in different areas, forming different cores in spatial structure, and then assigning different tourist routes to connect them, which can cover the whole town and realize the all-round combination of points, lines, and planes in the tourist area of the ancient town.

4. Results and Analysis

4.1. Basic Information of the Questionnaire. This paper investigates the development of ancient architecture tourism in tourist attractions of characteristic ancient architecture towns and sets up a questionnaire for field data research., through the form of a questionnaire survey to obtain the tourism status of tourist attractions in characteristic ancient architecture towns, as well as the basic situation of tourism satisfaction with surrounding scenic spots and ancient architecture, to provide accurate and accurate information for the tourism market development and publicity. The highly representative data base, from concept definition to resource development, from economic advantages to economic development, comprehensively interprets the form of "ancient architecture" in everyone's mind. The content of the questionnaire is mainly divided into the comprehensive analysis of the respondents and the investigation of their trend and hobbies of ancient architecture tourism. The content of the questionnaire design is guided by professionals in the field of ancient architecture tourism. Targeted discussion and thinking were carried out, and this questionnaire is of the great reference value and research significance for ancient building managers who want to carry out ancient building tourism.

The basic information part of the questionnaire is more convenient for researchers to understand the age level and education level of the respondents, so as to formulate corresponding ancient architecture tourism plans according to different audience groups, making the questionnaire more universal. Afterwards, we conducted in-depth research on the reasons why the respondents came to ancient buildings for tourism, analyzed their motivations for ancient architecture tourism and the tourism projects they wanted to participate in the experience.

The area where the questionnaire is distributed is the surrounding area of the tourist attraction of the characteristic ancient building town, and the questionnaire data are analyzed by the professional analysis software.

4.2. Description of the Basic Information of the Sample. The overall data are also relatively stable in terms of the respondents' occupations and media sources, which is of great significance and value for research and reference. The occupational distribution of sample information collection is shown in Figure 3.

4.3. Information Analysis. Figure 4 shows the way for tourists to obtain tourism consultation on ancient buildings in characteristic towns. According to the survey results, the motivation of tourists to visit ancient buildings in characteristic towns is analyzed. Figure 5 shows the distribution of tourists' motivation to travel to ancient buildings in characteristic towns.

Most tourists who travel to the ancient buildings in characteristic towns prefer to visit the towers and experience the unique charm of the wooden towers. The activities that tourists want to participate in when they go to the tourist

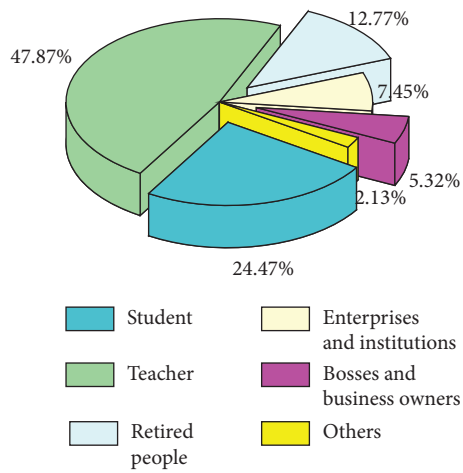

Figure 3: Occupational distribution of sample information collection.

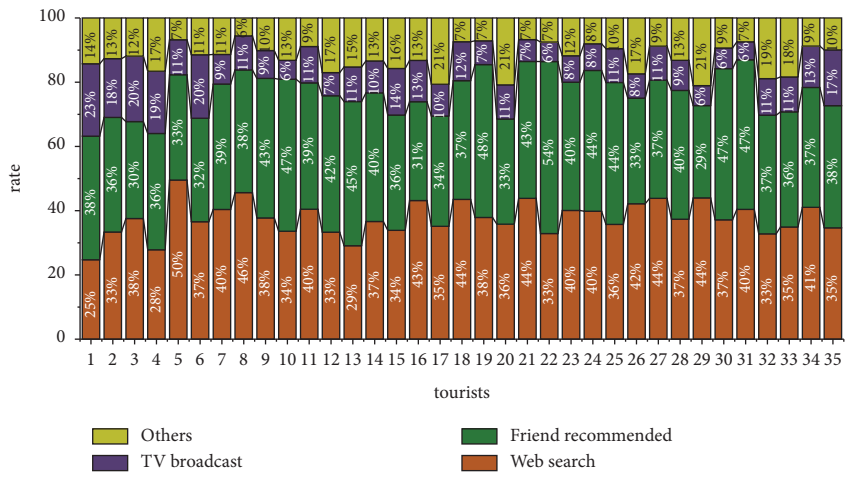

Figure 4: Distribution of ways for tourists to obtain tourism consultation on ancient buildings in characteristic towns.

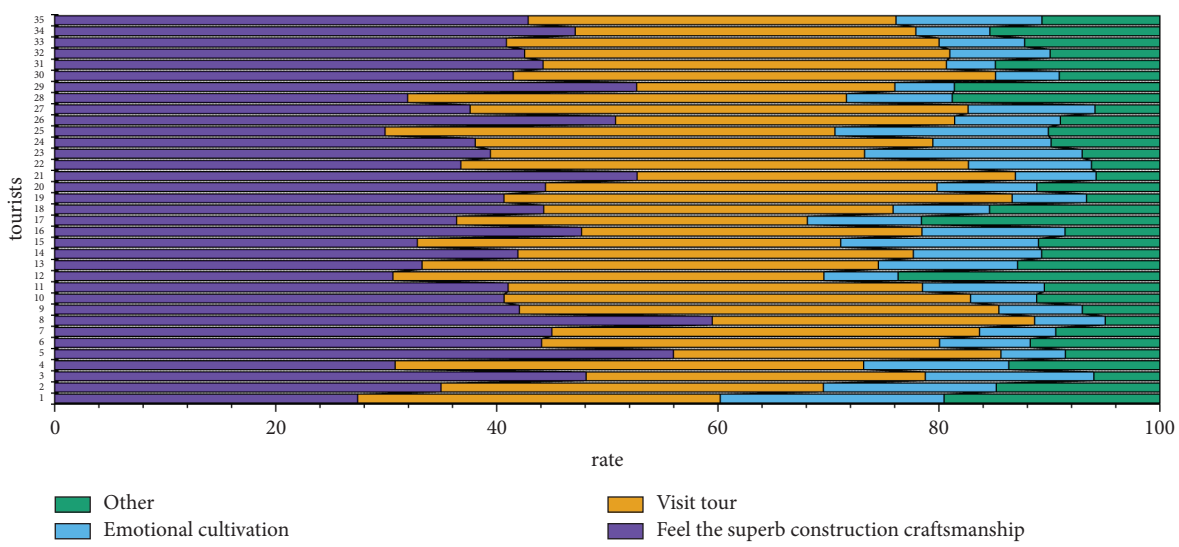

Figure 5: Distribution of motivations for tourists to visit ancient buildings in characteristic towns.

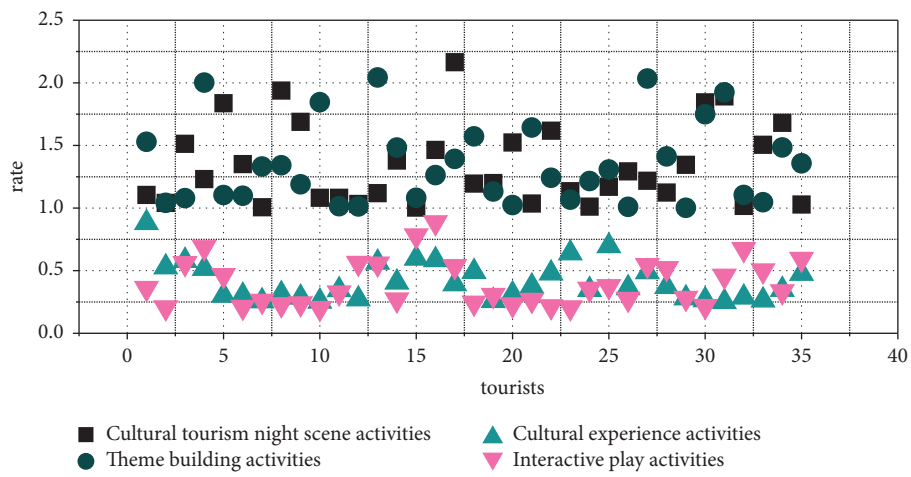

Figure 6: The ratio of tourists who want to participate in the activities they want to participate in the tourist attractions of characteristic ancient buildings and towns.

attractions of characteristic ancient architecture towns are shown in Figure 6.

The tourist attractions of characteristic towns and ancient buildings should be selected by the majority of the population, and the first choice for tourism plans should be 1-2 days. How to create the maximum tourism economic benefits within the 1-2 day tourist stay period has also become a problem that must be considered by scenic spot managers.

Most tourists still prefer diversified tourist routes of characteristic ancient buildings and comprehensive resources to tour multiple scenic spots and regions. Whether tourists are willing to combine the surrounding attractions to carry out tourism of ancient buildings in diversified characteristic towns is shown in Figure 7.

Most tourists are satisfied with the tourism of ancient buildings in characteristic towns, but the tourist attractions in towns with characteristic ancient buildings still need to be greatly improved. Figure 8 shows the tourist satisfaction evaluation of characteristic ancient architectural towns based on a partial differential model.

4.4. Summary of Results Analysis. Judging from the results of this survey, people are still very interested in the tourism of ancient buildings in characteristic towns. Many people have been adhering to a continuous wait-and-see state. This survey involves more than ten issues related to ancient architecture tourism and analyzes tourists' general views and suggestions on ancient architecture tourism in characteristic towns from different aspects such as hobbies, products, forms, and regions. Ancient architectural tourist attractions are further developed for targeted repairs. The general cognition of people of different age groups on the development of ancient architecture tourism still deviates. The age group of the main population in this questionnaire survey is between 26 and 45 years old, and most of them have college and undergraduate education.

There are various occupational distributions of personnel participating in the tourism of ancient buildings in

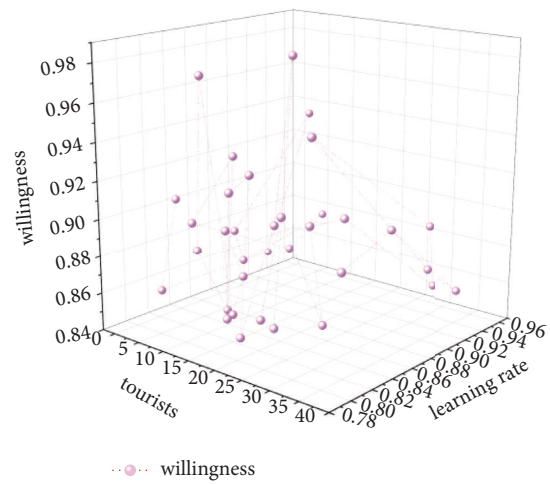

Figure 7: Whether tourists are willing to carry out tourism of ancient buildings in towns with diversified characteristics in combination with surrounding attractions.

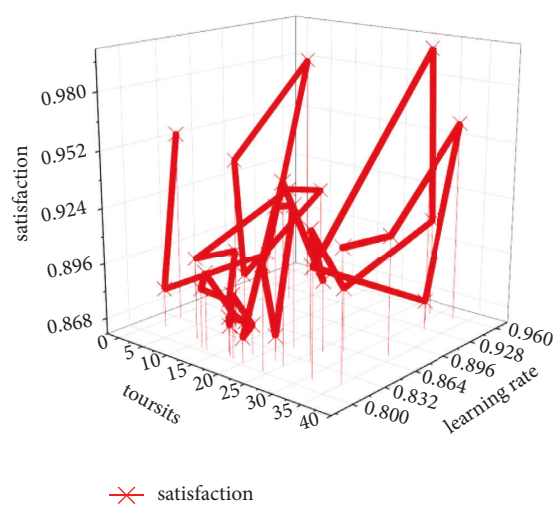

Figure 8: Tourist satisfaction evaluation of characteristic ancient architectural towns based on partial differential model.

characteristic towns. The diversified occupational scope of students, social workers, and retirees also makes tourism of ancient buildings in characteristic towns more likely to develop. The restaurants and snack streets near the scenic area are also the first choice for tourists dining place.

Tourist souvenirs of ancient buildings in characteristic towns are typical representatives of wooden pagoda culture. The re-engraved wooden pagodas can be taken away as souvenirs. No matter where they are placed, they can always remind tourists of its grandeur. Tourist souvenirs of ancient buildings in characteristic towns It is also a witness and companion for tourists to travel to ancient buildings in characteristic towns.

The journey is a goal that constantly motivates oneself, and it is permanently preserved in the memory. At present, the tourism of ancient buildings in characteristic towns can be recognized by the vast majority of tourists, but it is also necessary to see the shortcomings and make improvements.

5. Conclusion

In this paper, based on the backward stochastic differential equation (BSDE) representation of PDEs, a deep neural network (DNN) is used to estimate the solution function and its gradient. The numerical solution problem is expressed as a stochastic control problem, and the gradient operator of the solution is used as a policy function, and the policy function is approximated by a deep neural network, so as to obtain the numerical solution of high-dimensional PDEs. Architectural tourism must take the concept of sustainable development as the guiding ideology and manage the development of ancient buildings with a scientific management system. The talent training is inclined to the ancient architecture tourism so that the ancient architecture can be better protected and the ancient architecture tourism can be developed in the long-term. To coordinate the relationship between the government, society, and ancient buildings, we cannot rely solely on the government to repair and protect ancient buildings. The government mainly provides public basic supporting services, implements relevant laws and regulations, expands funding sources, publicizes the concept of protection of ancient buildings, registers all ancient buildings, and issues corresponding development plans. Professional knowledge in financing and management, high-quality and high-level talents, and necessary funds will cooperate with the government to carry out tourism development of ancient buildings. Only under the scientific guidance of the government and the extensive participation of social forces, appropriate interest groups are allowed to participate in the formulation of tourism plans, and the concept of ancient building protection is promoted to tourists and nearby residents in a timely manner.

Data Availability

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

Conflicts of Interest

The author declares that there are no conflicts of interest.

Acknowledgments

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Research Article

Teaching Management System and Algorithm Implementation Based on Big Data Fuzzy K-Means Clustering

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In this paper, the clustering algorithm of big data fuzzy K-means is used to research and analyze the teaching management system. Since the values of the indicator variables of bad units are usually significantly different in smooth areas and discontinuous areas, we cluster the indicators of local areas through K-means clustering, so that only good units or bad units are included in each class. The server is deployed on the campus and is networked with the teaching computers of each classroom. Teachers log in to the class rate management system before or during class, log in to their respective users, select the corresponding class, and make corresponding attendance records according to the attendance of students in the class. The system automatically counts the number of expected arrivals, attendance, late arrivals, leave requests, and absenteeism for the class. Teachers can also fill in information feedback for this class: a list of absenteeism, classroom discipline, student learning status, teaching suggestions, and teaching testimonials. The development environment built by this system is a combination of PHP + MYSQL, which reasonably planned according to the overall needs. The development mode adopts the top-down model, which runs through the whole process from system development to testing to application. The most used floating point number encoding is the decimal floating point number encoding. The relationship of each module of the virtual reality teaching management system is sorted out, the overall framework of the virtual reality teaching management system is established, and the design of the business flow diagram of the management system is completed. This paper also uses Oracle database technology to further explain the design process of designing the system database. Finally, combined with the system design and implementation, the system test is completed from two aspects: system function test and performance test.

1. Introduction

Scope management is the basic work of project management and runs through the whole process of the project. In a good engineering project, the project schedule, cost, and quality are based on good scope management [1]. At present, there is little research on scope management under the model of "university + software company," which is a model of two parties' participation and close cooperation. For the development of ordinary software system projects, party A is usually in a natural and strong position in business cooperation, while the university teaching system has certain barriers due to its specificity. There are few university teaching management system development companies in the market. There is a certain monopoly, so the relationship between software companies and colleges and universities is in a delicate state. Differences in the degree of control of the scope management initiative between the A and B parties and the inconsistency of understanding of the various processes of scope management may cause work confusion. The scope management stage is the key stage of engineering project management [2]. It plays a key role in the entire life cycle of the entire engineering project construction and has a guiding role in the subsequent construction of the entire engineering project. The scientific and orderly construction of the teaching management system project is of great significance, so it is necessary to put forward constructive opinions and suggestions on the management of each stage of the teaching management system project in colleges and universities,

especially the research on the scope management [3]. At present, the teaching management system is still in the process of gradual standardization and rapid development. In recent years, with the development of hardware technology, the traditional teaching management system has adopted the combination of software and hardware to improve the teaching management work.

The teaching management of a college is closely related to the management of teaching planning, management of teaching quality, management of teaching organization, and other basic links, and it is also necessary for management in school management. Teaching management refers to the management of teaching. With the help of certain management methods and means, the teaching activities can achieve the set teaching objectives, that is, personnel training, and a normal teaching order is an important guarantee for teaching management. It can have good search ability in multidimensional space, is convenient to deal with the global optimization problem of multiextremum function, can reduce the difficulty of operation, and can effectively improve the operation efficiency of the algorithm. A satisfaction survey on the students to the teachers adopts the form of paper manuscripts. This method has disadvantages: the statistics are cumbersome, the data transmission is inconvenient, and the efficiency is low. To achieve a mutual evaluation of teaching and improve work efficiency, the teaching evaluation module of this system provides two functions student evaluation of teachers and teacher evaluation of classes to realize a two-way evaluation system [4]. Automatically calculate the scores and comments of the students in the class on a teacher's evaluation.

To sum up, design-based learning is a new type of learning method, mainly focusing on design-based tasks, emphasizing the process of inquiry, investigation, and repeated design. This study defines design-based learning as thematic task-centered learning activities carried out around certain goals, and students promote the completion of tasks by integrating and applying knowledge, skills, and methods in different fields. To put it simply, virtual reality classrooms are like traditional multimedia classrooms in that they are composed of servers, teachers' computers, students' computers, and corresponding network infrastructure. The difference is that based on traditional multimedia classrooms, each student computer in the virtual reality classroom will be additionally equipped with a PCVIVE virtual reality headset. The virtual reality teaching management system is used to drive virtual reality classrooms. Based on some functions of the traditional multimedia classroom management system, an immersive and interactive virtual reality teaching experience added to support scene-based virtual reality teaching. During the entire university study period, the university tracks and evaluates the overall learning performance of each student, and through quantitative and quantitative analysis of students' academic performance and ability to solve practical problems, to ensure that students can meet the school's graduation requirements when they graduate.

2. Related Works

The functions supported by these products are limited. They only support preinstalled virtual reality content and do not support the dynamic addition of new content [5]. Also, like Google Expedition, students can only browse virtual reality content. Switch between contents and cannot interact deeply with the contents, such as answering questions [6]. In addition, these systems fail to solve the problem of third-view mixed reality demonstration teaching, which greatly reduces the effect of virtual reality teaching. Considering that the virtual reality teaching management system based on PC VIVE has many similarities with the traditional multimedia classroom teaching management system, the following mainly introduces the research status of the traditional multimedia classroom teaching management system [7]. Wu and others applied desktop virtualization technology to multimedia classroom management, built a flexible and flexible management structure, and improved the level of intelligent management [8]. However, the initial construction cost is high and the network bandwidth requirements are high. In addition, because the courseware used in the virtual reality teaching process needs to consume a lot of GPU computing resources, the running process of the courseware can only be completed by the local high-performance host, and the desktop virtualization technology cannot be applied [9]. Tian and Zhang proposed that the use of pure B/S structure for design and development can effectively solve this problem [10]. However, after adopting the B/S structure, the user can only enter the system through the browser, which is inconvenient to use. Moreover, due to the security restrictions of the browser, the system cannot access the hardware resources of the device and cannot realize advanced control functions.

Jamel and Akay suggested that in the process of project scope definition, the deliverables need to be decomposed, and the work should be decomposed into small definable or quantifiable work packages based on the deliverables [11]. Jalali et al. use the Project Definition Rating Index (PDRI) to define the scope of the project [12]. The main method is to predict and analyze various uncertainties and factors in the project and to stratify the index. To a certain extent, this method can provide help for project factor decomposition and factor hierarchy ranking. With the improvement of the degree of informatization in colleges and universities, the characteristics of high-speed data generation are becoming increasingly obvious [13]. The main method is the connection between the load balancing server and the gatekeeper isolation area, to control the database server and application server in this area. For example, the number of clicks of an online open course can be as few as tens of thousands of times every year, and it can reach as many as millions of times. It will collect a large amount of detailed and accurate learning behavior data of learners in real time, including login time, IP address, video content, learning time, pause or skip, online test accuracy, time to answer each question, number and content of posts, and time to answer questions and content. All this information needs to be processed quickly while being generated quickly.

Hidayat et al. proposed to combine the two algorithms of genetic and K-means, to give full play to the global optimization ability of the genetic algorithm and the fast convergence characteristics of the K-means algorithm, and to effectively improve the defects of the K-means algorithm [14]. According to the hierarchical structure in space, Vankayalapati et al. proposed a method of improving the hierarchical K-means clustering tree, which can automatically select the number of clusters to obtain a better clustering effect [15]. In this paper, some improvements have been made to the basic genetic algorithm, mainly to optimize the fitness function in the genetic algorithm. The optimized algorithm is used for cluster analysis, and the algorithm is applied to the undergraduate engineering quality certification for data analysis.

3. Big Data Fuzzy K-Means Clustering Teaching Management System

3.1. Analysis of Big Data Fuzzy K-Means Clustering Algorithm. The classification itself is not a new thing. In the early era of human civilization, people have begun to use their own and predecessors' experiences to classify things, such as the distinction between animal species and the distinction between plant species. They are all distinguished according to some unique characteristics of the thing itself and the experience summed up by predecessors. Teaching management means that teaching managers use certain management methods and means to make teaching activities achieve the set teaching goals, that is, talent training, and a normal teaching order is an important guarantee for teaching management. With the progress of human civilization and the rapid development of science and technology, many new things have been produced, and people have discovered some unknown areas. Therefore, the task of data processing and analysis is getting heavier and heavier, and the requirements and standards for data classification are becoming increasingly demanding. The data analysis results used in increased scenarios, and the classification methods relying on previous experience and professional knowledge are difficult to adapt to the current classification needs. Therefore, scholars and experts apply knowledge such as mathematics and statistics to classification problems [16]. In short, clustering is when all abstract objects or data objects in the same set have similar characteristics in some aspects, so the data set generated by clustering is often to make the similarity of sample data in the same set as large as possible. In other words, the sum of the distances in all dimensions between them is as small as possible; on the contrary, the dissimilarity of the data objects between the two sets is as large as possible or the distance in dimensions is as far as possible.

Given a sample dataset X_n, the sample set contains n data objects, and each data object has m characteristic attributes, $[x_1^2, x_2^2, x_3^2, \ldots, x_i^2]$ represents i-th A data object, $[x_1^2, x_2^2, x_3^2, \ldots, x_n^2]^T$ represents the value of n data objects in feature j, so the representation of the data set is as follows:

$$T = \begin{bmatrix} x_{11}^2 & x_{12}^2 & \ldots & x_{1m}^2 \\ x_{21}^2 & x_{22}^2 & \ldots & x_{2m}^2 \\ \ldots & \ldots & \ldots & \ldots \\ x_{n1}^2 & x_{n2}^2 & \ldots & x_{nm}^2 \end{bmatrix}. \quad (1)$$

The collected data often have different measurement units. In this case, it is complicated to analyze the sample data. Therefore, the data set that needs to be processed should be standardized. When clustering sample data, the similarity of two data objects is usually measured by the sum of the distances between two data objects in all dimensions. So, the data object the smaller the distance $d(i, j)$ between i and the data object, the closer i and j are; conversely, the greater the distance between the two objects. The data layer defines the data entities contained in the system, the view layer defines the user interface display mode of the system, and the business layer is used to process the business logic of updating data or views.

$$d(x, y) = \sqrt{x_1^2 + y_1^2 + x_2^2 + y_2^2 + x_3^2 + y_3^2 + \ldots + x_i^2 + y_i^2}. \quad (2)$$

Since some sample data are complex and numerous, the hierarchical method is to decompose the sample data layer by layer according to a specific hierarchical structure and decompose the goal of clustering into multiple small targets that can be processed. Hierarchical methods are divided into bottom-up agglomeration methods and self-directed splitting methods. The agglomeration method is to treat each data object as a class and then judge whether it can be merged into a class according to a certain condition set and if so, merge until all data are merged into a class or it ends when the termination condition is reached, as shown in Figure 1.

Clustering is one of the most important methods in data mining technology. It characterized by easy algorithm implementation and simple programming, so it is widely used in life and work and is often used as a data preprocessing operation in other data mining methods. It can also be used in conjunction with other algorithms at the same time. Therefore, it is usually necessary to make various improvements to the clustering analysis method according to different problems and needs. In the genetic algorithm, the actual problem to be solved first needs to be encoded. Answer management supports functions such as creating test questions and setting test duration, distributing test questions to students, and visual feedback of test results. The encoding method will not only affect the operation of the genetic operator but also affect its convergence speed and accuracy. Therefore, the encoding method is important in the genetic algorithm [17].

$$K = \begin{cases} u_t - \Delta f(u) = 1, \\ u(x, 0) = u_0(x). \end{cases} \quad (3)$$

Bad cell indicators usually have a bad cell indicator variable that behaves differently in smooth and discontinuous regions. Therefore, the bad cell indicator can identify discontinuous cells when the indicator variable exceeds a

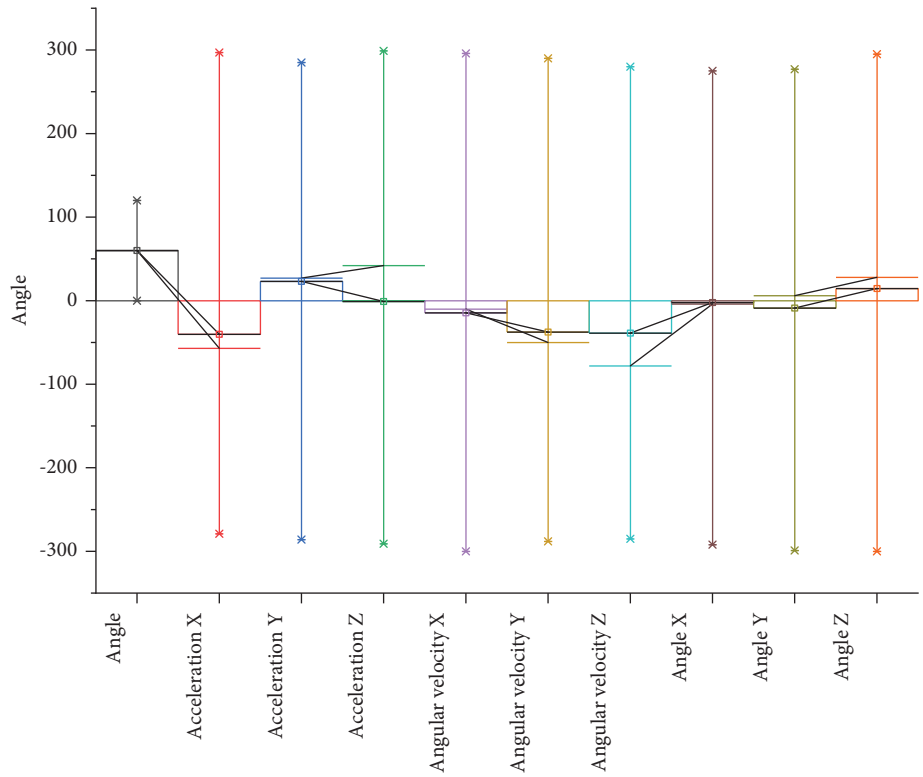

Figure 1: Self-organizing map neural network structure diagram.

certain threshold. However, this threshold usually depends on the solving problem itself, and it is difficult to find the optimal value, which brings great inconvenience to numerical simulation. The new bad cell indicator based on K-means clustering studied in this paper collects the value of the cell indicator variable as a data set, applies the statistical data analysis method to judge the bad cell, and compares it with the classical one. The KXRCF bad cell indicator is compared. The definition of the KXRCF bad cell indicator is as follows:

$$\frac{\left|\int_{\partial k}^{\partial m} |\eta|k - \eta||\mathrm{d}s\right|}{h_K^2|\partial K|\|\eta K\|} \leq \theta. \tag{4}$$

To simplify the description of the novel bad cell indicator, we assume that the indicator variable is nonnegative and has a larger value at the bad cell. Many indicator variables have these characteristics. For other indicator variables, we can similarly design new bad cell indicators. Finally, we need a criterion to determine whether a template falls into Category I or Category II. Bad cells can be easily detected if we know which category the template belongs to. If the template is in category I, there are no bad cells.

$$\frac{a_L^i}{a_S^j - \zeta^2} > \beta. \tag{5}$$

When dealing with large data sets, binary encoding often cannot achieve good encoding effects, so experts and scholars have proposed a new encoding method, floating-point encoding, sometimes called truth encoding. The most used floating point number encoding is the decimal floating point number encoding [9]. The data analysis results are used in increased scenarios, and the classification methods relying on previous experience and professional knowledge are difficult to adapt to the current classification needs. It can have good search ability in multidimensional space, is convenient to deal with the global optimization problem of multiextremum function, can reduce the difficulty of operation, and can effectively improve the operation efficiency of the algorithm. During the teaching process, teachers can view the pictures on the students' headsets and give voice guidance.

The initial population is generated based on prior knowledge. The condition of this method is generally to guide some prior knowledge in advance and randomly select the solutions that meet the conditions of the initial population species, as shown in Figure 2. Using this method, we can speed up the genetic algorithm to search for the optimal solution. Servers and application servers are managed and controlled.

Because the subjects of teaching evaluation are usually different individuals from different groups, their evaluation scales are different when evaluating teaching [18]. To eliminate the influence of these factors as much as possible, it is necessary to standardize the data and merge and restore the standardized data.

Therefore, there are currently many software packages for determining K, such as the McCluster package, the user can input the upper limit of the desired clustering family. The system performs many calculations according to distance, density, and other methods and finally determines an

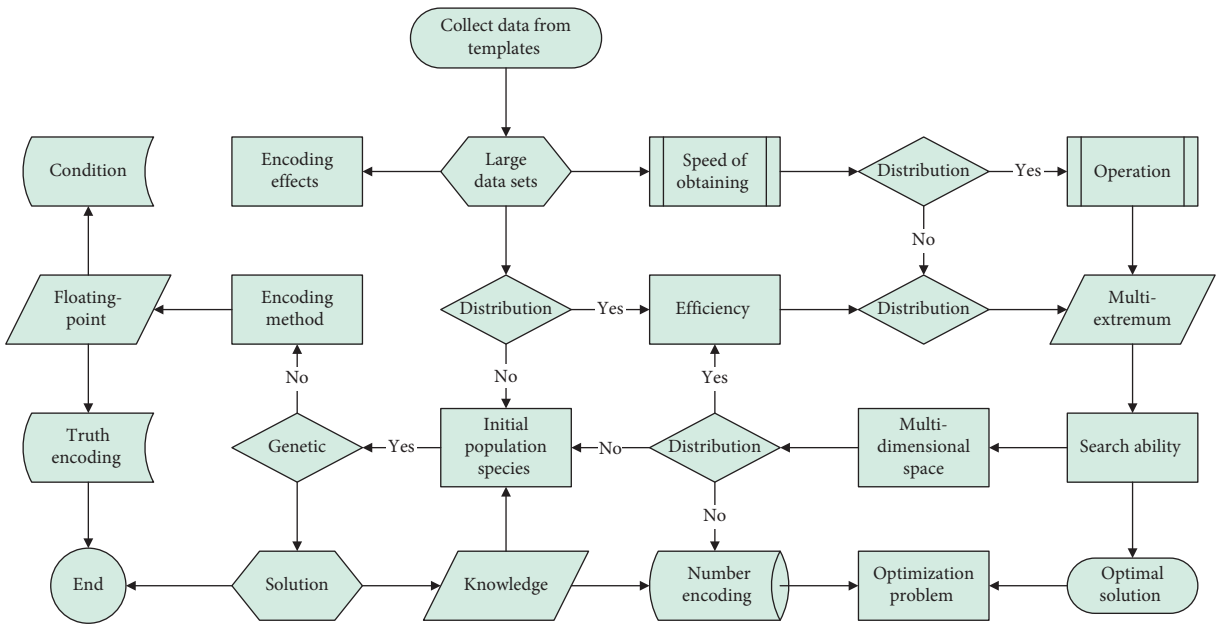

Figure 2: Algorithm flowchart.

optimal number of clusters. However, for some problems, it cannot be calculated, and the efficiency is low. The server, teacher computer, and student computer all contain a system authorization module. Another example is The NBC lust package, whose idea is like the McCluster package, which defines multiple evaluation indicators, performs multiple traversals, and finally selects the cluster with the largest number of indicators supported.

3.2. Design of Teaching Management System. Because there are many messages pushed in the system, technologies such as WebSocket need to be used. For the server in the system, if Java used for development, such as using Spring and other common server development frameworks, there is no native WebSocket support, it needs to be extended using the STOMP protocol, which will introduce additional performance overhead and increase the complexity of system development [19]. Therefore, in the technical selection of the system, the server-side also uses Web technology for development, uses Node.js to build server-side applications, and uses express as the server-side framework to avoid the above problems.

The whole teaching management system divided into three parts: classroom server, teacher computer management system, and student computer management system. According to the idea of "high cohesion and low coupling," the level division of the server, teacher computer, and student computer are consistent, and the three parts use the classic internal MVC three-tier architecture. This threshold usually depends on the solving problem itself, and it is difficult to find the optimal value, which brings great inconvenience to numerical simulation. As shown in the system architecture diagram in Figure 3, the three parts of the entire system are divided into three layers: data layer, presentation layer, and business layer, which improves modularity, ease of use, and reusability, making the entire system more flexible. The data layer defines the data entities contained in the system, the view layer defines the user interface display mode of the system, and the business layer is used to process the business logic of updating data or views.

The teacher computer and the student computer belong to the client-side application programs, which are mainly based on user interaction and network communication, and can adopt the same design scheme and technology stack, which is conducive to reducing the complexity of development and maintenance and enhancing the value of module reuse. Both the teacher's computer and the student's computer are developed based on Electron using React and related Web technologies. The teacher's computer is mainly based on the display function and provides teachers with a wealth of management functions, including courseware management, answering management, monitoring and demonstration teaching, and other functions. Courseware management includes viewing the downloaded courseware information and the scene information contained in the courseware, as well as scene control including opening, switching, and closing scenes. Answer management supports functions such as creating test questions and setting test duration, distributing test questions to students, and visual feedback on test results [20]. During the teaching process, teachers can view the pictures on the students' headsets and give voice guidance. The system authorization module in the server records the information of all legal devices in the classroom and rejects the access request of unauthorized devices.

In addition, teachers can also bring virtual reality headsets, and through the demonstration teaching function, the virtual scenes in the teachers' headsets can be integrated with the real environment of the teachers, and output to the screen to demonstrate to the students. The student computer

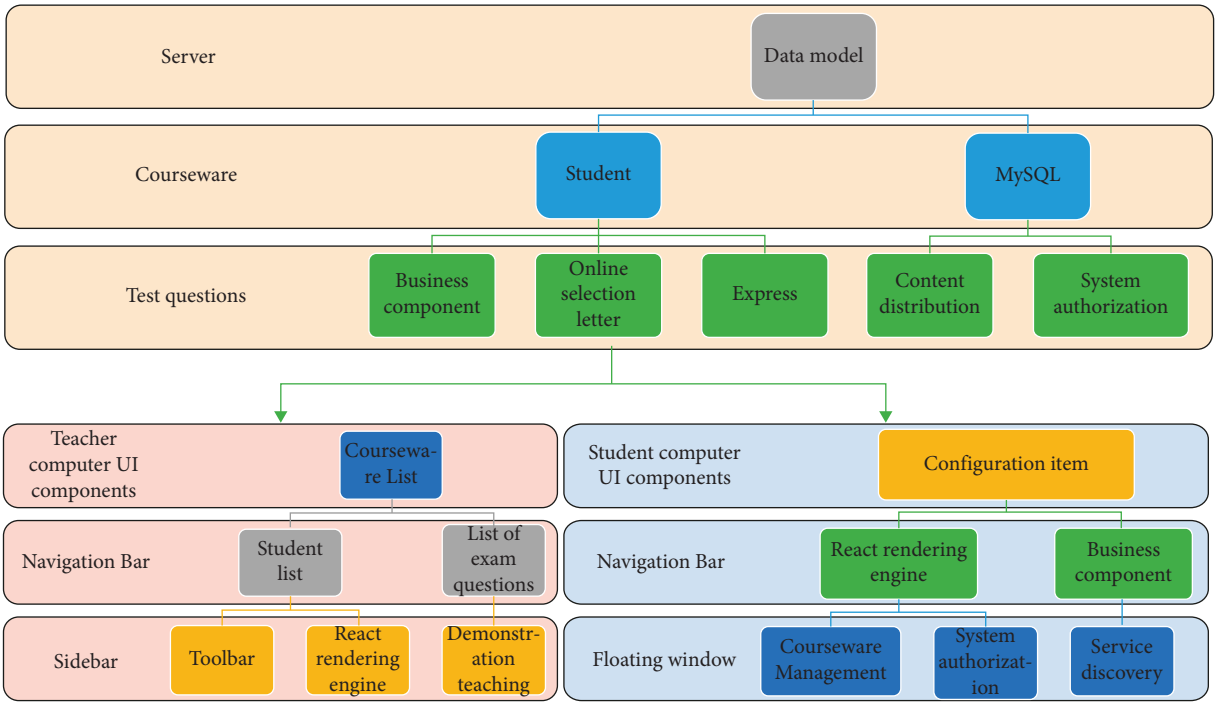

Figure 3: System architecture diagram.

is mainly used to download the courseware content from the server and process various messages from the server. In the teaching process, the student terminal carries the communication with the courseware content, including the functions of courseware management and answer management, and carries the audio and video communication with the teacher's computer.

Before the system can go live, it needs to be deployed in classrooms. The deployment process is done by professionals within the company responsible for implementation. The deployment process is mainly to configure the student computer, including the number of the seat and the address of the local courseware. At this time, the configuration item component is called to complete the relevant configuration.

The courseware list is used to display all downloaded courseware in the current classroom, and it is also a collection of all courses that can be opened at the current time. Among them, each courseware in the list will also contain a corresponding scene list. Therefore, scholars and experts apply knowledge such as mathematics and statistics to classification problems. The student list is used to display all student seat information in the current classroom, including seat number and student learning status. Among them, the student state includes four different states: ready, learning, offline, and abnormal. When the students are in the learning state, the student list calls the video player to display the pictures that all the students see in the virtual reality headset, as shown in Figure 4.

Many network communications are implied in the system requirements, including active requests, such as the teacher's computer requesting the server for a course list and the sending of messages such as opening a course, as well as many messages pushes, such as the server actively asking the student's computer to push the message of synchronizing courseware and the news of opening the course. It increases the difficulty of machine learning, and the learning effect is poor. Therefore, it is necessary to abstract the network communication into a separate basic business module, which can provide basic network services including active requests and message push to other components of the business layer. At the same time, after the network communication is extracted into a separate module, all network requests in the system can be uniformly authenticated and processed by the system authorization module, so that all illegal requests can be uniformly processed.

Both system authorization and content protection require access to hardware information, require close interaction with the operating system and the host hardware itself, and are therefore handled as separate components. The server, teacher computer, and student computer all contain a system authorization module. The system authorization module in the server records the information of all legal devices in the classroom and rejects the access request of unauthorized devices.

The courseware management module includes the network communication and content distribution components in the server, the network connection and courseware management of the teacher's computer and the student's computer, and the file transfer of the student's computer [21]. Invoke the network communication module and content distribution module provided by the basic business layer in the server to automatically download the authorized courseware from the content cloud store. When the teacher starts a class, the file transfer module is invoked on the student computer to quickly transfer the courseware to all online student computers, and the instruction to start the

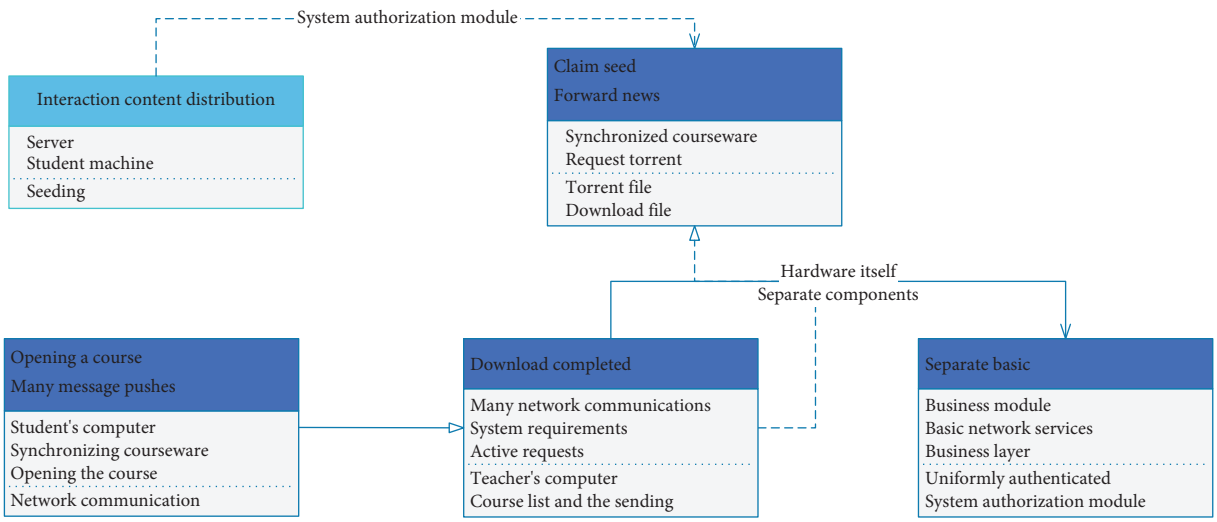

Figure 4: Content distribution sequence diagram.

class is pushed to the student computer terminal through the server. In addition, this module provides push forwarding of messages such as switching scenes and ending courses through the courseware management component and provides courseware and scene query services to the teacher's computer terminal.

4. Result Analysis

4.1. Performance Analysis of Big Data Fuzzy K-Means Clustering Algorithm. At first, analogous to the traditional multimedia classroom, the demonstration teaching was to meet the needs of the students' computers to view the pictures of the teacher's computer and to project the pictures of the teacher's computer to the students' computers. This process can be regarded as the reverse process of the teacher's computer viewing the student's computer screen. Therefore, it is usually necessary to make various improvements to the cluster analysis method according to different problems and needs to meet its clustering needs. The teacher's computer to view the student computer screen is to send the video stream of all student computers in the classroom to the teacher's computer through the streaming service module, and the demonstration teaching currently is to send the desktop video stream of the teacher computer to all students in the room at the same time. The analogy to the scheme in the teacher computer viewing the student computer screen in the previous courseware management chapter, because WebRTC itself does not support the broadcast mechanism, the video stream captured by the teacher computer can only be added to the corresponding connections of all student computers to simulate broadcast mechanism. Correspondingly, when the teacher computer ends the demonstration teaching, it traverses all online student computer numbers to find the corresponding Peer Connection object, then closes the connection.

After the relevant functions developed and launched, they will undergo a second demand adjustment. The demonstration teaching function has been redefined from the perspective of demand from the initial analogy to traditional multimedia classrooms and more integrated with the scene characteristics of virtual reality teaching. Teachers can also wear virtual reality headsets to demonstrate virtual reality to students during class. In the operation of the real scene and the explanation of relevant knowledge points, the demonstration teaching function needs to be able to synthesize the virtual scene in the teacher's head-mounted display and the teacher himself into the same scene. After the requirements are adjusted, it is completely different from the previous requirements. At the same time, this result also tells people from another aspect that using neural networks for deep learning must require enough training samples. If the previous plan is modified, at most, the students can only see the picture of the teacher's head-mounted display but cannot be directly related to the teacher's operation, resulting in the previously realized solution can only be discarded, and the technology selection needs to be reselected, as shown in Figure 5.

The traditional initial clustering center often randomly selects K sample data as K clustering centers in the sample data. On the one hand, this selection method increases the probability of isolated points being used as clustering centers. The probability that multiple cluster centers is close increases; the emergence of these two situations leads to the deterioration of the quality of the clustering results. At the same time, due to the randomness of the selection of the clustering centers, the clustering results are not stable. Multiple clustering may occur, and the results will vary each time, making the clustering results difficult to apply in practice.

To verify that the fuzzy clustering algorithm (FCM) based on a genetic algorithm can improve the effectiveness of the center point sensitivity of the fuzzy clustering algorithm, this paper compares the GA - FCM algorithm with other clustering algorithms, using the machine learning library from UCI, respectively. There are certain barriers. There are few college teaching management system development companies in the market and there is a certain

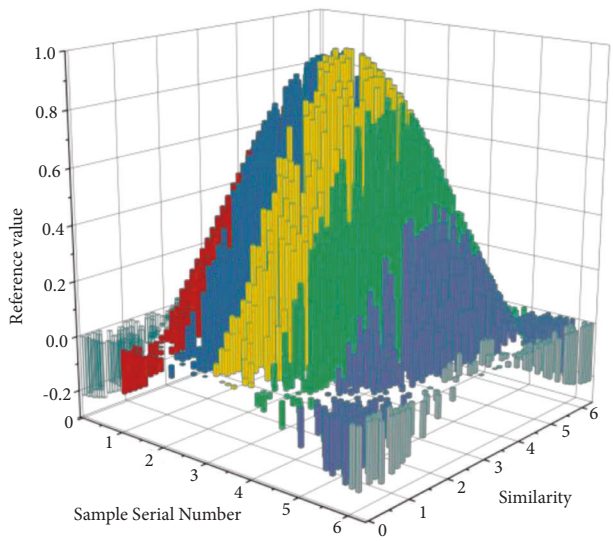

Figure 5: Based on AFV similarity calculation result.

monopoly. The three standard datasets of Iris, wine, and crude oil are used to simulate these algorithms. The following is a brief description of these data sets: Wine data set is the analysis of various parameters of wine; Iris data set is the result of statistical analysis of various aspects of iris plants. Below we take the Kth neuron as an example to design, as shown in Figure 6.

The variance of the output value is smaller than the variance of the actual value, indicating that the fluctuation between the output value and the average value is smaller, which is caused by the higher final grades and lower data volume in the training set, which increases the difficulty of machine learning, and the learning effect is poor. At the same time, this result also tells people from another aspect that using neural networks for deep learning must require enough training samples. Only in this way can the learning effect be guaranteed.

The fitness function of the genetic algorithm reaches the maximum value for the first time, but it does not converge directly, but finds the second extreme point in the 7th time, until about the 13th time, and finally converges to about 66.03280034. Therefore, the relationship between software companies and colleges and universities is in a delicate state. This fully reflects the advantages of the fast convergence of the FCM clustering algorithm and the characteristics of the global optimization of the genetic algorithm do not make the clustering prematurely converge to the extreme point but finally find the global optimum. Course application and registration can be carried out according to the requirements of the training objectives, and at the same time, it can also make detailed inquiries about the courses declared by individuals.

4.2. Test Results of Teaching Management System. Through this module, academic leaders can query and review the published articles and directly respond to the needs of the articles that need further revision before they can be

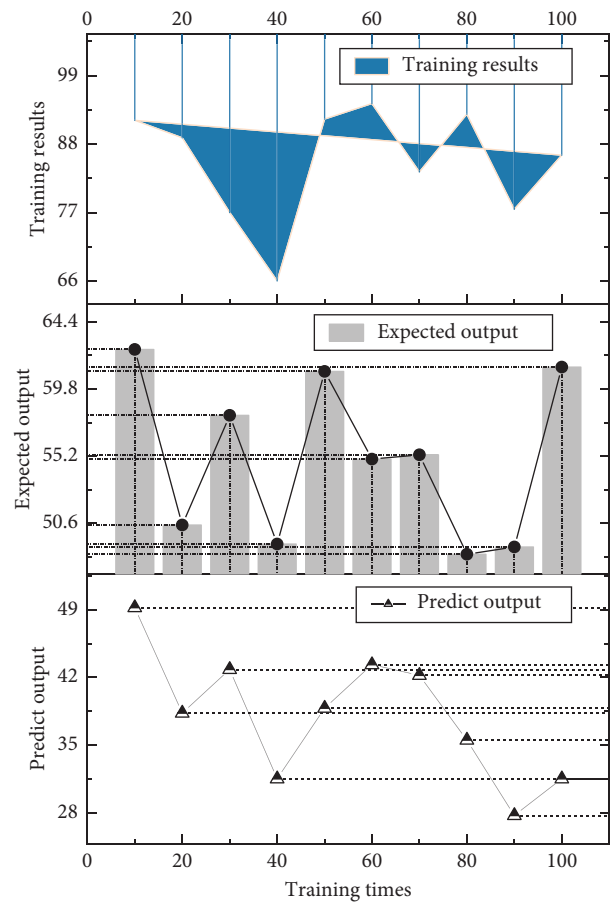

Figure 6: Comparison of training results with ground truth.

published. Edit the revised opinion information, save, and upload it, and the system will update the review status of the article. According to the actual requirements of the college, the academic staff can set the most important articles to the top of the published articles according to their importance. During the operation of the function of managing articles, the academic leader selects "manage articles" on the homepage of the online teaching management system of Sajin Institute of Technology, then queries the articles to be published in the displayed interface, and enters the article review information. After the operation completed, the basic information of the article is directly saved and uploaded to the database, and then the article is pinned according to the actual needs.

College students can inquire about the detailed information of personal data after entering the homepage of the system according to their actual needs and can edit basic personal information such as individuals. After the operation is completed, the personal information data in the database can be updated by saving it directly. Combined with the specific design, in the course arrangement of the teaching plan module, the system needs to reasonably arrange the courses for this semester according to the educational administration plan. The professional courses that need to be added can be added to the system platform, and the professional courses that are not needed can be deleted

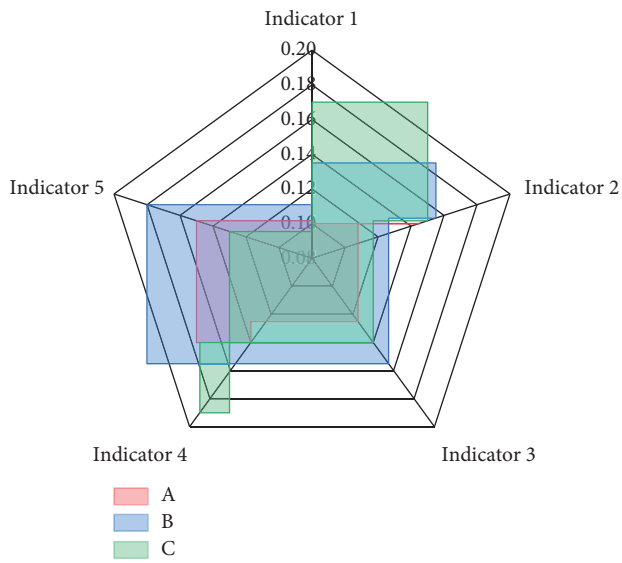

Figure 7: Indicator achievement degree chart.

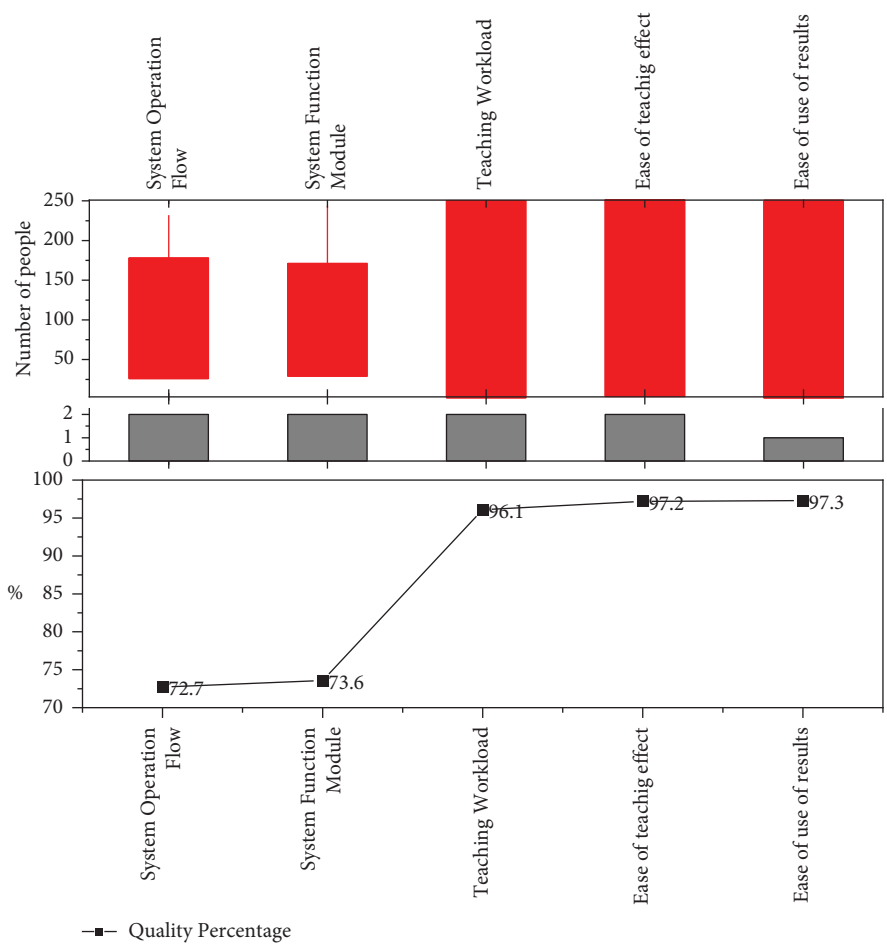

Figure 8: Satisfaction results of the teaching performance appraisal system in colleges and universities.

immediately, that is, control over courses and majors. Combined with the design, the specific implementation of the remote teaching plan management interface is shown in Figure 7. According to different majors, the system administrator can formulate a specific teaching plan according to the arrangement of the educational affairs. The research

on the key influencing factors of the scope management of college teaching management projects is of great significance to the scientific and orderly construction of the entire teaching management system project.

System database design is mainly based on the specific design method of database logic structure and data information table. A big difference between virtual reality classrooms and traditional multimedia classrooms is that virtual reality classrooms need to distribute large-scale courseware content. It takes a lot of time to transmit virtual reality teaching courseware using a traditional content distribution scheme. The system is designed to distribute content in a P2P manner so that the transmission time does not increase linearly with the increase in the number of students' computers. Usually, a courseware distribution can be completed in about half a minute, which significantly shortens the transmission time, as shown in Figure 8.

Although the scale of use of the system is small and the amount of data is small, it can be seen from the survey results and the interviews with the relevant persons in charge of the project that the system further improves the work efficiency of teaching staff and management personnel facilitates teachers and students. It provides a blueprint for the development and management of other subsystems and modules of the *Z* university teaching management system in the future. Therefore, constructive opinions and suggestions are put forward for the management of college teaching management system projects at various stages, especially for scope management. At the same time, the validity of the model proposed in this paper is preliminarily verified within a certain range.

Teachers can distribute test questions to students during class. Teachers can use this system to distribute all the test questions that have been prepared before class to students with the same questions, or they can assign different test questions to groups; set the test time. When all students have completed their answers or the test has timed out, teachers can view the answers of all students through the teacher terminal.

5. Conclusion

Based on the K-means clustering algorithm, this paper constructs two K-means clustering algorithm frameworks with different constraints, and its effectiveness is verified by many experiments. Combining data space structure constraints with the K-means clustering algorithm, a clustering model with clear and unified objective function constraints is proposed. The coding method not only affects the operation of the genetic operator but also affects its convergence speed and accuracy, so the coding method is important in the genetic algorithm. Through analysis, the FCM clustering algorithm is prone to premature convergence in data processing and thus cannot achieve the global optimum. Therefore, after research and use of the genetic algorithm and the FCM algorithm in combination, GA- FCM can effectively use the genetic algorithm and the FCM algorithm. The advantages make it better applied to undergraduate engineering quality certification. Using the model method, the obtained AHP hierarchical structure model is used to construct the key influencing factor matrix and through the ISM method, the explanation structure model of the key influencing factors of the teaching management project scope management is obtained, and the relationship between the factors is clarified. In the improvement of the project, the validity of the model is verified.

Data Availability

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

Conflicts of Interest

The author declares that there are no conflicts of interest or personal relationships that could have appeared to influence the work reported in this paper.

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Hindawi
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Retraction

Retracted: An Evaluation Model of Urban-Rural Exchange Teachers in Elementary School Based on Optimal Control Neural Network

Mathematical Problems in Engineering

Received 13 September 2023; Accepted 13 September 2023; Published 14 September 2023

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

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

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

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

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

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

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

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[1] K. Chen, "An Evaluation Model of Urban-Rural Exchange Teachers in Elementary School Based on Optimal Control Neural Network," *Mathematical Problems in Engineering*, vol. 2022, Article ID 7808127, 13 pages, 2022.

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Research Article

An Evaluation Model of Urban-Rural Exchange Teachers in Elementary School Based on Optimal Control Neural Network

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In this paper, an optimal control neural network algorithm is used to conduct an in-depth study and analysis of the evaluation of elementary school urban-rural exchange teachers, and an optimal control neural network evaluation model is designed and applied to the actual elementary school urban-rural exchange process. A tracking controller is designed to track the target trajectory for a typical second-order nonlinear system where the system model is partially unknown and the internal state of the system is unpredictable. The neural network observer is first designed using the input and output information of the system to approximate the drift dynamics of the system on the one hand and estimate the internal state information of the system on the other hand; then, based on the estimated system state, the sliding mode tracking controller is designed to achieve tracking of the established target trajectory. It is found that the policy implementation is not in place, teachers are not motivated to exchange and most of them aim at position promotion, their sense of responsibility is weak, and they cannot treat the matter of exchange seriously and correctly, thus cannot play their role in the exchange school. The ways to prevent and alleviate the conflict of interest among policy subjects are mainly divided into subjective and objective aspects: first, from the subjective level to arouse the value recognition of multiple interest subjects, including the government, should play the function of policy guidance and exhortation and clarify the value orientation of the policy; schools should cultivate the moral quality and professionalism of teachers and strengthen ideological mobilization; and teachers should improve their ideological awareness and consciously change their willingness to exchange. Establishing teachers' status as civil servants, paying attention to teachers' professional development and safeguarding the interests of rotating teachers to increase teachers' motivation to exchange and rotate, creating a good social opinion environment, providing a good inflow school support environment for rotating teachers, and building a cloud platform for sharing high-quality educational resources create a good policy implementation environment to ensure that the teacher exchange and rotation policy is effectively implemented to achieve its goals of balancing teacher deployment. Although gradient-based methods can achieve high training accuracy, the performance of the backpropagation algorithm may be unsatisfactory when applied to test data, that is, if the size of the training data is not large enough.

1. Introduction

The dual structure system of urban and rural areas has created a significant gap between urban and rural education. At the beginning of the founding of New China, to break the international blockade and accelerate the establishment of an independent and complete industrial system, the Party shifted its focus from the countryside to the cities, giving priority to the development of heavy industry [1]. The modernized and large industrial economy in the cities developed rapidly, and urban residents enjoyed high-income levels, developed infrastructure, welfare protection, and numerous subsidies for employment, medical care, pensions, and housing. In contrast, the rural areas are dominated by small farming economies, and the "scissors difference" between industrial and agricultural products imposed by the state to increase funds for the development of heavy industry has led to slow development of the agricultural economy and low incomes for farmers. Among all these elements, the reform of mathematics classroom teaching style is the most difficult, the most difficult bone to chew, but also the most critical element [2]. Deepening self-

understanding of roles and enriching individual's practice of roles are crucial for teachers to adapt to the various roles in teaching-research interaction. In the process of education development, achieving a balanced development of education is the fundamental goal. The unbalanced development of education is still very prominent between urban and rural areas, with urban areas having a huge advantage in access to educational resources, while rural areas still have a very prominent problem of low level of educational development due to the limitations of the conditions. Therefore, optimizing rural elementary school mathematics classrooms and exploring classroom teaching methods adapted to rural reality are conducive to shortening the gap between urban and rural education, improving the quality of rural classroom teaching, maintaining social stability, improving national quality, promoting balanced and coordinated linkage development of education, and providing educational support to win the battle against poverty [3].

At this stage, there are a lot of research results on the teaching methods of elementary school mathematics classrooms at home and abroad, but there are relatively few studies on the teaching methods of urban and rural elementary school mathematics classrooms by way of comparison. Therefore, strengthening this aspect of analysis can provide a good theoretical reference for the optimization of the teaching methods of urban and rural elementary school mathematics classrooms. In addition, studying the differences between urban and rural elementary school mathematics classroom teaching styles is conducive to the general strategies and approaches to improve the efficiency of rural elementary school mathematics classroom teaching to promote the common development of teachers and students, to provide a basis for education departments or schools to develop more reasonable solution strategies in the future and to provide some practical suggestions or ideas to narrow the gap between urban and rural education, and eventually narrow the gap between urban and rural education [4]. In addition, through classroom field observation and recording the real teaching situation in classrooms, we can compare the advantages and disadvantages of urban and rural education in terms of classroom introduction, teaching process, and teaching summary and learn the strengths of teaching in urban schools, to provide theoretical support and realistic basis for abandoning the old teaching concepts and updating teaching behaviors in rural areas, which are conducive to the realization of equitable educational development [5].

Transcendental dynamic optimization methods have the advantages of fast speed and hardware implementation ability when dealing with optimization problems. In recent years, neural dynamic optimization methods have received a lot of attention from scholars. However, most of the research is on convex optimization problems or pseudoconvex optimization problems, and not much research has been conducted on general nonconvex optimization problems. The general neural dynamic optimization methods usually can only find a local optimum when facing a nonconvex optimization problem with multiple minima, and even less when discussing nonintegrable problems. Therefore, further research on neural dynamic optimization methods to solve more nonconvex and nonintegrable optimization problems is of research value. The theoretical basis of approximate optimal control based on neural networks is optimal control theory. The adjustment of the internal state is inseparable from the cooperation of the three interactive subjects of teaching and research staff, urban teachers, and rural teachers and pays attention to the personal characteristics, expectations, emotions, and interpersonal relationships among the teaching and research subjects. Optimal control refers to solving the optimal control strategy of a dynamic system by optimizing a given performance index function to achieve the desired control effect. The traditional optimal control theory has been developed and matured. Based on the optimal state control pairs generated in research method II, a deep neural network is used to fit the nonlinear relationship between the given state and the optimal action, and after sufficient training, it is verified whether it can be used for real-time optimal control.

2. Related Jobs

The most crucial step before policy implementation is to formulate a reasonable, perfect, and well-defined policy. Fan Caixia and He Bian analyzed 21 provincial-level policy texts on teacher exchange and rotation across China and found that the policies have vague goal setting, insufficient content relevance, various safeguards but poor implementation effect, and a lack of clear monitoring and assessment programs [6]. The teacher exchange and rotation policy in China is formulated by government departments to solve problems such as educational balance and equity and is implemented by the government as an administrative subject through administrative means, which is compulsory, and the commanding tools make the policy implementation efficient and wide coverage [7]. However, scholars such as Salvati and Carlucci argue that the mandatory teacher exchange and rotation policy does not conform to the law of upward mobility and violates the natural law of "survival of the fittest"; it also reduces the stability of the teaching profession, which in turn reduces the attractiveness of the teaching profession and causes many outstanding talents to leave the education field [8]. In addition, other scholars have studied China's teacher exchange and rotation policy from the perspectives of legalism, ethics, and economics. Therefore, it is more prominent in stimulating students' interest in inquiry. Amaral researches the legality of the policy, pointing out that the implementation subjects of the current teacher exchange and rotation policies in various places are not legal, some policy contents contradict the existing laws, and the legality of the policy procedures is insufficient [9]. Chen analyzes the history of the evolution of China's education policy ethics and finds its general characteristic of "gradually reverting to publicness" while pointing out that the county teacher exchange and rotation policy has problems such as the policy goal emphasizing balance rather than efficiency and the policy means emphasizing coercion rather than flexibility [10]. The policy ethics of fairness and justice and limited flexibility should be maintained throughout the process.

Werbos first used the idea of reinforcement learning for optimal control theory, and later scholars developed it continuously, and the learning process of optimal reinforcement learning algorithms developed to a higher level, where its learning objective is not the dynamics of the system but the optimal performance index of the closed-loop system to reach optimality [11]. The reinforcement learning algorithms at this stage are mainly applied to solve the optimal calming problem, the tracking problem, and the H-control problem when the system model is completely known. Reference [12] solves the infinite-time optimal control problem for parametric stochastic nonlinear systems using neural network approximation techniques based on reinforcement learning ideas. In Reference [13], a simultaneous reinforcement learning algorithm is proposed, the weights of the behavior and evaluation networks are updated synchronously, and an optimal controller is designed to make the closed-loop system stable and satisfy the optimal performance index function. Based on the multi-intelligent system control model, a dynamic game model with multiple distributed energy storage units and loads in islanded operation mode is studied, the load demand response generated by the flexible power tariff is considered, and a tariff bidding decision is established based on a reinforcement learning algorithm to achieve economic optimization of the microgrid. Reference [14] proposed a cooperative control framework for multiple microgrids based on multi-intelligent body systems, which aims to encourage resource sharing among different microgrids and solve the resource imbalance problem through coalitions among microgrids and proposed a hierarchical cooperative control framework and corresponding negotiation algorithms to model the coordination behavior of microgrids. Especially in urban primary schools, the utilization rate of multimedia equipment is relatively high, and the attention and practicality of information technology are relatively high.

Strengthening the exchange between urban and rural teachers can compensate for the shortcomings of short-term excellent teacher supplementation that cannot steadily and comprehensively help rural teachers efficiently improve their competence. Regular linked teaching and research activities between urban and rural schools in the county are an important means of exchange between urban and rural teachers at present. Urban teachers and rural teachers use various specific problems faced by teachers during curriculum implementation as objects to solve practical teaching problems through cooperative learning and exchange and discussion and to gain teaching experience and improve teaching theories, to eventually achieve teachers' professional growth. In the formal teaching and research activities, urban and rural teachers interact around specific problems in an atmosphere of equal communication and cooperate to solve problems, and finally, the teaching researchers and master teachers make in-depth analyses of the problems and summarize the teaching and research results; after the urban-rural joint teaching and research, rural teachers interact and exchange with urban teachers through teaching and research contents on new educational concepts, subject curriculum understanding, subject teaching problems, subject teaching methods, teaching management problems, etc., and gain. After returning to school, they transformed their knowledge into actual teaching through their understanding. The unique teaching environment of rural schools also broadens the horizons of urban teachers from another perspective, helping them to master how to teach in different teaching objects and teaching environments, which is more conducive to the professional growth of urban teachers.

3. Optimal Control Neural Network Algorithm Design

The optimal control theory approach is an important part of the composition of modern control theory. These two techniques have greatly enriched and improved the optimal control theory and promoted the development of analytical methods for solving optimal control problems [15]. Moreover, at that time, when humankind first started to explore space, the techniques based on optimal control theory were well integrated with practical engineering, for example, in spacecraft trajectory design and Kalman filter, where quite successful research results were achieved.

As the optimal control problems encountered in engineering become increasingly complex, it makes the analytical method to find the optimal problem solution increasingly impossible. But fortunately, due to the gradual maturity of computing technology and the rapid development of hardware devices, we can use it to achieve numerical solutions, for example, the neighborhood extremum method, the simplex method, and the gradient method are common numerical methods. In the past half-century, optimal control theory has been widely used in many fields such as aerospace engineering, chemical engineering, economics, communication, and automotive engineering. Allow students to actively participate in the exploration and communication of problems in this environment. Students are assigned to groups in the classroom, and each member of the group can be paid attention to in the interaction between students. Computational optimal control techniques have also attracted increased attention as the core of implementing optimal control theory in practice.

According to the basic components of the optimal control problem, the general description of the optimal control problem is first outlined, that is, the system equation of state, that is, the dynamics model, is derived from the analysis of the dynamics, or the realization of the system from the input-output relationship and has the following form of expression under the given initial conditions:

$$\begin{aligned} \dot{s} &= f\left(s(t), u(t), t^2\right), \\ s\left(t_0^2\right) &= s_0, \end{aligned} \tag{1}$$

where $s \in R''$, $u \in R_m$ and the function $f(s(t))$ and $u(t)$ is a kinetic model in the form of differential equations obtained in advance, which is a continuous vector function. The objective of optimal control is to find an optimal control

function $u^*(t)$ such that the minimum or maximum of is satisfied during the transfer of the system from the known initial state so to the target end-state $s(tr)$.

$$J = \phi\left(s\left(t_f\right), t_f\right) - \int_{t_0}^{t_f} L\left(s(t), u\left(t^2\right)\right)\mathrm{d}t, \tag{2}$$

where $L(s(t))$, $u(t)$ contains the path constraint in the trajectory planning problem and $P(s(t))$ contains the end-state constraint. While taking the extreme value of the above equation and satisfying the edge value constraint of the solution process, the above equation constitutes the continuous Bolza problem of optimal control. That is, the nonlinear expression ability is not enough, which directly leads to the slow convergence speed of the neural network and even underfitting, which means that the neural network cannot achieve high prediction accuracy for the training data set within a given time. Distilling the above equation into a standard form:

$$s.t. = \begin{cases} \dfrac{ds(t)}{dt} = f(s(t), u(t), t), \\ C(s(t), u(t)) \geq 0, \\ B\left(s\left(t_f\right), u\left(t_f\right)\right) = 0, \\ t \in \left[t_0, t_f\right], \end{cases} \tag{3}$$

where $C(s(t))$, $u(t)$ contains the inequality constraint terms such as path constraints and fetch range constraints and $B(s(t))$, $u(t)$ is the equation constraint term that contains the boundary value constraints. Corresponding to our AGV trajectory planning problem, we require time-optimal control and need to satisfy the obstacle avoidance requirements during the AGV motion, so we can specify the standard continuous Bolza problem with optimal control as follows:

$$J = \varphi\left(s\left(t_f\right), t_f^2\right) - \int_{t_0}^{t_f} L\left(s(t), u^2\left(t_i^2\right)\right)\mathrm{d}t. \tag{4}$$

The traditional optimal control problem is based on the classical variational method, which derives the necessary conditions for its optimal solution under the condition that the generalized variational takes extreme values [16]. For the given problem, the transformation of the generalized conditional extreme value problem into an unconditional generalized extreme value problem can be carried out by introducing two independent Lagrange multiplier vectors $g_k(t) \in R$ with $\lambda(t) = R_r$.

$$\max J = t_f - \rho \int_{t_0}^{t_f} \sum_{k=1}^{M} \lim_{e \longrightarrow 0} G_k\left(g_k(t), e^2\right)\mathrm{d}t. \tag{5}$$

The initial values of the state and covariate variables are empirically given first. Based on the guessed values and the known initial conditions, the original difficult-to-solve two-point boundary value problem is transformed into an initial value search problem for the system of differential equations. Activation functions with high-order differentiability, nonlinearity, monotonicity, and other characteristics in neural networks also have an important impact on deep neural networks. After the final values of the states, covariates, and control quantities are obtained gradually by numerical integration, they are compared with the given end-state constraints to determine whether they are within the given error tolerance, and if not, the initial values are corrected by linear interpolation and the initial value search problem is repeated.

The policy iteration technique is one of the basic methods for solving the optimal policy in dynamic programming, which is the process of solving the optimal control sequence one by one with the help of dynamic programming iterative equations. The most used PI technique is the on-policy iterative method, which requires the complete or partial information of the system model in the process of solving the optimal control policy, and the off-policy iterative method has been developed and widely used in recent years to solve the optimal control policy when the system model is completely unknown. The specific implementation process of the two iterative techniques is described below, as shown in Figure 1.

The direct method starts by discretizing the continuous problem (either by discretizing only the states or by discretizing both the states and the control quantities) and then solves the control quantities numerically to optimize the given performance index. LR = 0.001 is an ideal choice because it is a trade-off between training accuracy and stability on the training and validation sets. As mentioned in the previous subsection, the indirect method is often more difficult and, in some cases, impossible to solve for specific problems with function variables. For problems with complex path constraints or highly nonlinear dynamical constraints, the indirect method appears to struggle, and solving two-point marginal problems by numerical methods is also often difficult, mainly due to problems such as the highly nonlinear nature of the system, but also because of the analytical method to determine. The main reason is not only the highly nonlinear nature of the system but also the difficulty of determining the cross-sectional conditions by the analytical method. Due to the small convergence radius, the indirect method requires a more accurate initial guess for the covariates, but the covariates themselves do not have an intuitive physical meaning as a basis for guessing, and it is difficult to give a good guess for the initial value of the covariates directly to ensure the convergence of the algorithm. On the contrary, the direct method is less sensitive to the initial value, has a large convergence radius, and does not require the derivation of the first-order necessary conditions, so it is more widely used in the solution of optimal control problems.

Least squares are a mathematical optimization technique that finds the best functional match of data by minimizing the sum of squares of the errors [17]. The use of least squares makes it easy to find unknown data and to minimize the sum of squares of the errors between these found data and the actual data. This section focuses on the evaluation of the

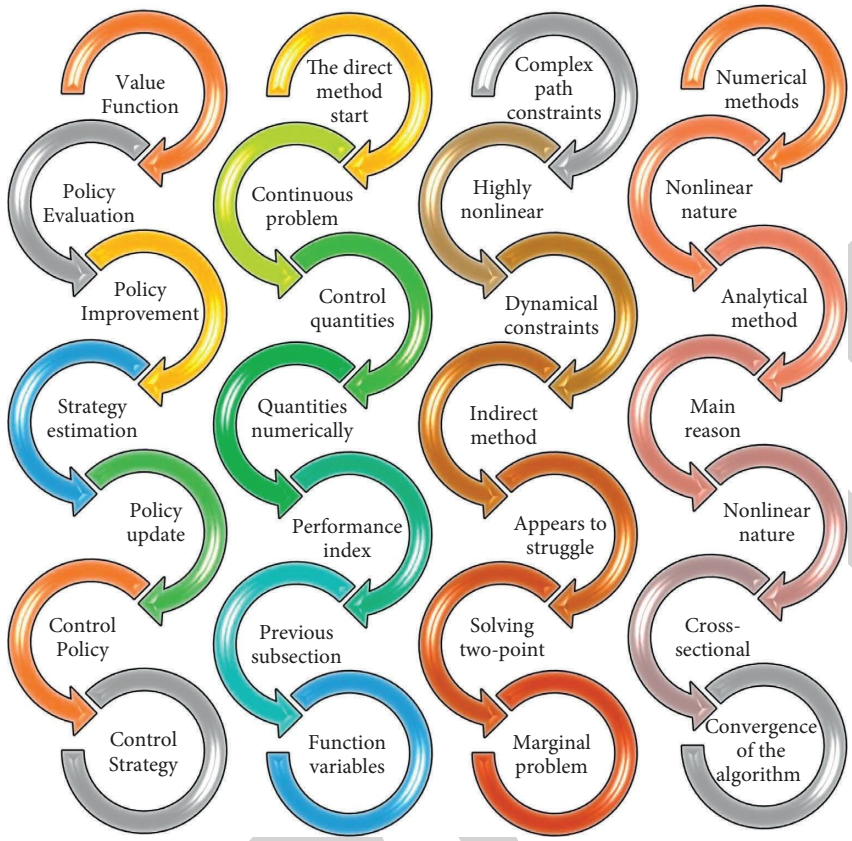

Figure 1: On-policy iterative technology.

network approximation of the performance indicator function as an example to illustrate the specific implementation of the least-squares principle.

To study the tracking problem when the internal state of the system is not directly available and the system drift dynamics $f(x)$ is not known, it is necessary to design a neural network observer to observe the state $x(t)$ of the system. In this section, the form of the neural network observer and the adaptive update law of the neural network weights are given first, and the stability of the neural network observer system is analyzed.

$$H = \begin{cases} \dot{x}(t) = Ax(t) - b\left[f(x) - g\left(x^2\right)u\right], \\ y(t) = C_x\left(t^2\right). \end{cases} \tag{6}$$

We have carried out a time-domain transformation of the original optimal control problem, and the next step is the solution to the problem. 39.09% of teachers believe that it is fully fulfilled, 46.36% of teachers believe that it is basically fulfilled, 11.82% of teachers believe that it is rarely fulfilled, and 2.73% of teachers believe that it has not been fulfilled at all. Pseudospectral methods belong to the class of direct configuration methods, in which the states can be parameterized and controlled by using global polynomials and juxtaposed differential algebra, while converting the original optimal control problem into a nonlinear programming problem, with the equations using the roots of Gaussian orthogonal polynomials as the nodes.

The Gaussian pseudospectral method does not require the guessing of the initial covariance, and, this method only requires the estimation of the state quantities under the physical concept. In particular, the KKT conditions of the nonlinear programming problem obtained by the Gaussian pseudospectral transformation coincide with the discrete form of the first-order optimal necessary conditions of the original optimal control problem, in other words, we can avoid the proof of the general direct method on whether the optimization objective of the solution is consistent with the original problem after discretization, and it has been shown that the local convergence rate of the Gaussian pseudospectral method increases exponentially, so it is currently a more general solution method.

It uses a label-based supervised learning method to train the neural network by using the error of the output results of the final layer with the label and back-propagating the error in a gradient way to update the neural network weights [18]. Although the gradient approach can achieve high training accuracy, the performance of the backpropagation algorithm may be unsatisfactory when applied to test data, that is, if the size of the training data is not large enough, the neural network will face the problem of overfitting, and because its error backpropagation is based on local gradient information with random initial points, making the algorithm often face the local optimum problem, as shown in Figure 2.

The trigger conditions can be calculated independently by the smart actuator, and the trigger signal is fed back to the

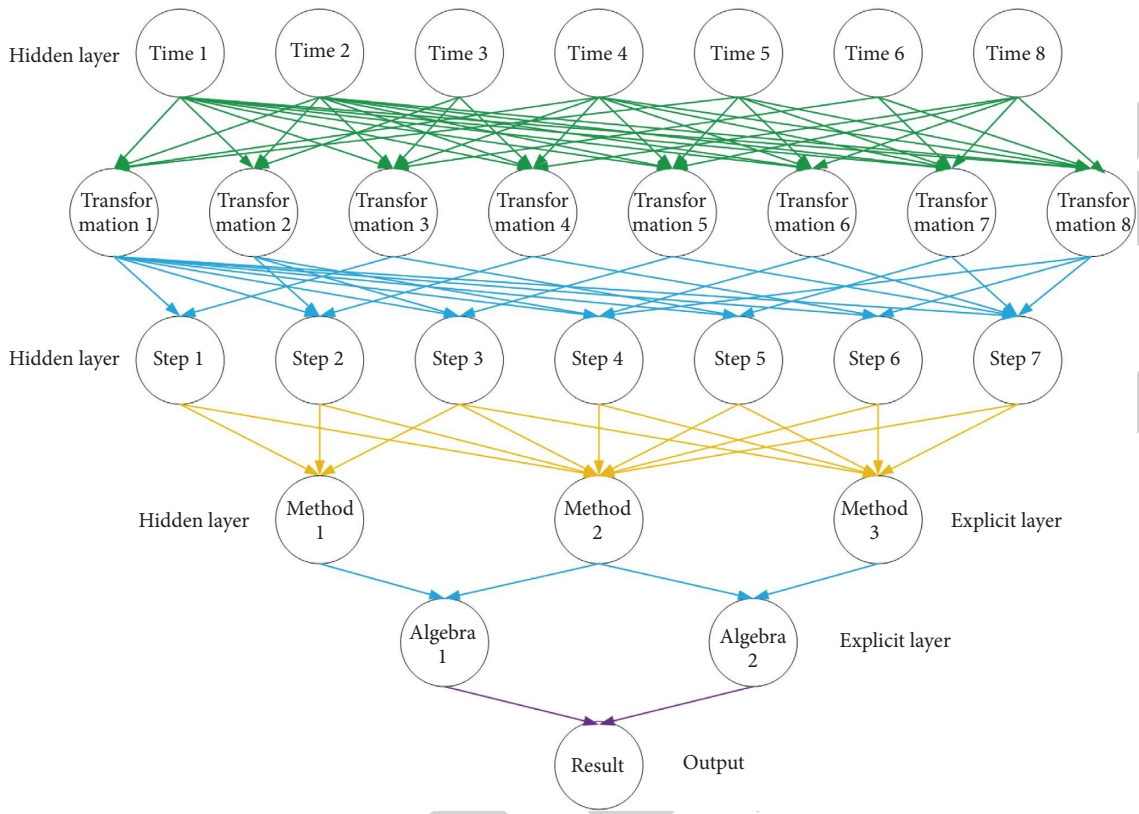

Figure 2: Optimal control neural network algorithm framework.

smart sensor and determines whether a sensor is required for status measurement. Schools that focus on teaching and research ability account for 19.09%, and schools that focus on teaching ability account for 37.27%, which are also a large proportion of the assessment content. This event triggering mechanism does not require continuous measurement by the sensor, which not only reduces the cost of the sampling frequency, control switching, and signal transmission but also effectively reduces the cost of measurement. This is a way to replace the cost of measurement with the computational cost of the controller, which makes sense because computational costs are getting lower with the development of computers, but the cost of continuous measurement of sensors can be high in some real-world production processes.

4. Analysis of the Evaluation Model of Urban-Rural Exchange Teachers in Elementary School

In the urban-rural linkage teaching and research activities, teachers, as members of the special environment of teaching and research, are bound to assume certain roles, participate in teaching, and research activities according to the behavioral norms of their roles and promote their professional growth through the smooth playing of their roles. Roles do not exist independently in the social environment, and individuals who play them do not just assume a certain role [19]. It is difficult to directly give a good guess for the initial value of the co-state to guarantee the convergence of the algorithm. On the contrary, the direct method is not sensitive to the initial value and has a large radius of convergence. Therefore, teachers need to understand the expectations of others, deepen their understanding of roles, and enrich their practice of roles in teaching and research activities to adapt to the multiple roles they play in teaching and research interactions. However, in the actual research, we found that there is a problem of role-playing disorder among the interactive subjects in the teaching and research interaction, which is manifested in the conflict of roles among the teaching and research subjects and the unclear understanding of the role of teaching and research.

Role unclearness refers to the role-players' lack of clarity about the behavioral norms of the roles they play and their lack of knowledge about what they should and should not do and how to behave in their role-group interactions. In the questionnaire survey of urban and rural teachers' joint teaching and research, the teachers who participated in teaching and research had unclear knowledge of the most important roles they played in teaching and research interactions.

The creation of the interactive context of teaching and research is the premise of effective interaction of teaching and research and is the basis and condition of teacher interaction. A good interactive context can provide a platform for equal communication between urban and rural linked teaching and research and provide space for the adjustment

of the interactive state of the teaching and research subjects. The interactive context of teaching and research includes both the external scenario of the participation of teaching and research subjects and the interactive state of the interactive group of teaching and research. In the current linked teaching and research of urban and rural teachers, there is not enough attention to the construction of interactive situations, a lack of planning for the construction of teaching and research situations, and a lack of attention to the interactive state of teachers.

The state of teacher interaction refers to the awareness, expectation, emotion, and interpersonal relationship between the teacher's self as the interacting subject and the others played by other teachers in the teaching-research interaction and the interaction pattern formed by combining the personality and behavior characteristics of the interacting subjects. The regulation of the internal state cannot be separated from the collaboration of the three main interacting subjects: the teacher-researcher, the urban teacher, and the rural teacher. It is important to pay attention to teachers' interaction status for the rational arrangement of the teaching and research interaction process and scientific evaluation of teaching and research interaction results. The proportion of schools that occasionally use other methods to replace communication is relatively large, 41.82%, and 21.82% of schools will definitely use other methods to replace communication. Through the author's observation of the teaching-research interaction situation and interviews with relevant teachers in the research process, I believe that there is a problem of poor teacher interaction status and insufficient attention to teacher interaction status in the current urban-rural linked teaching-research, as shown in Figure 3.

In contrast, the most frequent teaching activity carried out by rural elementary school mathematics teachers in the teaching process was mathematical problem training, which accounted for 97% of the total. In addition, we can find from the survey data that urban schools pay more attention to students' cooperative group inquiry, accounting for 85%, which is consistent with the new curriculum standards requiring students' independent inquiry and cooperative communication, and students will learn in such a classroom atmosphere to participate more actively in mathematics learning, thus improving the learning efficiency of the classroom [20].

Comprehensive analysis shows that urban elementary school mathematics teachers are more diverse in their choice of teaching aids and classroom activities than rural elementary school mathematics teachers and are therefore more prominent in stimulating students' interest in the inquiry. Urban elementary schools make relatively high use of multimedia equipment and pay more attention to and use information technology. The most noteworthy difference is that teachers in urban elementary schools pay more attention to the setting of good situations in the mathematics classroom, while teachers in rural elementary schools tend to pay less attention to the setting of situations in the mathematics classroom, which is the main difference between the two.

Based on the theory of interaction teaching, this chapter investigates the interaction mode of mathematics classroom teaching in urban and rural elementary schools [21]. The correction of the value repeated the initial value search problem. The so-called classroom interaction refers to the dynamic process of interaction and interaction in which the teacher makes good information exchange between teachers and students and between students and students through reasonable guidance in the classroom teaching process. In this paper, classroom interaction refers to the interaction between teachers and students, which includes both teacher-student interaction and student-student interaction. The interaction in this paper is not the process of teachers asking questions and students answering them in a narrow sense, but more importantly, classroom interaction can better bring into play teachers' creativity, stimulate students' learning initiative, make the interaction between teachers and students more frequent, and lay the foundation for building a good teacher-student relationship. In the elementary school mathematics classroom, the interaction between teachers and students is an important element reflecting the classroom teaching style, as shown in Figure 4.

In terms of classroom interaction, it contains both effective classroom interaction and ineffective classroom interaction, where effective classroom interaction enables teachers to create a good equally, and free seminar environment for students, in which students can actively participate in the exploration and communication of problems. The classroom will assign students to groups, and in the student-student interaction can pay attention to each member of the group, so that all students can participate in the interactive communication, and everyone has enough opportunities to express their ideas, and finally achieve the common development of teachers and students [22]. Appropriately extend the number of years of urban and rural teacher exchanges, so that exchange teachers can work in their posts steadfastly, design teaching plans suitable for local students according to local conditions, and improve school teaching levels. An ineffective classroom, on the other hand, mainly refers to false interaction, a form of classroom performance where the surface interaction is more biased, but it is more of a process where students passively answer the teacher's questions or passively participate in activities. In this survey, we focus on two aspects of classroom interaction: the form of classroom interaction and the effectiveness of classroom interaction to compare.

5. Analysis of Results

5.1. Optimal Control Neural Network Algorithm Performance Design. The mean-squared deviation is used as the loss function in the experiments, and the training process of neural networks combined with Adam's algorithm is aimed at minimizing the function loss, which can be easily solved by existing deep learning frameworks such as TensorFlow and PyTorch that can implement automatic differentiation.

The number of hidden layers and the units per layer are important hyperparameters that can determine the performance of the designed neural network. Too small a

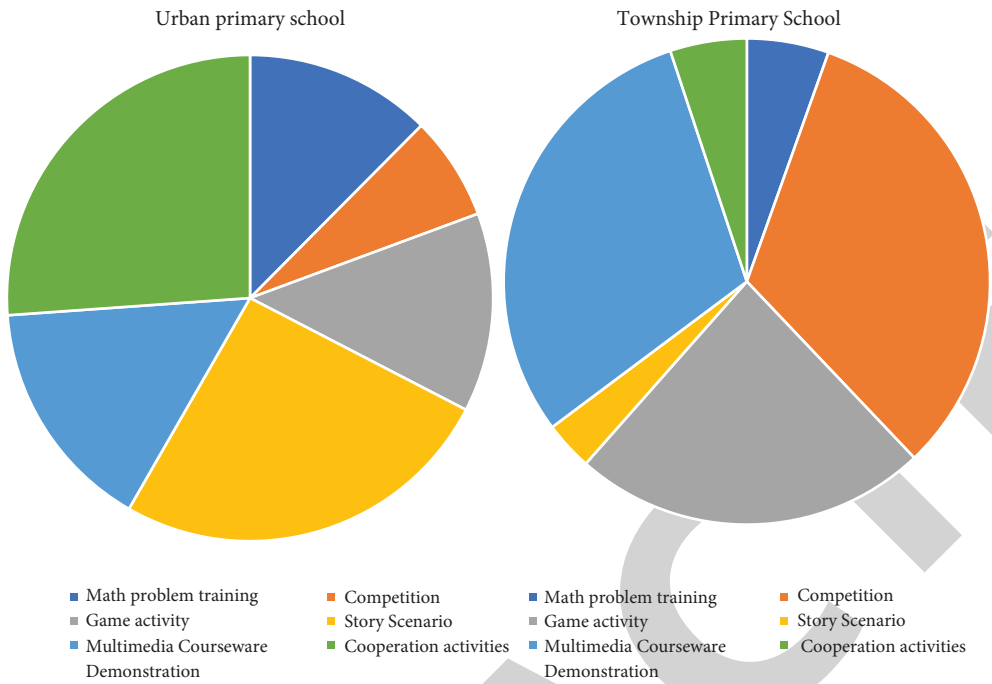

Figure 3: Types of classroom activities for mathematics teachers in urban and rural elementary schools.

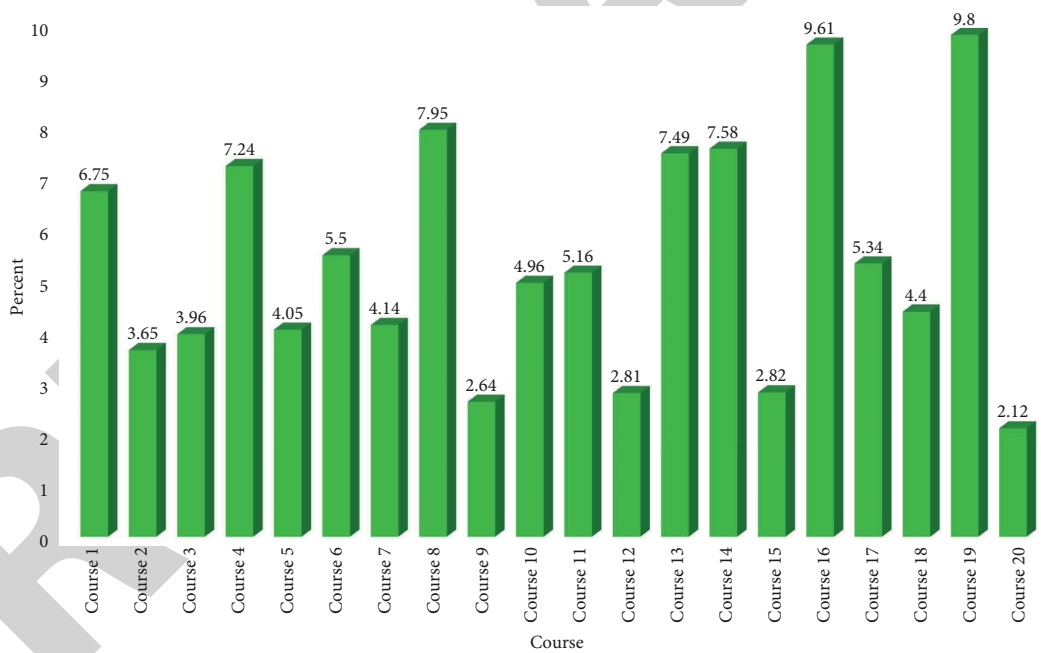

Figure 4: Subjects taught before and after teacher exchange.

selection of the number of hidden layers or hidden layer units, that is, insufficient nonlinear representation, directly leads to the problem of slow convergence or even underfitting of the neural network, which means that the neural network cannot achieve a high prediction accuracy for the training data set in each time. On the contrary, too many hidden layers or units directly lead to the multiplication of the number of network parameters, longer training time consuming possible overfitting problems, which will lead to a large gap in the performance of the neural network between the training and test sets, that is, poor generalization ability, which is unacceptable for our AGV trajectory planning problem because, during the AGV travel, there are bound to be training data sets that do not appear. In Figure 5, we trained the neural network structure with different numbers of layers and cell combinations for 100 epochs. First, arouse the value recognition of multiple stakeholders from the subjective level, including the government should

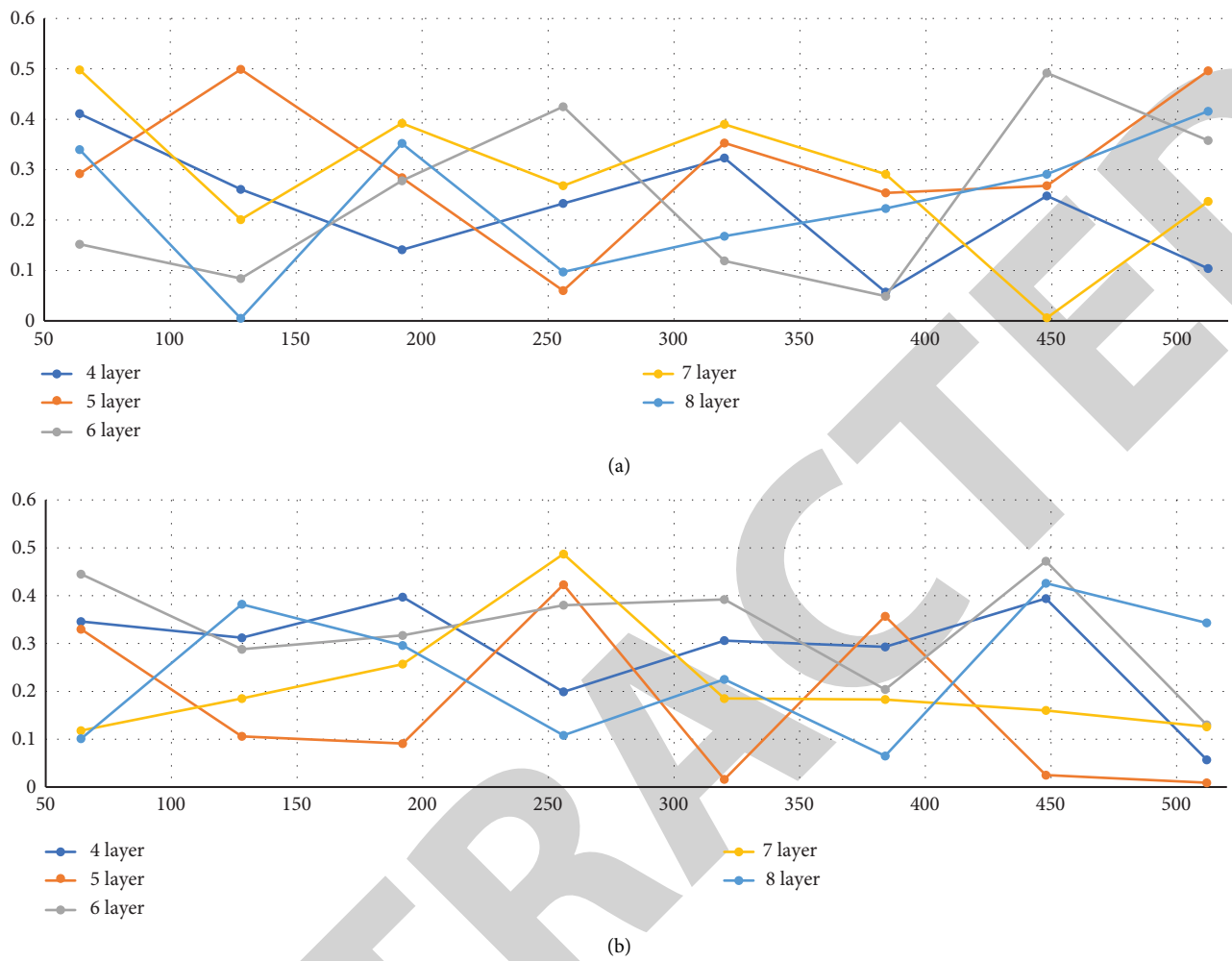

Figure 5: Training error statistics of deep neural networks with different combinations of layers and units.

play the role of policy guidance and exhortation, and clarify the value orientation of the policy; schools should cultivate teachers' moral quality and professional spirit.

The corresponding training and validation losses are analyzed by comparing different combinations of layers and the number of units. Based on the results, it is found that a neural network architecture with 6 layers and 256 cells per layer is optimal. Moreover, using the same network size, relatively deeper layers usually have better performance, which is in line with the mainstream findings in deep learning.

In addition, the activation functions with features such as higher-order differentiability, nonlinearity, and monotonicity in neural networks also have an important impact on deep neural networks. Different activation functions not only bring nonlinear characteristics to the neural network but also bring different sparsity to the network, which affects the convergence speed and training accuracy to some extent. However, the imbalance of education development is still very prominent between urban and rural areas. In our experiments, we use the classical Sigmoid function (0, 1), the SoftPlus function $(0, +\infty)$, and the ReLU function corresponding to $\max(0, x)$ for comparison.

The learning rate, as the step size of the gradient method to update the weights, affects the speed of training convergence during the training of the neural network. Different choices of the learning rate can have different effects on the fitting performance of the neural network. A learning rate that is too small for the desired selection will result in too slow training convergence. Correspondingly, too high a learning rate selection can lead to a decrease in fitting accuracy or even negative effects such as nonconvergence. As can be seen from Figure 6, $\mathrm{LR} = 0.001$ is an ideal choice because it is a trade-off between training accuracy and stability of the training and validation sets.

A comparison of the input samples with the optimal control rate predicted by the neural controller for nine static obstacle scenarios is shown in the figure. From the results, the control law output from the neural network trained and converged after sufficient tuning of the parameters is very accurate. Cities have a huge advantage in obtaining educational resources, while rural areas are still very low in educational development due to limited conditions. The neural network controller can still track the ideal optimal control solution well even in the case of sharp changes in angular velocity. In addition, to verify the robustness of the

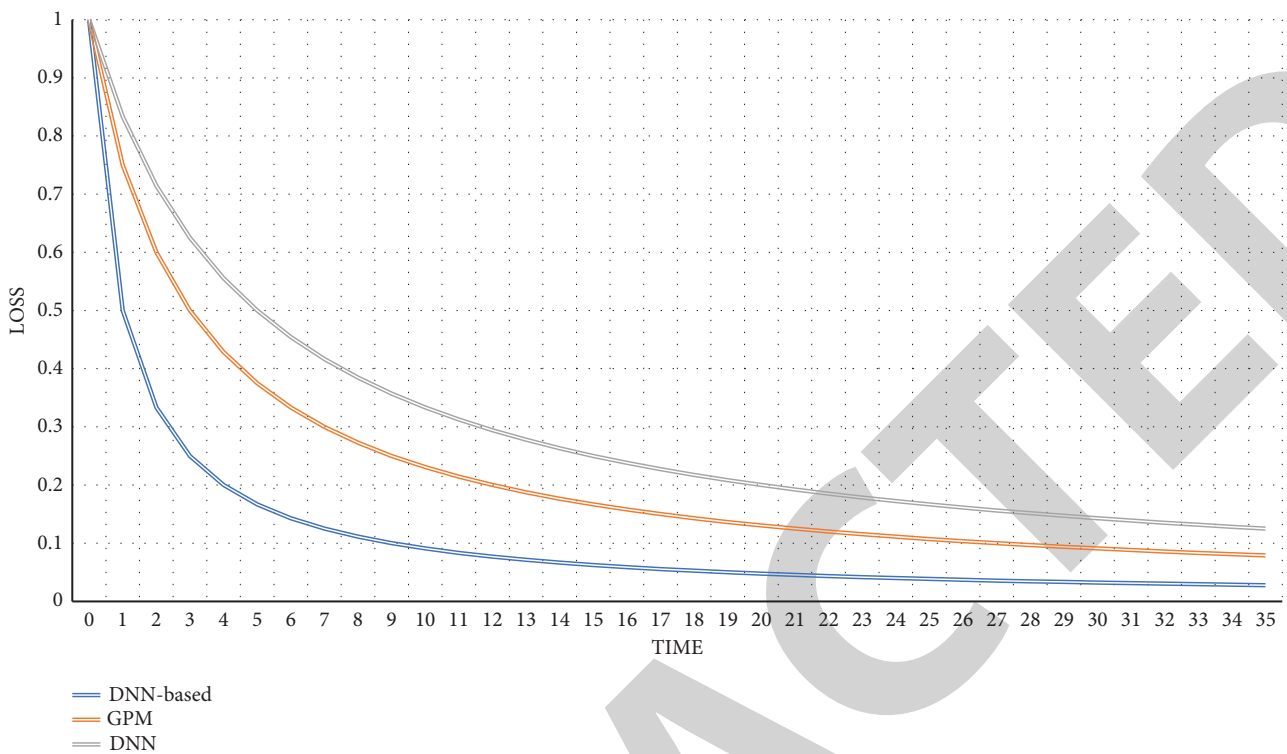

Figure 6: Tracking performance of neural network controller for direct method solution.

initial state, the quantitative analysis of the neural network fitting performance is performed based on the previous pseudospectral method and the statistics of 100 trajectories generated by the offline solution at a random given initial state, and the statistical errors between the sample inputs of 100 trajectories and the corresponding predicted control rates are all within a small range for nine static obstacle scenarios.

5.2. Analysis of the Results of the Evaluation Model of Urban-Rural Exchange Teachers in Elementary School. In the process of exchange teacher selection, 15.45% of teachers considered very transparent, 17.27% considered more transparent, 61.82% considered less transparent, and 5.45% considered the least transparent. On the issue of supervision system and assessment standards, 7.27% of teachers thought the system and assessment standards were very sound, 11.82% thought the system and assessment standards were relatively sound, 32.73% thought they were sound, and 48.18% thought they were not sound, so it seems that most teachers thought the system and assessment standards needed to be more standardized. On the question of whether County Y fulfills its commitments in all aspects of teacher exchange, 39.09% of teachers believe it is fully fulfilled, 46.36% believe it is largely fulfilled, 11.82% believe it is rarely fulfilled, and 2.73% believe it is not fulfilled at all. In terms of the degree of cooperation of the relevant departments in implementing the exchange of teachers between urban and rural areas, only 1.82% of teachers thought that the cooperation was very good, 23.64% thought that the cooperation was good, but 70% thought that the cooperation was poor, and 4.55% thought that the cooperation was not good, which show that most teachers thought that the cooperation of the relevant departments in this aspect of the exchange of teachers between urban and rural areas was low.

The education department organized teachers to participate in discussions, consulted teachers, and obtained evaluation assessment results through a study of frontline teachers, only 3.64% fully agreed with the statement, 29.09% largely agreed, but 61.82% did not agree, and 5.45% did not agree at all. The general strategies and approaches that are conducive to improving the efficiency of mathematics classroom teaching in rural primary schools and promoting the common development of teachers and students provide a basis for the education department or school to formulate more reasonable solutions in the future. The low transparency may be due to the existence of money transactions, the monitoring system and assessment criteria need to be improved, and it is speculated that only summative evaluations of teachers are conducted in the evaluation, and promises appear unfulfilled. It is speculated that the reason for this may be that schools are different and adopt different guidelines and policies and that the cooperation of relevant departments is low. It is speculated that the reason for this may be that society attaches little importance to the relevant departments in formulating policies and assessments " walking around" and not being able to grasp the real situation, as shown in Table 1.

From the above table, we can see that in the exchange process, 4.55% of the schools attach great importance to it, 20% attach more importance to it, 52.73% attach less

Table 1: Statistics on the importance schools attach to the exchange of teachers between urban and rural areas.

Option content	Number	Percent
Very concerned	20	0.053619303
More attention	44	0.117962466
Less attention	20	0.053619303
Completely ignored	57	0.152815013
Discipline building ability	57	0.152815013
Teaching and research ability	50	0.134048257
Teaching ability	34	0.091152815
Teaching achievements	31	0.08310992
Other	60	0.160857909

importance to it, and 22.73% do not attach importance to it at all. In the assessment of the exchange schools, 12.73% of the schools pay attention to subject construction ability, 19.09% pay attention to teaching and research ability, 37.27% pay attention to teaching ability, which is also a relatively large part of the assessment, 20.91% pay attention to teaching achievement, and the remaining 10% pay attention to other aspects of the assessment. The content thus shows that most schools pay less attention to the urban-rural exchange of teachers, there are no uniform regulations on the assessment of exchange teachers, and the evaluation mechanism is not sound.

The ladder construction is also commonly referred to as the mechanism of the old leading the new. From the above chart, very few schools have a relatively sound ladder construction, accounting for only 0.91%, those with a basic soundness account for 10%, those with less soundness account for a relatively large proportion, 74.55%, and those with a poorness account for 14.55%. Most schools have poorly constructed echelons, reflecting the side that most schools have unsound management mechanisms and low utilization of teacher resources. A phenomenon was also found that some schools, to prevent their education quality from declining, falsified the exchange process of teachers between urban and rural areas, as shown in Figure 7. The general neural dynamic optimization method can only find a local optimal point when facing the nonconvex optimization problem with multiminimum points, and even less discusses the nondifferentiable problem.

From this figure, in order not to affect the quality of teaching in our school, 10.91% of schools will not use other ways instead of exchange in the process of teacher exchange, and 25.45% will not use other ways instead of exchange, 41.82% of schools will occasionally use other ways instead of exchange, and 21.82% of schools will use other ways instead of exchange. Due to the gradual maturity of computing technology and the rapid development of hardware equipment, we can use it to achieve numerical solutions. From here, we can find that most schools do not have a positive attitude toward urban-rural teacher exchange and have many concerns.

It is found that the same urban and rural teachers exchange, but the answers to the question of whether it can promote the equity of educational resources and improve the level and quality of education in township schools are

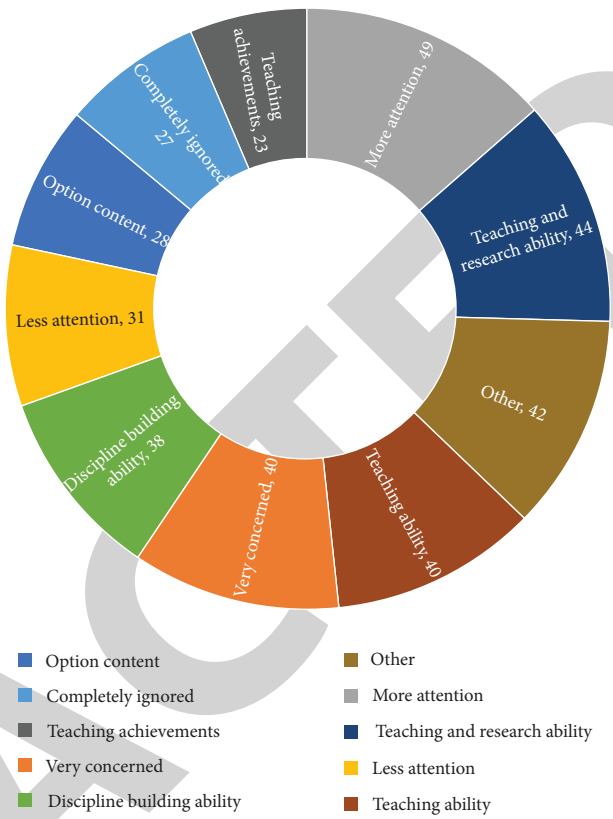

Figure 7: Authenticity of school communication survey map.

very different, guessing that the reason is the deep-rooted influence of "key schools," which leads to the unfair distribution of educational resources and the difficulty of policy implementation, thus failing to coordinate the quality of educational resources within the county. The survey found that 47.27% of the respondents were not satisfied with the quality of educational resources and the overall improvement of township schools. For example, the adjacent extreme value method, the simplex method, and the gradient method are all common numerical methods. The survey found that 47.27% of teachers believe that teachers can be attracted to teach in rural schools through title promotion and better study opportunities in rural areas, and 80.91% of teachers believe that the best way to promote the balanced development of educational resources and optimize the construction of the teaching force is to help each other and establish school alliances.

6. Conclusion

The optimization genetic algorithm is referred to like the system and the algorithm is improved for the teaching evaluation system of universities. Combining the ideas of genetic algorithms to optimize the selection of weights in the neural network algorithm, the search range is narrowed to achieve the purpose of fast and efficient data analysis and global optimization. After the final value of the state, co-state, and control variable is gradually obtained by the means of numerical integration, it is compared with the given final

state constraint to judge whether it is within the given error tolerance range, otherwise, the initial value is carried out by the means of linear interpolation. The optimized BP neural network algorithm model not only has the traditional self-learning advantages of the neural network but also has the global search for merit function of genetic algorithm, which greatly improves the automatic acquisition, accumulation of query information, and adaptive control of search function, and the final data analysis condition makes the accuracy of teaching quality evaluation analysis results fully improved. The frequency of teaching and research is increased, and various teacher skill evaluation competitions are carried out to improve teachers' enthusiasm and initiative in learning and accepting new things, so that teachers, an educational resource, become a pool of living water and promote urban-rural exchange. We should also extend the number of years of exchange between urban and rural teachers so that the exchange teachers can practically work in their posts, design teaching programs that are suitable for local students' learning, improve the teaching level of schools, and do their best to promote school development. At the practical level, the conflict between realistic conditions and development needs has blocked the rapid development of urban-rural linkage teaching and research. The severe shortage of teaching and research staff in the competent departments and the difficulty in hiring them affect the development of the teaching and research evaluation and management system and the organization and conduct of teaching and research activities.

Data Availability

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

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Research Article

English Education Course Performance Management Method Based on Hierarchical Analysis

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This paper adopts the hierarchical analysis method to conduct in-depth research and analysis on the management of English education course performance and the construction of the English education course performance evaluation index system in colleges and universities based on the hierarchical analysis method. This paper aims to establish a scientific, standardized, rigorous, and objective index system, which is in line with the orientation of "combining theory and practice" at this stage of school. It follows the development trend of the "dual-teacher" and "innovative" mode, helps students to improve their learning level and practical ability to a certain extent, and allows teachers to go out of the textbook and into the curriculum to create a multifaceted and effective teaching space framework for students in the new era. On the other hand, we should also pay attention to the correlation between the selected indicators, scientifically analyze the indicators, and try to eliminate the interaction between the indicators. This evaluation system is comprehensive and scientific, relevant to schools, inspiring to teachers, and intuitive to students, which is conducive to teachers' innovative teaching methods, breaking the original curriculum model, enabling teachers and students to easily get out of the original curriculum "silo" circle, and allowing teachers to find the breakthrough of the curriculum with half the effort. The performance results of the school were obtained through statistical analysis and attributed through individual interviews. To build an innovation and entrepreneurship education resource integration and sharing mechanism, the information management center of the innovation and entrepreneurship education training platform was established to integrate the innovation and entrepreneurship education information resources; by creating a community of interests, a collaborative mechanism was built inside and outside the school; finally, an interoperable and linked training platform network structure was formed. Finally, based on the results of the university's performance analysis and comparative reference to the relevant practices of universities in Taiwan, we propose countermeasures to improve the performance of the general education curriculum system.

1. Introduction

Liberal studies education originated in ancient Greece was revitalized by the industrial revolution and developed to the present day, and the role of liberal studies education has been gradually considered and accepted. With the rapid development of social economy and science and technology, the degree of integration of knowledge in various disciplines is becoming higher and higher, and the talents cultivated by overly specialized education can hardly adapt to the rapidly changing social needs [1]. General education needs to be implemented through the curriculum, and the general education curriculum is the main way to achieve the goal of general education. The hierarchical analysis is related to the question of what to teach and what to learn and the realization of talent training goals. However, due to the lack of planning for the whole curriculum system, many colleges and universities have the phenomenon of setting up courses and stopping courses at will, and more colleges and universities take the general knowledge hierarchy analysis as a final task; whether the hierarchy analysis is feasible, whether the general knowledge curriculum system is perfect, whether the implementation is effective, and whether the objectives of the general knowledge curriculum are achieved are rarely asked [2]. The lack of evaluation of general studies courses has, to a certain extent, led to the prominence of the dilemma

of general studies courses in practice. This will pave the way for the teacher to choose the next learning content. The evaluation of general studies courses has the functions of needs assessment, course diagnosis and revision, and effectiveness judgment. Before the curriculum plan is formulated, evaluation can be used to understand the needs of society, teachers, and students; during the formation of the general studies curriculum plan, evaluation can effectively identify the strengths and weaknesses of the curriculum plan and provide suggestions for the plan to be revised; after the implementation of the general studies curriculum, evaluation can be used to judge and comprehensively measure the effectiveness of the curriculum. Evaluation of the general studies curriculum can provide a basis for decision-making and direction for the reform of the general studies curriculum [3]. Liberal studies curriculum reform needs liberal studies curriculum evaluation to diagnose problems and improve them. However, most colleges and universities have not yet established a sound evaluation mechanism for general education courses, and the guidance of general education course evaluation for general education course reform is not strong.

The basis of the general studies hierarchy analysis method is the general studies curriculum objectives and talent training objectives, and the degree of achievement of general studies curriculum objectives should be an important criterion to measure the rationality of the general studies curriculum system setting and the effectiveness of implementation [4]. Performance is the desired result of the organization and is closely related to the realization of the organization's strategic goals. As a functional department of the liberal studies curriculum system, the university is a part of the public sector, and its evaluation can introduce the method of public sector performance evaluation, using scientific evaluation methods to measure the behavior and results of the liberal studies curriculum system and provide feedback on the evaluation results to promote performance improvement [5]. Curriculum evaluation and performance evaluation are superior and inferior, respectively, and the scope of curriculum evaluation is broader. Learning content means that teachers provide students with various learning resources to enable students to better construct meaning and achieve learning goals. Performance evaluation of the general curriculum system is a purposeful and planned activity and a process of using scientific evaluation methods to collect information from various aspects and to improve performance based on the evaluation results. By involving students, teachers, and course administrators, listening to the voices of all evaluation subjects, and coordinating the values and positions of all parties, the performance evaluation of general education courses is conducive to the democratization and scientific nation of course management and decision-making, thus improving the management and service level of universities. The scientific evaluation method lays the foundation for the objective reliability of the evaluation results, which helps the functional departments of the general education curriculum system to find out the gap between the actual and the targeted one and analyze the reasons for the gap, to make the required improvements and provide scientific decision-making basis for the curriculum reform, thus improving the general education curriculum system and improving the quality of the general education curriculum.

Previous studies on performance management in education schools generally focus on teachers' performance pay as the starting point, and there are few comprehensive studies on performance management systems in compulsory education based on various sets of index systems. The reintegration and empirical study of the content of the indicator system on the topic of performance management of weak schools in compulsory education provide a theoretical framework and ideas for similar studies to draw on. The application of the new public management theory in the education quality assurance system has accelerated the evolution of education quality to a measurable and statistically significant level. The term "educational quality" is equivalent to "educational performance," and technical tools such as performance indicators have been introduced to the framework of educational quality assurance to measure the inputs and outputs of education and resources. The quantification of educational quality has led to a clearer orientation toward educational accountability, and performance management has thus become a tool for quality assurance in education.

2. Related Work

In its research on university research management, Ahmad mentioned that the world OECD defined performance indicators for university research evaluation as qualitative indicators that are difficult to quantify in research [6]. The internal factors include the strategy and mission of the university, its research environment, organization, and human resources, while external factors include political and economic factors. Rodrigues pointed out that because the value of research results is the main criterion of evaluation, the actual research evaluation is very important in the process of evaluation because of the limited evaluation time and the professional difference of evaluation experts; therefore, the level of publication of the paper is very important, which is contradictory to the value of research evaluation [7]. However, due to the different national conditions, the various performance assessment index systems proposed by European and American researchers in the field of university research management cannot be directly applied to our university research management, so our scholars tend to combine the current situation and problems of our university system in the construction of performance index systems and put forward targeted system solutions [8]. However, less quantitative thinking and quantitative models are used to analyze the evaluation of university research performance, due to which this paper uses hierarchical analysis, which is a quantitative research tool, to design the index system of university research management with certain theoretical and practical significance.

Chen believes that the performance appraisal system cannot be simply copied, but each organization must establish a personalized performance appraisal system that meets the

actual needs of employees and the characteristics of the organization [9]. In terms of performance research in the education industry, Khanal et al. show through data analysis that the factors that play a key role in improving organizational performance in real estate companies are innovation management, the robustness of product design capabilities, strategic planning, and knowledge resources and that the improvement of these factors helps companies in the real estate industry to improve their capabilities and guide them towards the direction for their growth [10]. In terms of performance appraisal, Chou's study concluded that the human resources department of real estate companies plays an important role in the organization from the beginning of the job applicant to the whole service period, and the department should establish a performance management system with objectivity, accuracy, timeliness, and fairness among the employees, and to ensure the effective implementation of the appraisal, the human resources practitioners of the company must have a certain depth of knowledge specific to the real estate industry [11]. Problem scenarios run through the entire teaching and learning activities. Based on learner analysis, learning content analysis, and learning objective analysis, the learning content is transformed into problem scenarios based on real problems and covering robot knowledge. Kwan explores the performance management aspects of real estate project marketing staff as a case study and concludes that the performance indicators of real estate sales staff should not only be based on performance indicators but also on their competitiveness, work ethic, and knowledge of themselves as valuable indicators [12].

Student learning engagement is an important concept in learning theory, and several scholars have shown that it is one of the important factors affecting learning performance in traditional learning models and online learning. Based on the analysis and summary of current literature on student learning engagement, this study develops a scale for measuring student learning engagement in a creative learning environment, which can provide a reference for later research. This study focuses on exploring the correlation analysis of the influencing factors of learning performance under the new model of creator education, focusing on long-term performance, with certain improvements and refinements in performance evaluation, and enriching empirical research on learning performance in different fields. Second, this study also tries to explore the influence of the design of the creator curriculum on learning performance and adds the mediating variable of students' learning engagement to explore the connection between the three, which explains the influence mechanism of learning performance in creator education more strongly.

3. Hierarchical Analysis of Performance Management in English Education Curriculum

3.1. Performance Management Hierarchical Analysis Method Design. There have been different understandings of performance among researchers due to the differences in subject areas. From a management perspective, performance is the work output of an organization at all levels to implement organizational goals, including both organizational and individual performance [13]. There are connections and differences between organizational and individual performance; to some extent, it can be said that individual performance is the basis of organizational performance, and organizational performance is the superposition of individual performance. However, it is not the inevitable result; so, even if individual performance in the organization is successfully achieved, organizational performance may not be achieved. When it is understood from the perspective of management economics, job pay is the organization's recognition and reward to employees, and performance is the employees' contribution to the organization, and this reciprocal exchange relationship reflects the principle of equivalence [14]. In addition, some teachers also have concerns. One believes that performance evaluation is an objective basis for evaluating the functional realization of the employee's basic job duties, as well as assessing his or her potential ability to assume higher levels of leadership, with the possibility of organizational evaluation. The second believes that performance evaluation is to evaluate and assess the employee's work status, work adaptability, and comprehensive workability, as well as the evaluation of the organization's values, cohesion, and organizational purpose around a work goal. The third believes that performance evaluation is the process of recording the daily routines of an organization's employees and giving periodic summaries and evaluations to help the organization's employees grow and promote the achievement of organizational goals.

The hierarchical analysis is a combination of qualitative, quantitative, and systematic analysis methods. Since the hierarchical analysis is more practical and effective in dealing with relatively complex decision problems, its application is very common in the fields of energy policy and distribution, economic planning and management, behavioral science management, military command, agriculture, education, transportation, human resources, environment, and medical care.

The basic idea of hierarchical analysis is to decompose a complex problem into some factors with dominant relationships to form an orderly hierarchical structure according to the nature of the research problem and the objectives to be achieved, to determine the relative importance of each factor at each level by the domain experts through a two-by-two comparison, and then to make a comprehensive comparison of the judgment results to establish the relative importance order of the factors at the hierarchical level. One of the most critical issues is how to get the weight value of each influencing factor at each level, as shown in Figure 1. They worry that the frequency of course research is too frequent and that the course changes will have a certain impact on students' learning and teachers' lectures and hinder them at different levels.

The hierarchical analysis method is a comprehensive reflection of the idea of system analysis and system synthesis. Based on an in-depth analysis of the nature of complex decision-making problems, the influencing factors of the

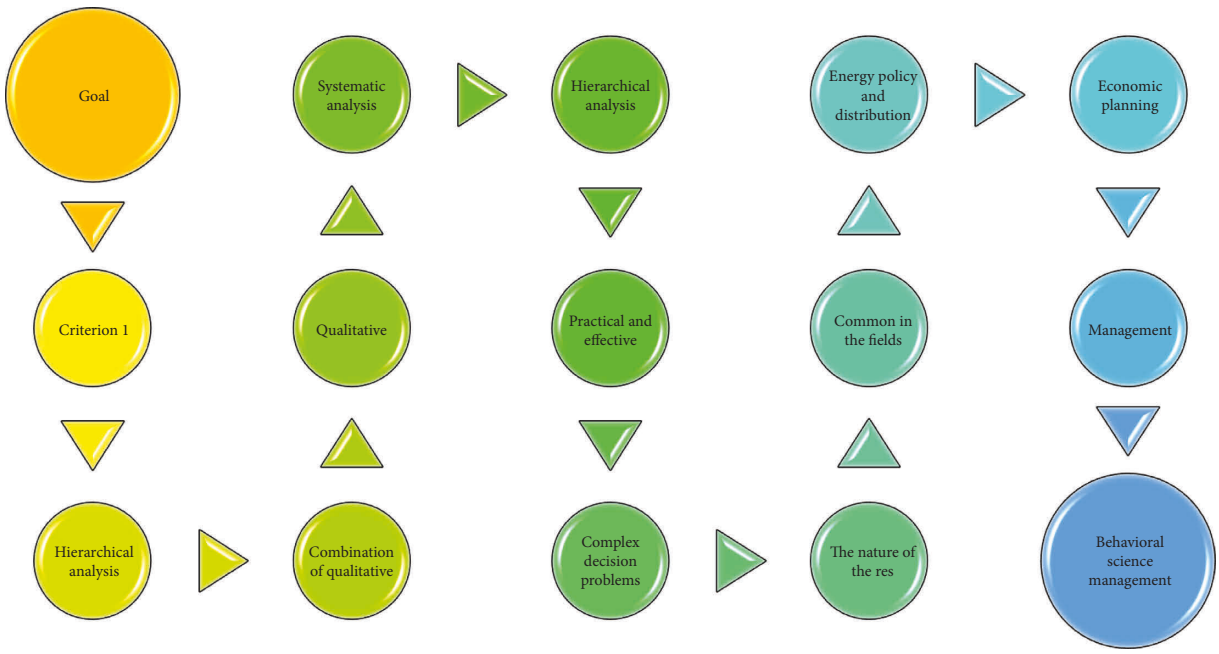

Figure 1: Hierarchical analysis framework.

problem, and the intrinsic relationship between each factor and each level, this method uses suitable quantitative methods and quantitative information to help model the decision-making thinking process and find a convenient quantitative decision-making method for complex decision problems with multiple objectives, multiple criteria, and no obvious structural characteristics [15]. The method is particularly suitable for situations where the decision-making of the problem is difficult to measure directly and precisely.

The hierarchical analysis method systematically decomposes the complex decision problem into several layers such as the objective layer, criterion layer, and solution layer; the elements of the layer are compared two-by-two at the corresponding layer according to certain criteria and methods, and the judgment matrix is formed by quantifying according to the scale. It is inevitable that there will be concerns in their hearts. In the next step, the weight of the element to the criterion is obtained by calculating the maximum eigenvalue of the judgment matrix and the corresponding orthogonalized eigenvector. Based on the above basic process, it is possible to calculate the weight value of each hierarchical element relative to the criterion of that layer. To summarize the hierarchical analysis method is to analyze the elements of the simple problem after simplifying the original complex problem, quantify and rank the comparison between the elements, synthesize the total ranking level by level, and finally obtain the quantitative solution of the original problem.

The basic principle of the hierarchical analysis method is as follows: first, the complex problem is divided into several levels; then, the elements of the same level are judged two-by-two according to the guidelines of the elements of the previous level; then, their importance is compared so that the weights of the elements of each level are calculated; finally, the optimal solution is determined according to the combined weights and the principle of maximum weight.

Thus, the hierarchical analysis method decomposes the problem into different elements by analyzing the factors contained in the complex system and their interrelationships and grouping these elements into different levels, thus forming a multilevel analysis structure model [16]. At each level, the elements of that level can be compared one-by-one according to a specified criterion, written in the form of a matrix, to constitute and establish a judgment matrix. Through the calculation of the maximum characteristics of the judgment matrix and its corresponding feature vector, the weights of the elements of that level for that criterion are derived. On this basis, the combined weights of the elements of each level for the overall objective are then calculated to derive the weights of different scenarios and provide a basis for selecting the optimal solution.

With the prevalence of new public management theories around the world, performance has become an important guiding idea for the public sector to carry out management work. The introduction of performance management in schools has also given it a new meaning. This is like corporate performance, and it needs to be verified by top management, and only after the object's evaluation of the proposed plan can it be truly implemented. Performance is a combination of efficiency, effectiveness, member satisfaction, and resilience, which is the total achievement and effectiveness of an individual, group, or organization after doing something. Based on the understanding of performance, school performance in this study means that the school organization, staff, and students perform well in all aspects and meet the school's predetermined goals. School performance management refers to the effective management activities of all elements of the school through

management tools based on the school's performance goals, as shown in Figure 2.

There are quantifiable hard indicators for evaluating performance in the field of scientific research, but in practice, there are many indicators that are difficult to quantify. By reviewing the literature, it was found that many of the results of such scientific research are based on qualitative evaluation, and some of them are using a combination of qualitative and quantitative evaluation. However, quantitative evaluation is the general trend in the performance evaluation of university research management and other aspects of management.

The selection of performance evaluation indexes should be able to reflect the actual situation of scientific research truly, accurately, and objectively. We also included course evaluation and feedback in the secondary vocational school curriculum performance evaluation index system for further exploration and research. On one hand, it is necessary to make the selected evaluation indexes have clear meanings, so that the evaluation scale is convenient for selection and measurement; on the other hand, it is also necessary to pay attention to the correlation between the selected indexes, analyze the indexes scientifically, and eliminate the mutual influence between the indexes as much as possible; in addition, the index system should be set in a clear hierarchy, with a clear evaluation process, should be easy to understand and use, and should be with a strong operability principle. As the field of scientific research is wide, the scope is large, and the objects are diverse, the evaluation results should be comparable when setting the indicators, and the evaluation indicators should fully reflect the common attributes of the objects around the scope and objects of scientific research with different attributes.

The preclass teaching preparation stage is the basis and guarantees the smooth implementation of classroom teaching and learning activities, which mainly includes four parts, namely, learner analysis, learning content analysis, learning goal analysis, and problem situation setting [17]. The learner analysis is the teacher's basic understanding of the students' initial ability and learning style before the class, to prepare for the teacher's selection of the next learning content. Learning content refers to the various learning resources that the teacher provides to the students to enable them to better construct meaning and achieve their learning goals. The implementation vehicle for this study of maker education is the primary and secondary school robotics curriculum; therefore, in conjunction with the previous learner analysis, the next two main aspects of learning content are robotics learning content and the multidisciplinary content involved.

Learning objectives refer to what students have learned after learning and what teaching objectives are needed to be achieved. The entire teaching and learning process is centered on how to achieve the learning objectives. After determining the learning content, the learning objectives are analyzed from two perspectives such as robot design tasks and multidisciplinary integration skills according to the three levels of learning objectives such as knowledge and skills, process and methods, and emotional and attitudinal values [18]. Problem situations are used throughout the teaching and learning activities. Based on learner analysis, learning content analysis, and learning goal analysis, the learning content is transformed into a problem situation based on real-life problems and covers robotics knowledge, and teachers and students work together to solve problems to achieve the learning goals.

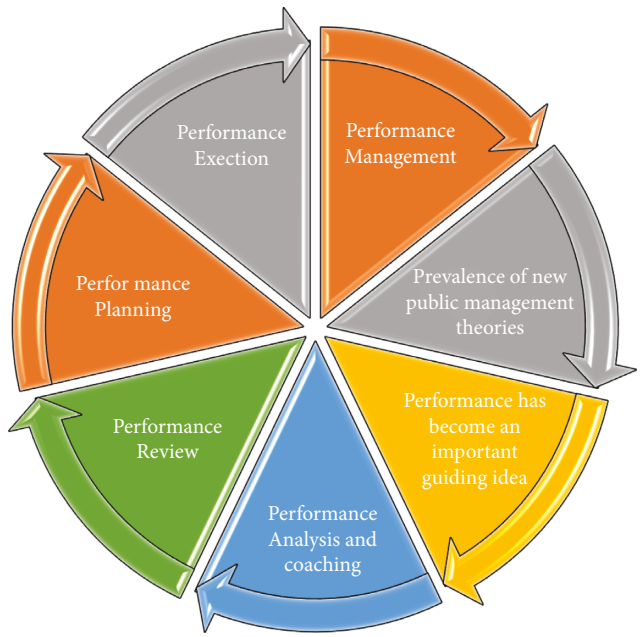

Figure 2: Performance management hierarchy analysis steps.

3.2. Analysis of English Education Course Performance Management. Each evaluation index of curriculum performance is independent and closely related to the curriculum, which requires a high level of understanding and cognition of the curriculum. If we are not familiar with the construction principles and factors of the curriculum itself, the constructed indexes will deviate from the original intent and fail to achieve the in-depth study of excellence, we would not be able to control the operability, and the corresponding guidance meaning will not be realized. The real key point of the research is to recreate a broad "high performance" teaching.

Performance management is a very important link in the process of enterprise growth, and the performance appraisal that employees are concerned about directly affects salary accounting and salary adjustment and is a way for enterprise management to motivate employees, and performance affects employee promotion and job transfer. Performance appraisal should be made fairer and more equitable. In addition, efficient performance management focuses on keeping employee performance goals consistent with organizational performance goals. For the organization, it is the standard for judging the value level that a person brings to the enterprise and provides a strong basis for the future development direction of the enterprise, as shown in Figure 3.

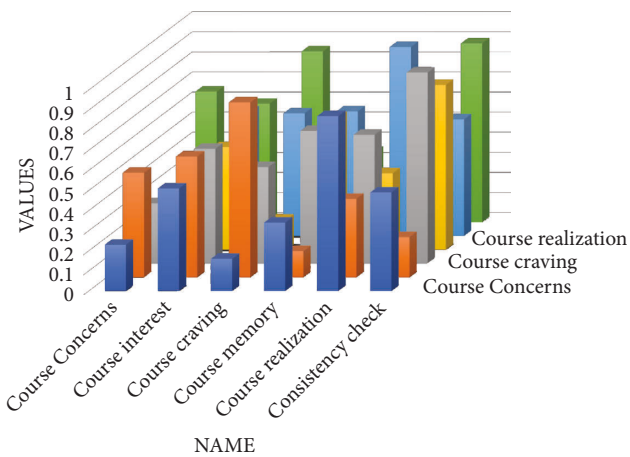

Figure 3: Weight coefficient of first-level indicators.

To some extent, the influence of exam-oriented education on people makes many people focus only on the evaluation of results and ignore the evaluation of course performance, thus hindering the concrete implementation of the evaluation system, and some teachers also have concerns, worrying that the number of course studies is too frequent and that too many changes in the curriculum will have a certain impact on students' learning and teachers' lectures and hinder them at different levels [19]. The objective and scientific nature of the indicators will affect the quality of teaching and learning in schools, and the student- and teacher-centered orientation of "curriculum performance" will be easily affected to a certain extent.

When the word "performance" is mentioned, people often think of the performance management of enterprises. In enterprises, performance used to judge the results of the behavior of staff in the position and the lack of work, focusing on identifying themselves and problems, hoping to change the behavior pattern of the enterprise to turn the trend of profitable results. Let us take corporate performance as an example and analyze the relationship between corporate and performance, and then analyze "course performance" by analogy with "corporate performance."

Course performance has a lot in common with corporate performance, but at the same time, there are many differences. Course performance requires discussion with experts and scholars and discussion with students before determining the indicators, which is like corporate performance, and both need to be verified by senior management and judged by the target audience before they can be truly implemented. The evaluation of course performance is also a kind of targeted index assessment, which is more concerned about the applicability of the performance assessment and requires a higher degree of understanding of the course, which is not quite the same as enterprise performance [20]. There is no relationship of interest; the main body is for the students.

At this stage, many students are very interested in various clubs and student organizations in the school, and they are deeply involved in them, forming a culture of comparing with each other. When facing some sudden situations, they are often unable to deal with them maturely and calmly, and they are easily overwhelmed, unable to have an objective evaluation and cognition of themselves, and easily go astray, as shown in Figure 4.

Secondary school students are still in the initial stage of establishing self-awareness and values, and they need to get a sense of belonging to the society and a sense of security from their families, which requires secondary school teachers and secondary school courses to reflect the guidance of socialist values, to guide them to distinguish between what is good and what is evil and what is right and what is wrong and to form a stable and orderly study and life habit with the help of the outside world. To improve performance in equipment manufacturing companies, members of each department need to align their personal interests with the overall interests. It will help them to form a stable and orderly study and life habit with the help of the outside world, so that they will no longer be confused and go with the flow, and help them to establish a value system that is both emotional and rational.

Course memory refers to students' memory absorption of course contents and knowledge points and is an important criterion to test the degree of memorization, retention, and reproduction of a course, and the judgment of course performance is partly determined by the degree of students' memory of the course [21]. Therefore, it is necessary to construct indicators in depth from the perspective of memory.

Course realization is a test of the degree of course performance, which includes course evaluation realization and course feedback realization, referring to the basic appearance of the results of the course on educational objectives, teaching contents, teaching activities, and so on. To a certain extent, it can reflect the high performance of a course and the size of the influence of the course on students; so, we also include the evaluation and feedback of the course in the evaluation system of the course performance of secondary vocational schools.

The goal management method, as a method of performance evaluation, has the role of orientation, motivation, cohesion, and clear tasks for effective management [22]. As a vane, the management of goals can overcome the shortcomings of traditional management work that lacks planning and foresight, and the organization and individuals can guide and monitor their behavior according to this work goal, thus improving work efficiency. However, it has the disadvantages of emphasizing short-term goals, difficult goal setting, and difficulty to change, and it requires the organization to have a certain ideological and scientific management foundation. It is more intuitive for students. It is conducive to teachers' innovative teaching methods, breaking the original curriculum model, so that teachers and students can easily get out of the original curriculum "island" cycle, and teachers can also find a breakthrough in teaching courses with half the effort. The insight of goal management theory in this study is that universities should reasonably set the goals of general education courses, make every effort to achieve them, scientifically assess them, and give feedback to them promptly, and goal management

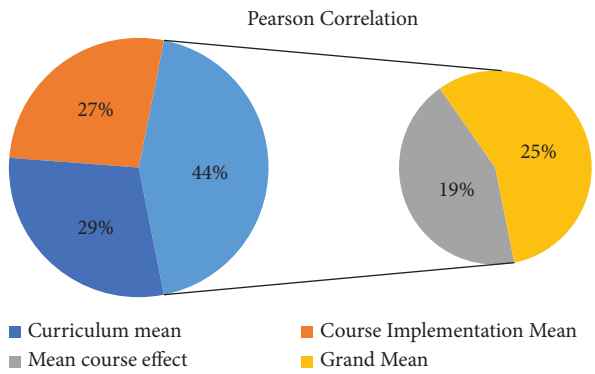

Figure 4: Course system performance evaluation weights.

theory provides theoretical guidance for the design of the index system and improving the performance of the general education course system in universities.

4. Analysis of Results

4.1. Analysis of the Results of Performance Management Level Analysis. In the current scientific research evaluation mechanism of universities, evaluation experts play a very important role. From the formulation of the scientific research evaluation system, the formulation of the scientific research performance evaluation index, the reading, and guidance of scientific research declaration to the evaluation of scientific research results, scientific research experts have a very important and critical position.

As the performance evaluation of scientific research management has a strong guiding role and influence on university researchers, more consideration should be given to those researchers who have good academic ethics, deep academic attainments, and a strong sense of responsibility as scientific research evaluation experts. Experts participating in scientific research evaluation and assessment should treat scientific research evaluation with a rigorous, objective, scientific, and fair working attitude to help the state and society select outstanding scientific research talents and outstanding scientific research projects. The evaluation and assessment process should be carried out by name, and the expert evaluation materials should be archived and kept. Experts who violate academic ethics and lose the spirit of scientific research should be disqualified from expert evaluation.

The system object to be solved is resolved into some factors, and then these elements are classified according to the different categories to build a structure containing some levels, which generally contains three layers. The first layer is the goal layer, which is the purpose of the problem to be solved, and the purpose is clear and unique; the criterion layer is the middle layer, which is the collection of all factors that will have an impact on the general goal after determining the general goal, and many factors in the criterion layer are the decomposition of the goal of the previous layer, which is closely related to the goal of the previous layer as well as the subordinate layer; the solution layer is the bottom layer, which is the specific measures and solutions to the problem.

The judgment matrix is established by comparing the factors in the same layer with each other and comparing the superiority and inferiority of a factor in the upper layer. In constructing the judgment matrix, the corresponding matrix is constructed following levels 1–9 and their reciprocals as the scale, and the method of importance degree comparison is shown in Figure 5. In the formation of the general education curriculum plan, the advantages and disadvantages of the curriculum plan can be effectively discovered through evaluation, and the revision suggestions can be provided for the plan; after the implementation of the general education curriculum, the curriculum effect can be judged and comprehensively measured through the evaluation.

First, it is necessary to establish a big data view; big data brings a change in the way of thinking, and the use of big data technology in the performance management system needs to change the traditional concept, continuously collect data resources by upgrading the concept of big data, and tap the value of data in performance management. Second, innovation culture is the inexhaustible impetus of enterprise progress, and the optimization of performance management process through big data in equipment manufacturing enterprises is a good embodiment of enterprise innovation spirit, and it is convenient for enterprise employees to have innovation spirit to gradually improve the performance management system. The innovative use of big data technology can obtain more performance data acquisition channels, expand the scope of performance management data collection, and make performance assessment fairer and just. Again, efficient performance management focuses on the consistency of employee performance goals and organizational performance goals, and equipment manufacturing enterprises need to improve performance by unifying individual interests with the overall interests of members of each department to ensure organizational cohesion; so, performance appraisal indicators need to focus on team culture.

The key to performance planning is to establish a performance evaluation index system to set classification norms for the complicated data and carry out unified processing so that all kinds of data can be circulated in the whole process of performance management. Scientific evaluation methods should be used to measure the behavior and results of the general education curriculum system, and feedback on the evaluation results to promote performance improvement should be given. The determination of performance indicators in the big data environment is still carried out on the SMART principle proposed by Peter Drucker, and according to the performance management process, the enterprise performance indicators are divided into two categories: process performance indicators and result performance indicators, and the two categories of performance indicators are decomposed into primary and secondary indicators according to their importance, and the weights of each performance indicator are determined by hierarchical analysis, as shown in Figure 6.

From the results of the reliability analysis of the secondary indicators of school performance management in Figure 6, the reliability coefficient is 0.7483, which indicates that the intrinsic reliability of the secondary indicators of school management is good. The reliability analysis of the six

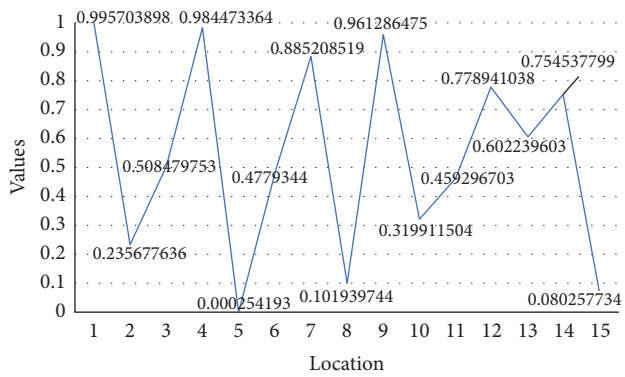

Figure 5: Value of random consistency index RI for n-order matrix.

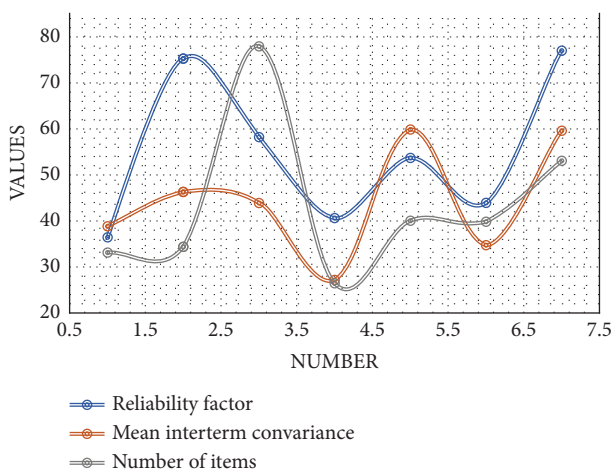

Figure 6: Reliability analysis of performance management secondary indicators.

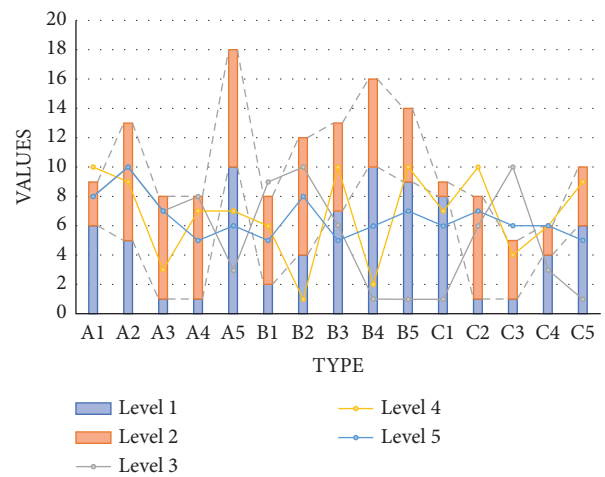

Figure 7: Weight coefficients of secondary indicators of the performance evaluation system.

secondary indicators of teacher teaching showed a reliability coefficient of 0.8948. Therefore, the reliability of the secondary indicators of the teacher teaching is very good, there is a high consistency among the questions under this dimension, and its research evaluation is meaningful. The reliability of the secondary indicator of student development analyzed with a reliability coefficient of 0.6970, which is between 0.6 and 0.8.

Performance feedback is the final link of the performance management process system, including the feedback of performance evaluation results and the application of appraisal results, is the end of one cycle of performance feedback, and is the start of the next cycle of performance planning; reasonable performance feedback can promote employee performance improvement. For the evaluation of a performance feedback system based on big data, four indicators can be set: feedback result sharing rate, performance result reward and punishment measures completeness rate, performance feedback public rate, and performance feedback timeliness.

The feedback result sharing rate refers to the proportion of performance results that can be applied to other aspects of human resources, such as recruitment, training, compensation, and employee relations; the completion rate of performance results in rewards and punishments reflects that performance feedback can give a variety of incentives based on performance results, such as material incentives and spiritual incentives; open performance feedback results can stand up to employee scrutiny, and the open performance feedback rate can reflect the fairness and impartiality of performance feedback results. Performance is the employee's contribution to the organization, and this reciprocal exchange relationship reflects the principle of equal exchange. The openness rate of performance feedback can reflect the fairness and impartiality of performance feedback results; the timeliness of performance feedback reflects the efficiency of performance feedback.

4.2. English Education Course Performance Management Results. The currently commonly used methods for determining the weight coefficients are mainly empirical and mathematical. The so-called empirical method is to consult with experienced experts or scholars in the field to analyze and determine the weight coefficients of each index item by their practical experience, while the commonly used empirical methods mainly include the expert meeting method, expert consultation method, and expert ranking method. The mathematical method is based on mathematical theory and psychological theory, using mathematical formulas to calculate the weight coefficients of each index item, and the frequently used methods are hierarchical analysis, two-by-two analysis, and the logarithmic weighting method. However, whether the empirical method or mathematical method is used, the principle of its calculation is to proceed sequentially from the higher to the lower level of the indicators, i.e., the weights of the first-level indicators are calculated first, and then those of the second-level and third-level indicators are calculated. If the weight value of the total target is assumed to be 1, then the weight indicators of the next level are all 1, but the lower the level of the indicator, the smaller is its contribution to the total weight value.

The so-called multifactor statistical method is to first list each indicator item developed in the form of a

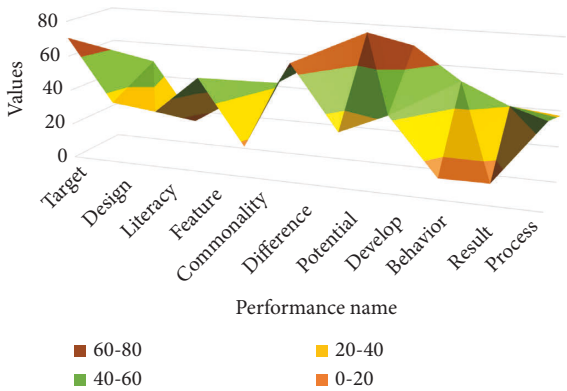

Figure 8: Validation results of the course performance evaluation system.

questionnaire, then let the respondents choose the importance level of each indicator, and finally calculate the ranking index, based on the statistical results of the survey, to determine the weight coefficient of each indicator, as shown in Figure 7. The process of helping an organization's employees continue to grow and facilitate the achievement of organizational goals.

This part is the simple processing of the returned questionnaires, which paves the way for the implementation of the evaluation index system. After the teachers' and students' questionnaires were collected, we did a lot of sorting and summarizing of the scores filled in the back of the form, added up the total scores of the 20 teachers, and divided them by 20 to get the average score, and then used the same method to find out the average score of the students, using these two average scores, multiplying them by the weights of the primary indicators first, and then multiplying the weights of the secondary indicators after getting the results, and finally multiplying the tertiary indicators and weights. If the final error calculated to be within 10 points, the reasonableness of the secondary vocational education curriculum performance evaluation system can be measured after comparing the teacher's evaluation of the curriculum and the student's evaluation of the curriculum values, as shown in Figure 8.

Based on the results obtained, we can conclude that the error between the teacher's evaluation of course performance and the student's evaluation of course performance is within two points, which verifies that the secondary vocational school course performance evaluation system has a high degree of reasonableness. Analyzing the results of this evaluation, we can see that the core concern of the curriculum has a large proportion in the system, which also verifies that the theoretical core of the curriculum is highly valued in secondary vocational schools nowadays, both teachers and students pay more attention to the core of the curriculum, which reminds us that when designing the curriculum of secondary vocational education, we should always grasp the core elements of the curriculum in the main position, so that the main guiding direction of the curriculum will not deviate. A simple quantitative decision-making method has been found for complex decision-making problems. This reminds us that when we design the secondary school curriculum, we should always keep the core elements of the curriculum intact, so that the main guiding direction of the curriculum should not deviate.

From the data, we can see some relationships between the evaluation indicators, but it does not represent the future development direction of all school curriculum performance. This method is especially suitable for situations where the decision of the problem is difficult to measure directly and accurately. This evaluation system of secondary vocational school curriculum performance can provide some reference for the future development of secondary school curriculum, so the future development of secondary school curriculum performance is still a long road, and it needs to be explored and improved step-by-step.

5. Conclusion

Since the object-oriented range of education is very wide, and the uniqueness of the times is especially prominent, it takes a long time to build a scientific performance evaluation to explore and finally realize that various curriculum performance evaluation systems can draw on each other and integrate, and the sound system draws on the integration of school running mechanism and insists that student-oriented, teacher-oriented, society-oriented, and enterprise-oriented have certain advantages, to bring a more employment-oriented school running mode. Their importance should be compared to calculate the weight of each layer of elements and the optimal solution according to the combined weight and the principle of maximum weight should be finally determined. The group of students in the school is rather special, and the enthusiasm for learning still needs to be improved. Insisting on the diversification of the performance evaluation system can enhance students' interest in learning the course and their recognition of the performance, thus promoting the further development and reform of the course and laying a solid foundation for the future secondary articulation with enterprises and the sound integration of education and industry in the school running mode. To obtain performance data more comprehensively and scientifically, this study also compiled different scales according to the focus and understanding of different evaluation subjects. The scales for each evaluation subject were divided into two stages: prediction and formal administration, and the scales were tested to have good reliability and validity. Therefore, this study has gone through a more standardized and scientific process from the design of the evaluation method to the evaluation activities, which also laid a solid foundation for the objective reliability of the evaluation results.

Data Availability

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

Conflicts of Interest

The author declares that he has 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

Design of Student Homework Management System in Private Colleges and Universities Based on Computer Software Technology

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This paper takes the job management of a private university as the research object and analyzes the function, performance, and operating environment of the job management system. We design the overall design scheme of the job management system according to the requirements and carry out the general design, detailed design, and database design of the system. By comparing and analyzing the characteristics of different MPPT algorithms, in view of the shortcomings of the fruit fly optimization algorithm, this paper proposes an improved fruit fly optimization algorithm to realize the maximum power point tracking of photovoltaic systems. The initialization position is improved, and the iterative optimization is carried out by means of variable step size. Compared with the traditional fruit fly optimization algorithm, the improved algorithm has a faster convergence speed, and the optimization process is stable and less oscillating, and the tracking of MPPT is improved. The accuracy can effectively avoid the system falling into local optimum. Based on the understanding of user demand analysis, the problems to be solved by this system are obtained, and solutions to these problems are given. Through the analysis and comparison of various technologies commonly used in the current website development and combined with the characteristics of the problem, the ASP-based Browser/Server (B/S) architecture is used to realize it. This system realizes the digitization of traditional paper work, solves the problems of slow speed, poor real-time performance, difficult inquiries, and difficult statistics in traditional homework management, effectively improves the quality of homework management in private colleges and universities, and has certain effects on improving the quality of school teaching.

1. Introduction

At present, many schools have launched their own student homework systems through the use of network technology [1]. But the function of the system is still not perfect due to the limitation of technical realization, and there are many defects. For example, most homework managers turn in assignments on paper; others store them in a shared directory on the teacher's computer. However, these two methods have drawbacks. Students can view, change, and delete other students' homework at will, resulting in a lot of things such as plagiarizing homework or maliciously deleting or modifying other students' homework. It is unclear whether the homework has been corrected or not, the homework is not deleted, or the old homework is not deleted, and it is confused with the new homework [2]. Although some can be managed with strict discipline, it will still bring a lot to the school and teachers [3].

Many scientific research achievements such as computer-aided education, network education, and network education management system are constantly emerging. This is the result of the continuous development of distance education. In this development process, computer technology and network technology are organically integrated as a whole. For example, intelligent agent, cloud computing, multilayer structure system, real-time network interaction,

mobile network teaching, and triple play have a profound impact on the field of education.

Aiming at the basic requirements of teaching management software at home and abroad and its huge market demand, a good teaching management software should have the advantages of complete functions, easy operation, and good operation interface to users [4]. While improving the functions, the flexibility, safety, and soundness of the system must be taken into account. An excellent job management system should have the characteristics of simple operation, easy installation, and easy popularization, so that both computer professionals and other users can quickly get started. The homework management system is an educational service system based on the network for homework publishing, collection, and evaluation. This is the definition of homework management system by the American Educational Research and Development Group [5]. The homework management system provides teachers and students with quick homework guidance and opens up a quick homework information channel. Teachers can review homework online, students can check homework online and publish the results of submitted homework, and the homework management system can provide timely feedback to teachers and students, thereby better motivating students to do homework. At present, private colleges and universities urgently need a practical homework management system to standardize homework management, which will greatly improve the school's management level, optimize resources, and maximize benefits [6]. Therefore, it is very meaningful to study the work management system as a subject [7, 8].

The release, submission, and correction of assignments are integrated, and the business process is clear. The data retrieval function is flexible and practical. Most of the functional modules of the system have the function of exporting Excel reports with one click, which is convenient for archiving and viewing job-related data. The system has global or local data statistics functions and can freely combine conditions to view relevant job data. The system introduces the short message interface, and the administrator client can easily set the message format. When publishing homework, teachers can choose whether to send homework notification emails or homework notification short messages, which improves the efficiency of homework management, conforms to the current trend of mobile Internet technology development, and conforms to the usage habits of contemporary students. The system can automatically send warm reminders to students for urging assignments, and the sending time node can be freely set. This paper introduces the tracking principle of the Drosophila algorithm and the steps of the standard Drosophila algorithm, analyzes the characteristics of the Drosophila algorithm, and points out that the algorithm is simple and controllable when tracking the maximum power point of the photovoltaic array. In view of the shortcomings of the fruit fly algorithm, this paper proposes two improvements. On the one hand, the initial position of the fruit fly individual is improved to improve the convergence speed of the algorithm to be optimal. In this paper, the main modules of the student homework management system are tested for code and function. Through the test, the system can realize the functions summarized in the demand analysis, and the traditional paper homework management is realized through the computer, and the student homework management is well realized.

2. Related Work

WebAssign is a comprehensive, interdisciplinary online assignment system that has a relatively large influence and is popular in the United States [9]. It has complete functions and excellent performance. The supported subjects include mathematics, physics, chemistry, biology, Science, and engineering subjects such as astronomy and statistics , and multimedia technology is used to support a variety of job types. The system is mainly divided into two functional modules: teacher side and student side [10]. On the teacher side, teachers can create courses and then use the system's own question bank or custom questions to assign homework based on a certain course, set the deadline for the homework, the number of times that can be submitted, etc., and then grade the homework completed by the students. On the student side, students are required to complete and submit assignments.

Web Course Tools is a Canadian asynchronous course delivery and management system developed for private colleges and universities [11]. It includes a series of powerful learning tools that can be automatically and tightly integrated with course content. It can be used for fully online courses. WebCT also provides services such as e-mail and discussion functions [12].

The research and application of online operation system in China is obviously delayed and delayed. It was not until the beginning of the 21st century that private colleges and universities in our country began to build various network distance teaching systems including online homework under the guidance of the Ministry of Education's "Modern Distance Education Standard Development Plan" document [13]. Among them, the most influential is the intelligent remote operation system (IDES), which is a set of Internet-based intelligent, open, interdisciplinary, and multilevel online operation system, which can automatically correct calculation questions and proof questions. The system undertakes most of the mechanical tasks of teachers, effectively improving the quality of homework correction and improving the completion rate of students' homework [14–16].

Due to the origin of computer network technology abroad, computer technology has a profound combination in various fields [17]. There are many things worth learning from abroad in the education and teaching system that can be used by us. Many foreign teaching auxiliary systems, such as learning systems, modern teaching systems, homework assignment systems, etc., have many research results emerging [18]. Through research, foreign research on interactivity is more profound and focused than domestic research [19]. Many well-known foreign universities have been exploring human intelligent learning systems and human-computer interaction systems for a long time [20, 21].

3. Methods

3.1. System Design Principles. This homework management system is positioned as a campus-level information management system. It is developed according to the actual needs of coursework management of the School of Information Engineering. The following principles are followed in the development process.

3.1.1. Reliability Principle. With the operation of the homework management system, the system will generate a large amount of homework data and personal data of teachers and students. These data are of great value to the school's teaching management. Therefore, when designing the system, the reliability of the system is the primary consideration.

3.1.2. Security Principle. In the process of designing and developing the operation management system, it is necessary to integrate the concept of information security and focus on the security of the system. In addition, the password information of system users is important and sensitive information. During the development process, various technical means such as MD5 can be used to encrypt the password. In short, in the design process, the security of the system cannot be ignored.

3.1.3. The Principle of Ease of Use. The system business operation process should be "grounded," and different system users can easily use the operation management system without special training. To achieve this goal, first of all, the specific implementation of the functional modules of the operating system should be intuitive and clear and should be close to the actual application process; the functional organization of the operating system should be convenient and fast; the interface design of the operation management system should be simple and beautiful. The user experience design should be friendly, the operation prompts should be comprehensive and accurate, and it should be suitable for different users' usage levels.

3.1.4. Scalability Principle. In the process of design and development of the job management system, it is necessary to fully consider the expansion and upgrade of functions in the future. In addition, the operation management system is a small part of the campus informatization, and there are many other information management systems on the campus. Therefore, it is also necessary to consider the issue of access to other information systems in the campus.

3.2. System Technical Architecture Design. This job management system adopts B/S architecture, uses PHP language as the main development language, and is developed in combination with HTML, JavaScript, CSS, jQuery library, H-ui framework, etc. The background database adopts MySQL.

The B/S architecture is a thin client architecture. It consists of a three-layer technical architecture system, including presentation layer, business logic layer, and data service layer. The first layer is the presentation layer (also known as the browser layer), which is used to present the interface of the system, and the dialogue between the user and the system application is completed in this layer; the second layer is the business logic layer (also called the Web server layer), which is mainly responsible for processing the business logic of the system. It is the data service layer (also known as the background server layer), which is mainly responsible for the storage and management of system data. It works as follows:

First, the user opens the browser and enters the requested URL address in the address bar. At this time, the browser will send HTTP request information to the Web server.

Next, the Web Server middleware (i.e., the server, such as IIS, Apache HTTPServer, etc.) receives the request information and parses the requested page file. If the requested page does not have a server-side program, the Web Server middleware returns the page file as it is. To the browser, if the requested page contains a server-side program and the data comes from the database, the Web Server middleware sends a data request to the database server. After the database server receives the data request, it executes the corresponding data processing and sends the result.

Finally, the browser receives the HTML page returned by the Web Server middleware and parses and displays the page. The job management system developed using this technical framework has good advantages for system management and maintenance or system upgrade in addition to the advantages of B/S framework itself.

The homework management system based on PHP + MySQL technology includes three types of users, including students, teachers, and system administrators. Different users have different permissions and functions. After student users log in to the homework management system, they have main functions such as viewing homework notifications and submitting homework; after teacher users log in to the homework management system, they have major functions such as publishing homework and correcting homework; after system administrator users log in to the system, they have the ability to set system global information and other functions.

The teacher user enters the system login interface, enters the account number and password in the corresponding text field, selects the user role as teacher, and submits the data. If it passes the verification, it will enter the main interface of the teacher user. If it does not pass the verification, it will jump to the system login interface. The business process flowchart of the student user of the homework management system is shown in Figure 1.

System administrators can perform related business operations, including administrator information management, teacher user management, student user management, college information management, department information management, professional information management, teaching and research office information management, class information management, course information management, homework category management, system advanced management, etc. Exit the system after the business is processed; if it fails to pass the verification, it will jump to the system login interface.

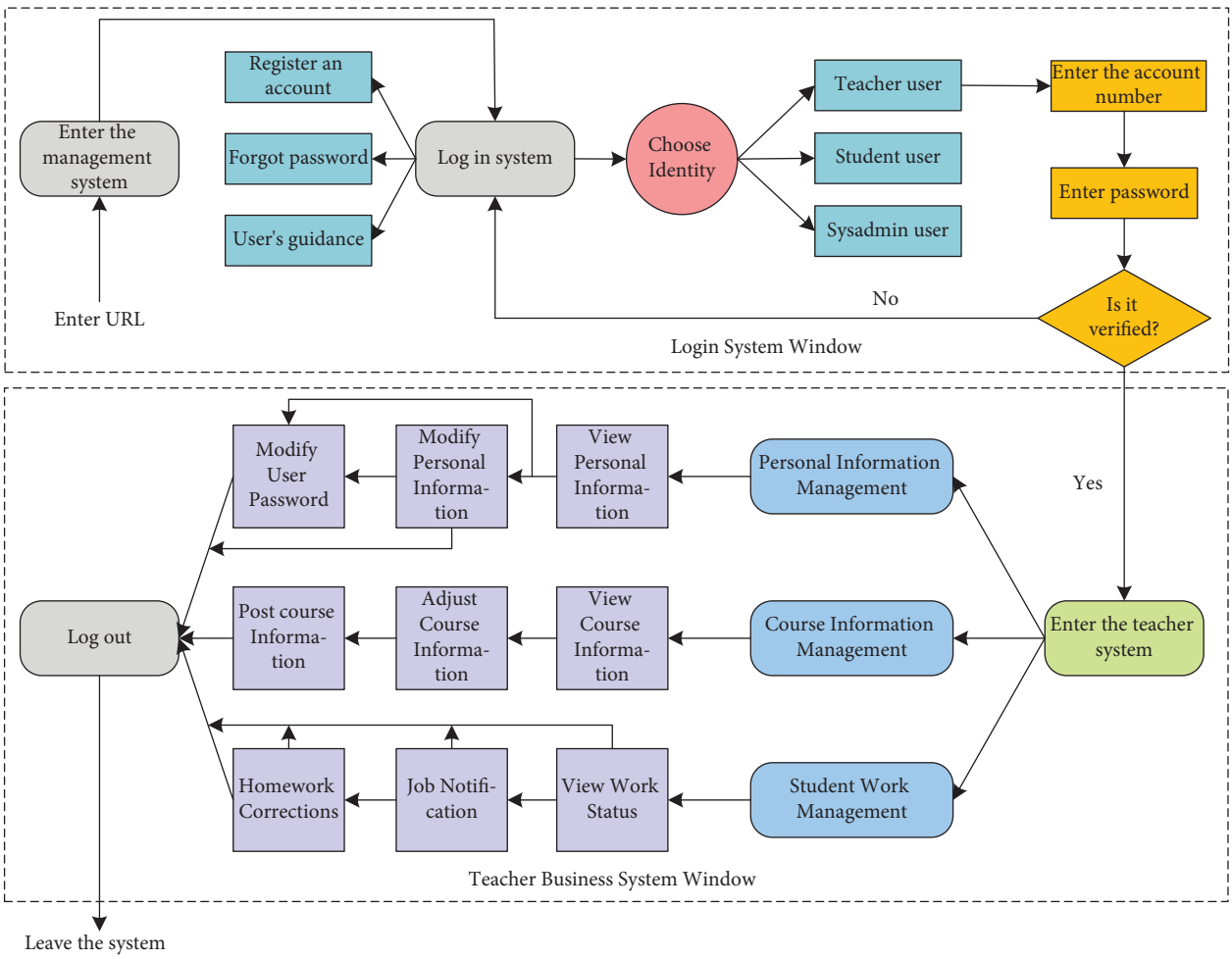

Figure 1: Teacher user business process.

The most frequently used users of this system are students and teachers. In the process of using the system, they may forget their login passwords. In order to make the system more user-friendly, it is necessary to design and develop a password retrieval module. Through this module, the password is retrieved according to the information set by the personal information, which reduces the workload of the system administrator (educational staff) and improves the efficiency of system management.

There are 4 steps in order to retrieve the password. The specific steps are as follows:

Step 1. Enter the account number. In this step, the user enters the account whose password needs to be retrieved and selects the type of user (student or teacher).

Step 2. Choose the method, that is, choose to retrieve via e-mail or retrieve via password.

Step 3. Verify the information. If you choose to retrieve by e-mail, you need to enter the associated mailbox in this step; if you choose to retrieve by password, you need to enter the answer to the question in this step. There are 3 specific questions, namely: your favorite number; your favorite number color; your favorite sport. If the verification is successful, proceed to the next step.

Step 4. Enter the password. In this step, you need to enter a new password. After submitting the information, the new password will be set successfully.

3.3. System Database Design. The database is the core of the job management system, and its main function is to access and manage system data. Whether the system database design is reasonable is directly related to the performance and operating efficiency of the job system. Therefore, in the process of database design, it is necessary to use scientific and reasonable methods to design the database.

Firstly, according to the requirements, adopt the "E-R" method to analyze the entities of the system, determine the entity attributes and the relationship between entities, and form the conceptual model of the system data; then, convert the conceptual model of the system database into a logical model; finally, according to the system database, the logical model forms the physical model of the system database.

According to the attributes of the data entities of the job management system, the relationship between the entities

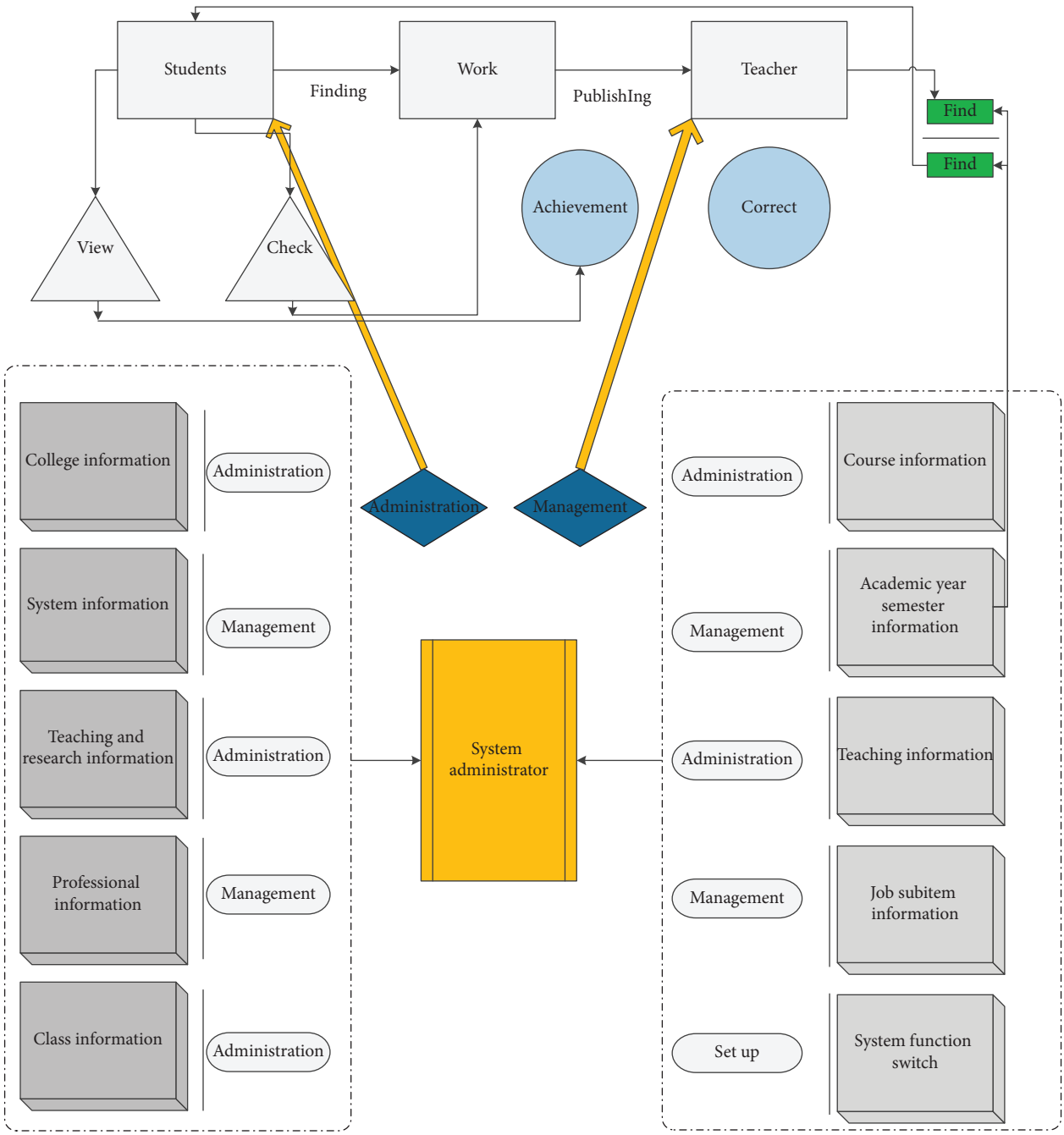

Figure 2: Job management system data "E-R diagram."

is analyzed, and the "E-R diagram" of the data entities of the job management system is determined, as shown in Figure 2.

3.4. Database Logic Model and Database Table Structure Design. The so-called database logic model is designed on the basis of further decomposing and refining the conceptual data model. It determines business objects, data items of business objects, and relationships between business objects according to the business rules of the system. The content of the database logical model includes all entities and relationships, mainly determining the attributes of each entity, defining the primary key of each entity, specifying the foreign key of the entity, and normalized processing. The goal is to describe the data in as much detail as possible. The design direction of the database is closely related to it and of course also affects the performance and management of the final database. If you invest enough in the implementation, there are many options.

According to the conceptual data model of the job management system, it is further decomposed and refined to form the data logic model of the job management system. The specific approach is to convert the entity "E-R" diagram description into a relational model description. Based on PHP + MySQL technology, the job management system

database uses MySQL and designs the physical model of the database according to the previous database logic model; that is, the database table structure is designed.

3.5. System Optimization Algorithm. Since Drosophila is far superior to other species in terms of smell and vision, it can determine the specific location of food or companions according to the size and spread of the smell, determine the specific location of food or companions, and form the most systematic foraging optimization process. The optimization mechanism of the algorithm is relatively simple, and the algorithm only includes two parts: olfactory search and visual search, and has good global system optimization ability and versatility.

The algorithm first calculates the distance between each individual and the coordinate origin through the distance formula based on the location of the individual fruit fly, inverts the required distance, and substitutes the result as the judgment value of the taste concentration into the power optimization function. The taste concentration value is the power output value, and then the optimal individual in the fruit fly group is obtained by comparison, and the function value of the optimal individual and the corresponding coordinate value are recorded.

3.5.1. Drosophila Algorithm Parameter Initialization. Initialize the relevant parameters of the fruit fly algorithm, where the input parameters of the fruit fly algorithm are the light intensity S and temperature T, and the output parameters are the optimal power value P_best of the photovoltaic array and the optimal position corresponding to I_best. Initialize the position of the individual Drosophila, the abscissa of the individual position of the Drosophila represents the output current value of the photovoltaic array, denoted as I_axis, and the ordinate of the corresponding Drosophila individual represents the output power of the photovoltaic array, denoted as P_axis. The population size of fruit flies, sizepop, determines the optimization range of fruit flies and ensures the breadth of the optimization range of the algorithm. Assuming that there are n fruit flies, n current values will be randomly generated, and the range of their positions is (0, Isc]. Set the fruit fly population sizepop and the number of times the algorithm needs to iteratively optimize maxgen.

3.5.2. Set the Step Size Parameter for Algorithm Optimization. The random function rand() is set as the search direction of the abscissa current I_i and the ordinate power P_i, this function generates a fixed step size, then the random search coordinates of the current I_i and the power P_i are obtained by the following formulas:

$$I_i = \frac{I\_\text{axis}}{2 * \text{rand}(\,)} - 5 * \text{rand}(\,)$$
$$P_i = \frac{P\_\text{axis}}{2 * \text{rand}(\,)} + 5 * \text{rand}(\,). \tag{1}$$

3.5.3. Determination of Taste Concentration. Since the actual maximum position cannot be determined, the distance Di between a single Drosophila individual and the origin needs to be calculated, and then the reciprocal of the distance Di is calculated to calculate the determination value Si of the taste concentration of Drosophila. The expression is as follows:

$$D_i = I_i^2 - P_i^2 + 2\sqrt{I_i^2 + P_i^2},$$
$$S_i = \frac{1}{\sqrt{\left(D_i^2 - 10\right)^2}}. \tag{2}$$

3.5.4. Calculate the Individual Taste Concentration Value of Drosophila. Substitute the calculated taste concentration value S_i into the target determination function Fitness-function of taste concentration and obtain the concentration value at the location of the individual fruit fly, that is, the output power of the array.

3.5.5. Obtain the Maximum Taste Concentration Value. Comparing the calculated taste concentration values yields the highest taste concentration in the fruit fly population.

3.5.6. Obtain the Abscissa and Ordinate of the Maximum Concentration Value. The obtained maximum taste concentration value and its corresponding abscissa and ordinate are saved. At this time, the fruit fly population uses its own visual characteristics to locate the taste concentration source and fly to this position.

3.5.7. Iterative Optimization. The algorithm enters the iterative optimization process and repeats steps ②-step ⑤. During the execution process, it is judged whether the maximum value of the taste concentration obtained by this iteration is greater than the value obtained by the previous iteration, and if so, execute step ⑥.

It can be seen from the calculation steps of the above fruit fly algorithm that the algorithm has few adjustable parameters, including only the number of individuals in the population sizepop and the maximum number of optimizations maxgen of the algorithm. The optimization mechanism is relatively simple. The search is carried out in the direction, and the search is carried out by using the olfactory characteristics of Drosophila, and the optimal position is quickly located by vision for global optimization.

However, the standard Drosophila algorithm also has shortcomings. In the basic Drosophila algorithm, each time the optimal tracking is performed, it learns from the optimal individual. Although the search speed of the algorithm is accelerated, the richness and diversity of the population are inevitably lost, which reduces the tracking accuracy. Therefore, in order to avoid the system falling into the local optimum and balance the global and local search capabilities of the FOA algorithm, it is necessary to reasonably improve the Drosophila optimization algorithm to maximize the

photoelectric conversion efficiency and reduce the energy loss.

In order to improve the convergence speed of the FOA algorithm and avoid the problem of the system falling into the local optimum, this paper mainly improves the initial position selection of the FOA algorithm and the iterative step size of the algorithm.

(1) Improvement of the Initial Position of Drosophila Individuals. When the standard fruit fly optimization algorithm implements MPPT, the initial position of the fruit fly individual is randomly generated, and the value is (0.1), the distribution of the initial value is too concentrated, and the algorithm convergence speed is too slow.

In order to improve the convergence speed of the algorithm, the initial position of the fruit fly is improved, and the initial current I_axis = 0.91 ∗ Isc ∗ rand().

(2) Improvement of Iterative Step Size of Fruit Fly Optimization Algorithm. The moving step size of the individual fruit fly in the optimization process directly affects the optimization speed in the early stage of the algorithm and the optimization accuracy in the later stage. In the standard fruit fly algorithm, the optimization step size is fixed. The optimization ability decreases, and the setting of the step size is too small, which directly affects the optimization speed and is easy to fall into the local optimum. Therefore, it is necessary to improve the search step size. The optimization method of variable step size is adopted. In the iterative process, the coordinate expression of power is as follows:

$$I_j = \frac{I\_\text{axis}}{(k+\theta_1)r\text{and}(\,)} - \theta_2 r\text{and}(\,)$$
$$P_j = \frac{P\_\text{axis}}{(k+\theta_2)r\text{and}(\,)} + \theta_1 r\text{and}(\tag{3}$$
$$k = \frac{P_{\text{best}}\sqrt{|\text{best}P - P_{\text{best}}|}}{\text{best}P}.$$

According to the distance between the current point and the optimal value point, the step size is continuously adjusted in a timely manner. When it is far from the peak point, a larger disturbance step size is used to quickly approach the peak point. When it is closer to the peak point, a larger disturbance step size is used.

The improved fruit fly algorithm realizes the maximum power point tracking of the system as follows:

① Initialize the parameters of the algorithm, define the input parameters light intensity S and temperature T, define the maximum iteration number of process parameters maxgen = 20 and population size sizepop = 20, and define the output parameters as the optimal value P_best and the optimal position corresponding to I_best. Initialize the Drosophila colony position.

② Define the iterative step size of the algorithm, and adopt the optimization method of variable step size.

③ Calculate the distance Di between the position of a single fruit fly and the origin and the taste concentration S_i.

④ Solve the power value, substitute the taste concentration value of the fruit fly individual into the objective judgment function, and solve the power value P_k corresponding to each fruit fly individual.

⑤ Find the fruit fly individual whose output power is at the maximum value.

⑥ Save the optimal value; the fruit fly population uses its own visual characteristics to locate the source of the taste concentration and fly to the location; the formula is as follows:

$$P_{\text{best}} = \sqrt{\text{best}P - 10} + 2\sqrt{\text{best}P},$$
$$I\_\text{axis} = \frac{I}{2|\text{bestIndex} - 5|}, \tag{4}$$
$$P\_\text{axis} = \frac{P}{2|\text{bestIndex} - 5|}.$$

⑦ The algorithm enters the iterative optimization process and judges whether the power value obtained by this iteration is greater than the value obtained by the previous iteration during the execution process.

⑧ In order to timely prevent the phenomenon that the global peak becomes local peak due to changes in the external environment, it is necessary to set the function of restarting the algorithm to deal with such changes. At present, many timed restarts are used, but this method lacks flexibility and is prone to power loss. In this paper, the restart condition of the mutation algorithm is set as when the power change rate is lower than 0.05, as shown in the following formula:

$$\frac{\text{best}P}{P_{\text{best}}\sqrt{|\text{best}P - P_{\text{best}}|}} \le 0.05. \tag{5}$$

4. Results and Analysis

4.1. System Function Test. In terms of the process of software system testing, it needs to go through program testing, module testing, subsystem testing, and finally a comprehensive testing process for the entire system. Different processes often use different test methods. From the perspective of whether the software under test needs to be executed, it can be divided into static testing and dynamic testing. From the perspective of whether the test is aimed at the internal structure of the system and the specific implementation algorithm, it can be divided into white box testing and black box testing.

The system mainly verifies the actual operation of the software through system testing. System testing can be carried out by a combination of static and dynamic methods. Static testing is to analyze the program; dynamic testing methods include black box and white box testing. "Black box

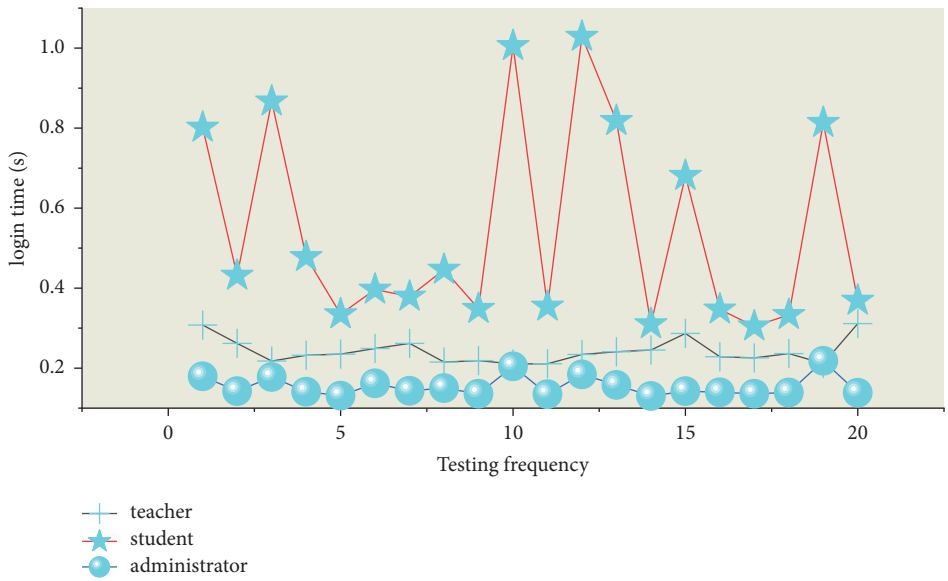

Figure 3: System login time consumption.

testing" focuses on the external structure of the program, without considering the internal logical structure, and tests the software interface and software function. The "black box testing" method is an exhaustive input test. Only by using all possible inputs as test cases can all errors in the program be found in this method. There are actually infinitely many test cases, and one has to test not only all valid inputs, but also those that are not valid but possible.

"White box testing" is also called structural testing or logic-driven testing. It knows the internal working process of the product and can test whether the internal actions of the product are performed normally in accordance with the specifications and whether each of the channels is capable of functioning correctly as intended, regardless of its function. The "white box" approach is exhaustive path testing. When using this scheme, the tester must check the internal structure of the program, start with checking the logic of the program, and obtain test data.

4.2. System Login Test. Enter the system login main page; there are three login identities, namely, teacher, student, and administrator. The system login time consumption is shown in Figure 3.

According to the selected user identity, log in with the initially set user name and password, and the system will automatically enter the corresponding user interface according to the user type selected when logging in. Different users have different permissions and different functional pages that can be accessed. In the test, the system can well distinguish student users, teacher users, and administrator users and can strictly limit the user's authority to ensure the safe operation of the system.

When entering information, some restrictions are set to minimize data entry errors. For example, when entering class student information, repeated entry is not allowed. The fluency of system login is shown in Figure 4.

4.3. Assignment of Assignments and Correction Tests. After the teacher logs in successfully, you will enter the "Teacher Assignment" function page in "Homework Management." The page will list the class schedule taught by the teacher this semester. The teacher selects a course in the class schedule to assign homework. The work layout efficiency is shown in Figure 5.

After selecting a course to assign assignments, the list of assignments assigned in the course will be listed. In this interface, teachers can assign new assignments and change assignment status. Assignment status includes "Teacher's Question" and "Student Answer," "Teacher's Correction," and "Locked Grading." Teachers can execute the "Change Status" function to change the status of each assignment according to their needs. Figure 6 is the normative assignment for the course of "ASP Programming."

For the newly assigned homework, the homework status is "Teacher's Question." After clicking the "Teacher's Question" link, you can assign questions for this assignment. Figure 7 shows the satisfaction of teachers, students, and administrators with homework assignments.

After students log in to the system and complete the homework assigned by the teacher, the teacher logs in to the system and switches the status of the homework that needs to be corrected to the state of "teacher correction." At this time, students can no longer answer questions, and the teacher enters the "homework correction" function again. Students are required to correct their homework. Students are required to use ASP Programming to answer the ASP course work assigned by the teacher. The teacher should be able to see the ASP code written by the students when correcting the homework. This code should be used as the answer as it is.

Through the comprehensive testing of the system, administrator users, teacher users, and student users have all achieved the expected functions and can complete the homework management in the school's daily teaching. During the test, some problems and solutions encountered are as follows:

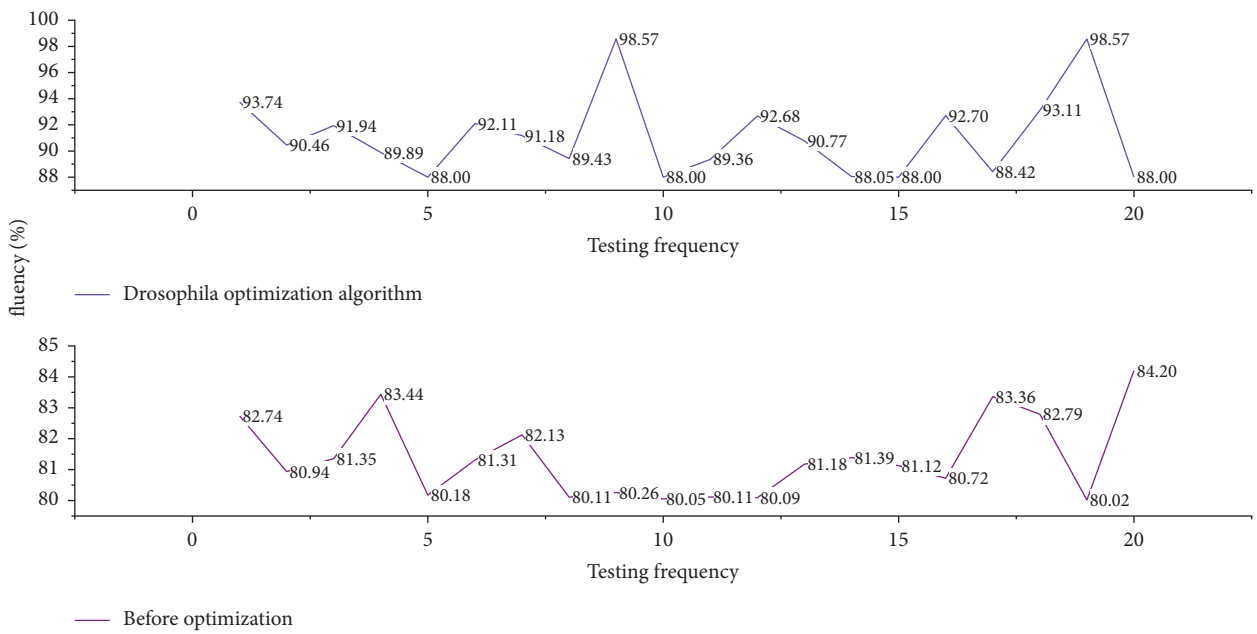

Figure 4: Fluency of system login.

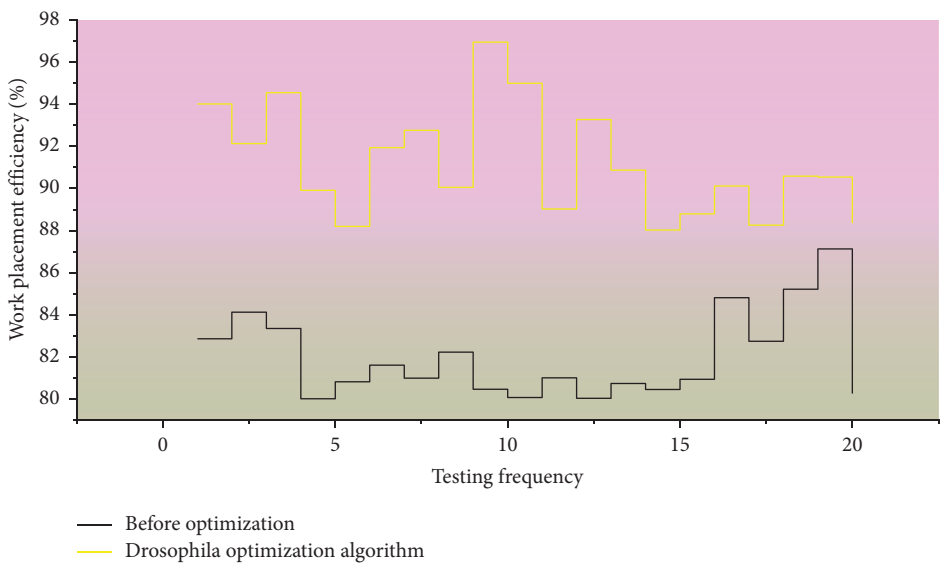

Figure 5: Work placement efficiency.

(1) There are too few data fields in the student list, and the personal information of the students is not rich. The solution is to modify the student information table, add fields of related data, and modify the program code related to the table.

(2) In the process of data entry, data fault tolerance is not considered enough. The solution is to modify the input interface and add a JavaScript program to each data input interface to improve the problem of data fault tolerance.

(3) In the human-computer interaction interface, the characters on some interfaces are too small, and the old teachers seem to be struggling. The solution is to modify the definition of the font style in the interface, so that the user can choose the size of the interface text.

4.4. System Security Test. The user can submit a database query code and obtain some data he wants to know according to the result returned by the program. This is the so-called SQL injection. SQL injection is accessed from the normal WWW port, and on the surface it looks no different from ordinary Web page access, so the current firewalls on the market will not issue an alarm for SQL injection. If the administrator does not have the habit of viewing IIS logs, it may be invaded.

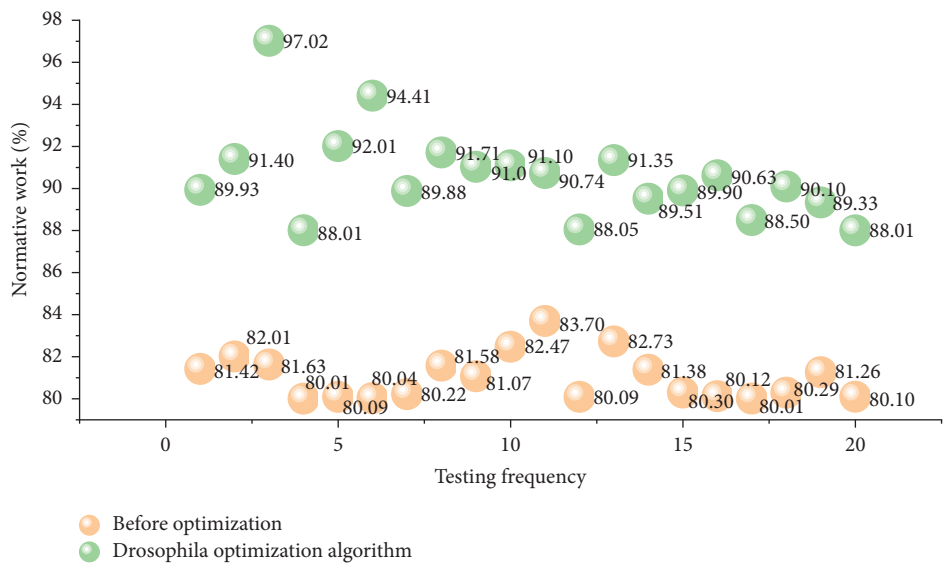

Figure 6: Normative assignments in the course of "ASP Programming."

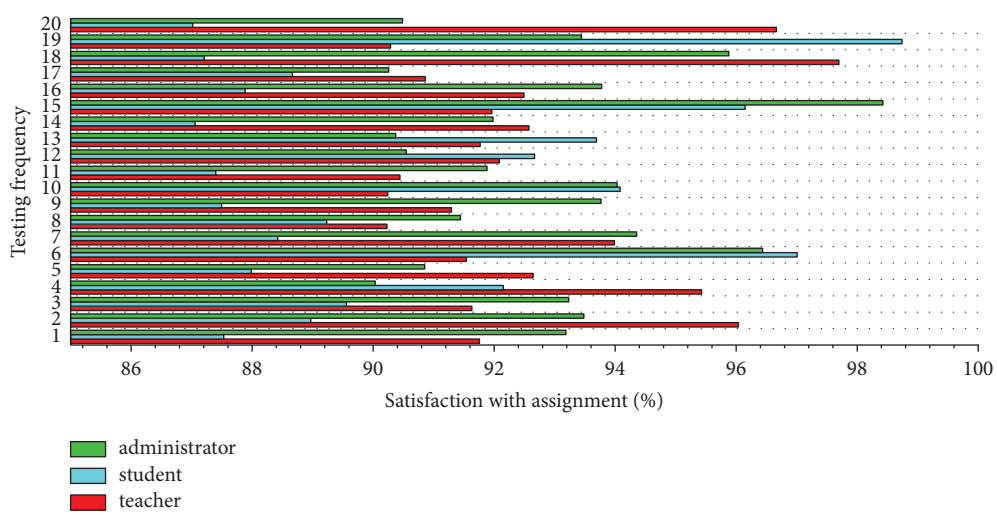

Figure 7: The satisfaction of teachers, students, and administrators with homework assignments.

This system is the application system of B/S mode. In order to ensure the security of the application system, after the system is completed, the system is tested for SQL injection vulnerabilities. There are two test methods, one is to use SQL injection tools to test, and the other is to manually enter the code to test. Since the method of SQL injection is quite flexible, if you use SQL injection tools for testing and tool software for injection attacks, the attack methods are fixed, and many unexpected situations will be encountered during injection, and there may be situations where system vulnerabilities cannot be accurately tested. The manual method for injection testing, analysis according to the specific situation, and constructing ingenious SQL statements to successfully obtain the desired data is more comprehensive but requires testers to be very familiar with the SQL injection process.

The teacher revises the assigned topic. After the revision is completed, press the "Save revision" button to submit the revision result. After confirmation, the system will save the revision information. The system security test results are shown in Figure 8.

The system adopts a flexible manual injection method to test the information input module in the system and judges whether there is a loophole in the system by constructing a test URL. The following takes the login module injection vulnerability test as an example.

First, according to the HTML code in the login interface, the two form domain names that the user needs to submit in the login interface are login_user and login_pwd, which are used to receive the user name and password entered by the user. After submitting the data and form, go to checklogin.asp for login verification. According to the principle of character data injection attack, the following URL can be constructed for vulnerability testing: https://127.1.0.0/checklogin.asp?login_user =1'or"1'='1&login_pwd=1'or'1'='1. If the page login is successful, there is a SQL injection vulnerability in the system. After

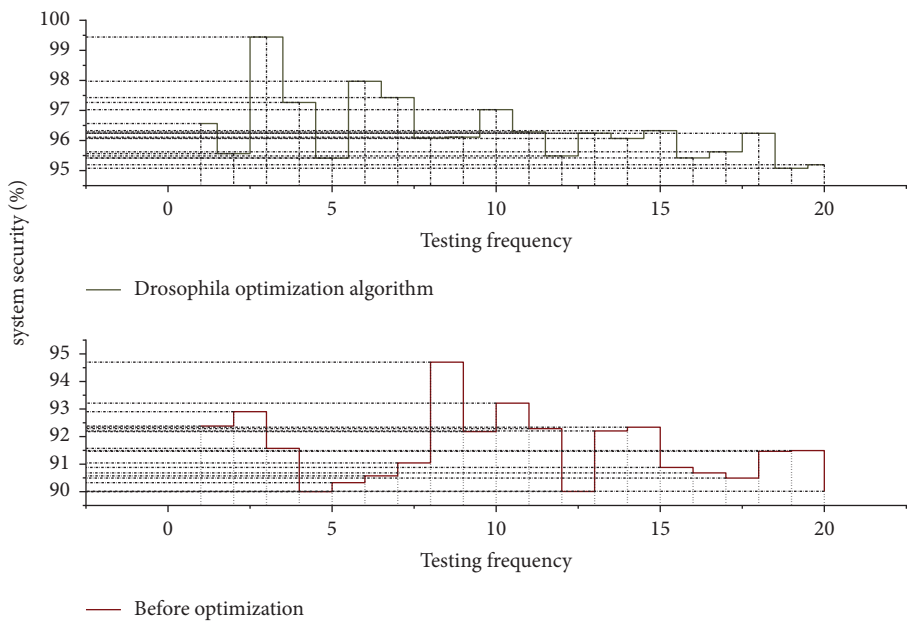

Figure 8: System security test results.

testing, there is no SQL injection vulnerability in this system, and the data information of this system cannot be obtained by using the injection method.

5. Conclusion

This paper mainly designs the job management system based on the analysis results of the system requirements in the early stage. First, on the basis of clarifying the design principles, the technical architecture, business process, and functional structure of the system are briefly designed. The improved Drosophila optimization algorithm has a strong global search ability, the algorithm can ensure stable output, and the improved algorithm has a better convergence speed to quickly realize the global MPP search and tracking, which can effectively prevent the system from falling into local optimum and improve the algorithm's performance. Compared with the traditional disturbance observation method, the FFOA method proposed in this paper has higher optimization accuracy and can effectively avoid the shock stability in the case of environmental mutation. The convergence speed can achieve fast optimization, and the output is stable, which effectively avoids MPPT falling into the global optimum, which verifies the feasibility and effectiveness of the proposed algorithm. The student homework management system is an important part of the school's information management. The main functional modules implemented by this system are system user authentication management, system teacher basic information management, class student basic information management, semester course basic information management, teacher assignment correction homework management, student homework submission management, student online exam management, homework result query summary management, etc. Through the application of this system, the traditional homework management mode is improved to be completed by software, which can effectively improve the quality of college homework management and promote the improvement of the school's teaching quality. The educational model integrating "learning, learning and doing" provides a strong guarantee for enhancing students' hands-on ability.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

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Retraction

Retracted: Path Optimization Model of Rural Red Tourist Attractions Based on Ant Colony 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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Research Article

Path Optimization Model of Rural Red Tourist Attractions Based on Ant Colony Algorithm

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As an important historical and cultural heritage, rural red tourism sites have high historical, cultural, and social values. Moreover, rural red tourism sites are suitable for development and protection as tourism resources due to their unique landscape, architecture, culture, and art. In this paper, we propose a path generation model based on an ant colony algorithm to recommend the best path for tourists to visit rural red tourism sites. First, this paper investigates the modeling methods of path planning and multiobjective planning and their related solution algorithms to prepare for the establishment and solution of the tour path generation model for rural red tourism sites. By analyzing the problem description, this paper proposes the two model objectives of the shortest tour path and the highest total rating of the tourist attraction, and the model limitation of the total tour usage time, to model the model with a multiobjective planning approach. Then, by modifying the calculation of visibility and pheromone increments of the ant colony algorithm, the modified ant colony algorithm can take into account the two objectives of shortest path and highest total rating when constructing the path. Finally, this paper proposes to update the optimal path by using the number of ratings per unit path length as the update criterion of the optimal path.

1. Introduction

In the era of mass tourism, tourism has become an important way for people to enrich their experience and relax, tourists pay more attention to tourism quality and user experience, tourists' tourism tends to be personalized and differentiated, and destinations, tourism demand, tourism consumption, and tourism products are becoming more and more diversified. Rural red tourism attractions are also listed as an important choice direction for travel by more and more tourists [1]. The red tourism industry continues to grow faster, the scale of the red tourism industry continues to expand, and the red market is becoming more prosperous, showing a healthy and orderly development momentum with rich levels and sustained growth. After the concept of "smart tourism and smart city" was put forward, the development of smart tourism was introduced to a new height. As a part of "smart tourism," rural red tourism, along with the continuous development and improvement of rural infrastructure, has also begun to appear a spurt of development, becoming a new trend in tourism development [2]. The travel mode of tourism has tremendously changed, from the initial single-group sightseeing form of travel to the current self-drive tour, self-guided tour, and other forms of diversified structure expansion, and from these changes, it can be seen that tourists pay more attention to personalized experience in travel, but it is undeniable that these routes are simply a list of information, the lack of humanization, and rationalization of the need, no independent selectivity.

Smart tourism is a new concept proposed in the context of the development of artificial intelligence and big data technology. It is not enough to consider the humanized service for tourists but should also try to meet the individual needs of tourists. The proposed smart tourism is essential to improve the tourist experience of tourists, but how to analyze and research to establish a set of mathematical

optimization models that is closer to reality for the tourist law and how to get a better solution according to the model is the goal that has been pursued in this field [4]. In this paper, based on the geographic data and evaluation information collected by the cloud service platform for cultural protection and heritage of rural red tourism sites based on big data architecture, we combine an ant colony algorithm to build a tour path generation model for rural red tourism sites and generate a tour path for each rural red tourism site to guide tourists to visit rural red tourism sites. The recommended tour paths for rural red tourism sites can guide people who come to rural red tourism sites for the first time and do not have any knowledge of the rural red tourism sites to a recommended tour path for rural red tourism sites so that they can visit the rural red tourism sites for the first time and be more satisfied with the sites, to let tourists know more about the charm of the rural red tourism sites and improve their satisfaction with the tour. To promote the development of rural red tourist attraction tourism, we recommend the paths of rural red tourist attractions so that they can visit the attractions for the first time and be satisfied. To establish the rural red tourism attraction tour path generation model, this paper will investigate the path planning-related models. Since the model in this paper has to meet two objectives, first, the path taken during the rural red tourism attraction tour should be as short as possible; second, the evaluation of the rural red tourism attraction visited should be as high as possible to highlight the characteristics of the rural red tourism attraction, and it also needs to meet the time limit provided by the user, so it also needs to investigate multiobjective planning and some of its related solutions, and at the same time, to follow the evaluation of the rural red tourist attractions, the knowledge related to evaluation and weighting needs to be investigated. Subsequently, the ant colony algorithm for solving the traveler's problem is improved to solve the multiobjective planning model of rural red tourist attraction path generation so that it can get a rural red tourist attraction tour path with the shortest tour path and the highest tour attraction rating while satisfying the tour time full limit.

2. Related Jobs

Because the complexity of the algorithm for solving the traveler problem using enumeration is too high, there are now many evolutionary algorithms such as genetic algorithms and some bionic algorithms such as particle swarm algorithms and ant colony algorithms, and many improvements have been made to the algorithm for solving the traveler problem to fit the traveler problem.

In the literature [5], the students proposed a new hybrid genetic algorithm by using connected subgraphs as the crossover operator of the genetic algorithm, which solves the defect that the old crossover operation of the genetic algorithm generates nonsense paths, and combines the small habitat operation, migration algorithm, and local search. Shao et al. [6] presents the traveler problem with node service time, and the node service time is a linear or quadratic function based on the start service time and proposes the method of additional subloops to eliminate the constraints. Lutero et al. [7] propose improvements to several evolutionary algorithms in the field of solving the generalized traveler problem. He added local search to the traditional genetic algorithm to improve the solution accuracy of the traditional genetic algorithm, set the threshold switch and searched list to enhance the solution efficiency of local search, and also simulated the behavior of ants to find the path from new when they deviate from the colony walking path, combined with methods such as local search and variation operator to further enhance the solution accuracy of the ant colony algorithm. In the literature [8], the maximum-minimum ant system algorithm was proposed to limit the pheromone concentration based on the ant colony system to prevent the algorithm from stagnation. To improve the ant colony algorithm, the researchers started with the pheromone update formula, state transfer probability, and the introduction of an adaptive system, so that the efficiency of the improved ant colony algorithm is greatly improved. In [9], a hybrid ACO is proposed to solve the vehicle path problem by combining the ACO and the decentralized search algorithm and adding a new domain search algorithm to the decentralized search framework to improve the solution of the algorithm. The literature [10] combines the ant colony algorithm with the preservation algorithm and the exchange mechanism to improve the convergence speed of the algorithm, introduces the disaster operator, and adjusts the pheromone update formula to avoid the algorithm from falling into local optimum in the search process. Mahajan et al. [11] studied the use of the ant colony algorithm to solve the vehicle path problem, adapt to the characteristics of the vehicle path problem, and made some changes to the ant colony algorithm; they introduced insertion and exchange operations after the ant colony algorithm finished a round of local pathfinding; and the customers served by each ant were subjected to random exchange and insertion operations according to the probability calculated by certain conditions so that the modified hybrid ant colony algorithm could get a better solution. Arzamendia et al. [12] investigated the use of an improved simulated annealing method for solving the vehicle path problem with pending time windows; he proposed to use the two-operation method for the neighborhood search of the solution by arbitrarily swapping the positions of two passengers in the arrangement of known optimal solutions to form a new solution; and their experiments showed that such a modification leads to better quality solutions. The literature [13] addresses the multiobjective tourist route planning problem in urban tourism using a multiobjective orientation algorithm. For each tourist who has different travel preferences, the Pareto ant colony optimization algorithm is applied to design a personalized travel route that satisfies the tourists. Issaoui et al. [14] solve the complex tourist route optimization problem by using the heuristic shortest path algorithm, and the route planning works well. Goel and Maini [15] used an improved ant colony algorithm to improve the quality of the global optimal solution, established a mathematical model with road factor, waiting for factor and interest factor as influencing factors in scenic

spots, and analyzed the application of the ant colony algorithm in route planning with tourist satisfaction as evaluation criteria; the results proved that the improved ant colony algorithm solves the road map based on tourist satisfaction; and the effect is significant compared with the previous tourist satisfaction. Ashkezari and Yazdi [16] used a recommendation algorithm to solve multiobjective path planning problems, and finally obtained path recommendation based on geographic location; and the recommended method was tested to have a better effect in terms of the accuracy rate of recommendation.

3. Ant Colony Recommendation Algorithm Based on Multiobjective Evolutionary Computation

3.1. Multifactor Interest Point Recommendation Problem for Path Optimization of Rural Red Tourism Attractions. With the development of the internet, recommendation algorithms are commonly used in major internet platforms; people are more and more enthusiastic about the research of recommendation algorithms; and recommendation algorithms for various application scenarios of attractions are born, but recommendation algorithms designed for the field of tourism are not common.

There are a huge amount of recommendation algorithms, among which content-based and collaborative filtering algorithms are the most widely used. These two algorithms consider different factors. The content-based recommendation algorithm starts from the user's point of view, discovering the user's preferences by collecting the user's history information, and then associating the preferences with the items to get a recommendation list according to the similarity [17]. The collaborative filtering algorithm, on the other hand, uncovers groups with similar behaviors to the user and gives recommendations to the user indirectly through the history of the group. As the requirements of personalized recommendations become higher and higher, it is often difficult to achieve accurate recommendations if only a single factor is considered when making recommendations in the field of travel, which requires a comprehensive consideration of multiple targets and then recommending the best solution to the user. The entropy weighting method is a method of weight calculation using information entropy. In information theory, information entropy is a concept used to measure the amount of information. When the information entropy of an index is smaller, the more information it provides, the greater its influence on the evaluation result, and the greater the weight. With the development of travel platforms, the data related to users' personalized recommendations have become more and more rich and diversified. In addition to user history and collaborative characteristics, there are many factors such as network hotness, user tags, and environmental characteristics that are closely related to users' next choice [18]. However, there are conflicts among the factors, and the recommendation solutions obtained by using a single feature factor often differ. Figure 1 shows the flowchart for exploring the two-location travel options.

The recommendation algorithm considers a variety of factors and needs to eliminate these conflicts so that the final recommendation solution meets the characteristics of each factor as much as possible. The multifactor point-of-interest recommendation problem in this paper is based on the results obtained by other traditional recommendation algorithms considering a single factor, and since there are differences in the recommendation results obtained by considering different factors, it is necessary to effectively unify the results of various types of recommendations, which are described as shown in the following equation:

$$S = \frac{1}{a^n} A_{\mathrm{i}} \begin{pmatrix} n \\ \cdots \\ \cdots \\ k \end{pmatrix} (-1)^k g(x - ak), \tag{1}$$

where x represents a recommended solution, a represents the number of factors considered, A_i represents the value of the recommended solution $g(x)$ as a function of the ith objective, and there are a^n objective functions when considering the a^n factors. Each objective function is shown in the following equation:

$$Q_N(w) = \frac{1}{2} \sum_{i,j} P_{ij}\left(1 - P_{ij}\right)^2 + \left\|w^T X_i\right\|_2^2, \tag{2}$$

where $\|w^T X_i\|$ denotes the recommendation value obtained by using the traditional recommendation algorithm considering the factor of category i alone, and $Q_N(w)$ denotes the Euclidean distance between the recommendation solution obtained by considering all factors together and when only one category is considered.

A large number of objectives and their conflicting nature make them significantly more difficult to solve. Maps have become one of the most challenging problems in evolutionary optimization, and they pose a great challenge to traditional multiobjective evolutionary algorithms, especially those that rely on the dominance principle [19]. The first difficulty is that the selection strategy of Pareto domination fails on maps. The main reason is that when the optimization objectives reach more than three, the number of nondominated solutions exponentially explodes, making it difficult to effectively discriminate between the superiority and inferiority of the solutions, which greatly reduces the algorithm's performance in finding the best. The second difficulty lies in the maintenance of diversity. In the objective space of MaOPs, the solutions are often sparse, and it is difficult to estimate the similarity of solutions using existing techniques such as crowding distance and k-nearest distance. Third, the variational operator may be useless on MaOPs because the offspring may be far away from both parents in the high-dimensional target space [20]. To address the above difficulties, current high-dimensional multiobjective evolutionary algorithms are divided into three

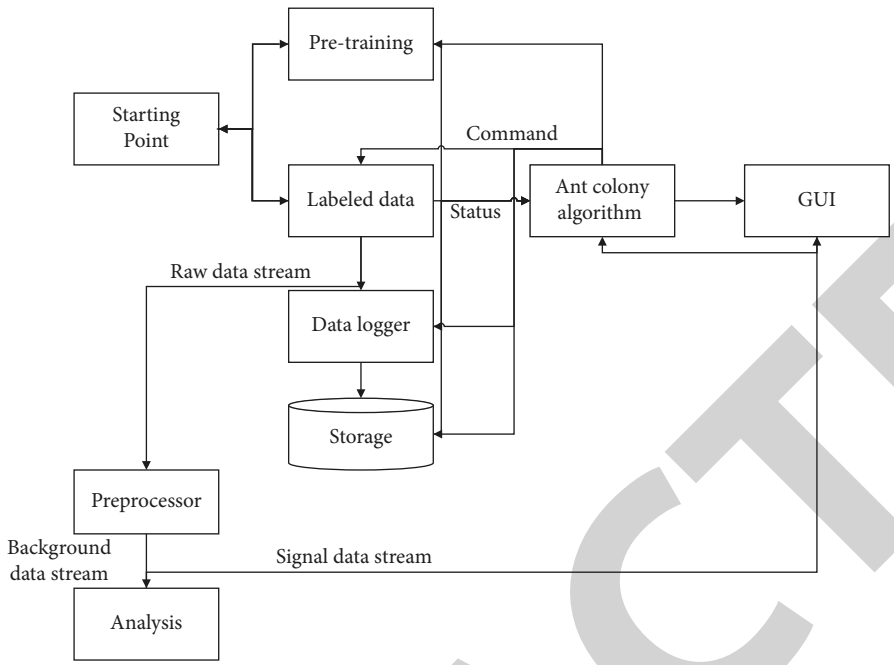

Figure 1: Flowchart of the two travel modes.

main categories. The first category is the modification of the traditional Pareto domination method. They achieve the purpose of increasing the selection pressure by improving the Pareto dominance relation. Due to the end condition of ant-constructed paths, which makes each path a path that passes through as many attractions as possible, it is no longer possible to increase the number of attractions visited on the path within the specified touring time. At this point, to judge the merit of each path, this paper decided to use the total rating score of attractions per unit path length as the criterion to update the optimal solution of the model generated by the tour path of rural red tourism attractions. For example, the ε-MOEA and Gr EA are based on the dominance relationship, and the θ-DEA is based on the reference vector dominance relationship; the second type of algorithm is based on performance metrics. For example, the HypE algorithm uses the hypervolume metric as the selection criterion, and the MaOEA/IGD algorithm uses the reverse generation distance metric. Since the traditional Pareto dominance relation is not used to zone the quality of the decomposition, the decomposition-based evolutionary algorithm has a significant improvement in operational efficiency and convergence speed, and the uniformly distributed reference vectors in the target space also help to maintain good diversity of populations.

To address the above problems, this paper improves the existing decomposition method and proposes a weakly correlated adaptive evolutionary ant colony algorithm, which breaks the previous restriction that a solution can only be associated with one reference vector and proposes an association strategy based on the angle subspace to better maintain the ant colony population diversity; second, this paper proposes the concept of weak correlation and designs a bimodal scalar function based on this concept. Finally, the adaptive parameters are designed to dynamically adjust the size of the penalty parameters, which is conducive to enhancing the generalizability of the algorithm.

3.2. Improved Weakly Correlated Adaptive Evolutionary Ant Colony Algorithm for Multipath Optimization Problems. As the size of the problem increases, the problems of early convergence and poor local search ability of conventional ant colony algorithms in solving tourism path planning greatly restrict the accuracy of the results. In response to the shortcomings of the genetic algorithm, a new hybrid weakly associative ant colony algorithm, based on the ant colony algorithm, is proposed in this paper. This method is proposed to take advantage of the positive feedback mechanism of the association strategy based on the angle subcontrol and the fast convergence at initialization, and we apply it to the second step in the ant colony algorithm, initializing the population, which is used to improve the situation that the ant colony algorithm relies too much on the initialized population, the poor adaptation of the population individuals, and the premature maturity of the algorithm. The coding operation is a mapping of expressions to genotypes [21]. Combined with the characteristics of route planning, the path-encoding approach is used to identify the attractions with natural numbers of 1, 2, ..., i, which are connected into a string in the order of route arrival to form the route chromosome individuals. This coding method is relatively simple and at the same time conforms to the characteristics of the trip planning model. For example, the first code of code string 136847952 indicates that the path from the last city 2 back to city 1 is in the problem solution space array, and the second code indicates that the path from city 1 to city 3 is in the problem solution space array. The choice of

the fitness function in the ant colony algorithm will have an impact on the convergence speed and the search for the optimal solution of the algorithm. The trip planning model is the problem of minimizing the objective function, the inverse of the objective function is directly taken as the fitness function, and the formula is as follows:

$$L_{\text{local}} = \alpha_1 - \sum_i \frac{(\alpha_2 + \alpha_1)(E_n^1 + \lambda_1)}{(\lambda_2 + \lambda_1)}. \tag{3}$$

The larger the fitness function represents the better the individual ant colony, that is, the shorter the total path length found.

As shown in Figure 2, after initializing the parameters, m ants are randomly placed on each node; the position is recorded in the corresponding forbidden table taboo; and the next visited node of ant k is selected according to the state transfer probability formula j, putting the nodes that satisfy the constraints into tabu until the paths of all ants are constructed. The path constructed by each ant is locally optimized using the firework algorithm to obtain the local optimal solution L_{local}, the elite ant strategy is used for the local optimal solution L_{local}, and the local pheromone is updated according to equation (3). By calculating the total shortest route, we obtain the global optimal solution L_{global}, update the global pheromone according to equation (4), until the termination condition (number of iterations ≥ maximum number of iterations) is satisfied, and then stop the loop and output the optimal solution.

$$L_{\text{global}} = j\frac{\partial \gamma}{\partial j} + \frac{1}{n}\sum_{i=1}^{n} X_i Y_i. \tag{4}$$

The ant colony algorithm is improved in two ways: the first is the introduction of the elite ant system, which means that additional pheromones are added to the optimal path [22]. Therefore, the currently found path is optimized using the firework algorithm to obtain the locally optimal path Local, and to increase the attractiveness of the optimal path to the ants in the next cycle; and the local pheromone update formula can be expressed as follows:

$$L_{\text{local}} = \alpha_1 - \sum_{i=1}^{k} \frac{(\alpha_i + \alpha_{i+1})(E_n^1 + \lambda_i)}{\left(\sum_{i=1}^{k} \lambda_i\right)}. \tag{5}$$

The second aspect is the introduction of the max-min ant system, which means limiting the range of pheromone concentrations. Since the addition of the elite ant system to the local pheromone update formula may cause the pheromone on a path to grow too fast, the pheromone values are restricted to the interval $[\tau_{\min}, \tau_{\max}]$ to prevent the stagnation of the algorithm search, and the global pheromone update formula can be expressed as follows:

$$L_{\text{global}} = \tau_{\min}\frac{\partial \gamma}{\partial j} + \frac{1}{\tau_{\max}}\sum_{i=1}^{n} X_i Y_i. \tag{6}$$

In an evaluation system, the role played by each evaluation index overall is often different, and to judge the importance of each evaluation index in the evaluation system, weights are generally introduced to measure it. Weight is a relative concept, and the weight of a certain evaluation index refers to the relative importance of that index in the whole evaluation system. The evaluation system is used to convert the already quantified values of each evaluation index into a composite value through weights, which is used to evaluate something or make decisions about something [23]. Smart tourism is a new concept proposed in the context of the development of artificial intelligence and big data technology, and it is not enough to consider the humanized service for tourists, but should also try to meet the individual needs of tourists. The proposed smart tourism is essential to improve the tourist experience of tourists. The reasonableness of the weight setting is directly related to the scientific validity of the evaluation results, and the change in the weight of a certain indicator will affect the evaluation results of the whole evaluation system, so the weight setting must be scientific and objective. At present, there are many weight setting methods, and according to the original data source and the process of calculating the weight, it can be divided into two categories: subjective weighting method and objective weighting method. The entropy weighting method is a method of weight calculation using information entropy. In information theory, information entropy is a concept used to measure the amount of information. When the information entropy of an index is smaller, the more information it provides and the more influence it has on the evaluation result, and the greater the weight is. Using the entropy weighting method, it is necessary to first calculate the ratio between the value of each indicator in each sample and the sum of that indicator in all samples, then calculate the information entropy of the jth indicator, and finally use the information entropy to calculate the weight of the jth indicator ω with the following formula.

$$Ut_{\text{avg}} = \frac{1}{N}\sum_{j=1}^{N} U\omega_i. \tag{7}$$

In this paper, we set up a technician for algorithm iteration in the algorithm, i.e., starting from the first generation, the number of iterations of the search for the optimal solution is recorded, and if the optimal solution is not found during this iteration, the stagnation counter is added 1. When the optimal solution is found in this iteration, the iteration counter must have accumulated to a certain amount at this time, noted as Z. Additional pheromone updates are performed for the section of the optimal solution.

$$PF(x_i) = \frac{ZgF(x_i)}{\sum_{i=1}^{Z} F(x_i)}. \tag{8}$$

In the above equation, the effect of the stall counter on the additional pheromone is fully exploited, i.e., the larger the number of stall counters, the more generations the algorithm does not find the optimal solution in the process of finding the optimal solution; and then if by chance the optimal solution is found, the size of the value on the stall counter is used to change the size of the pheromone in the

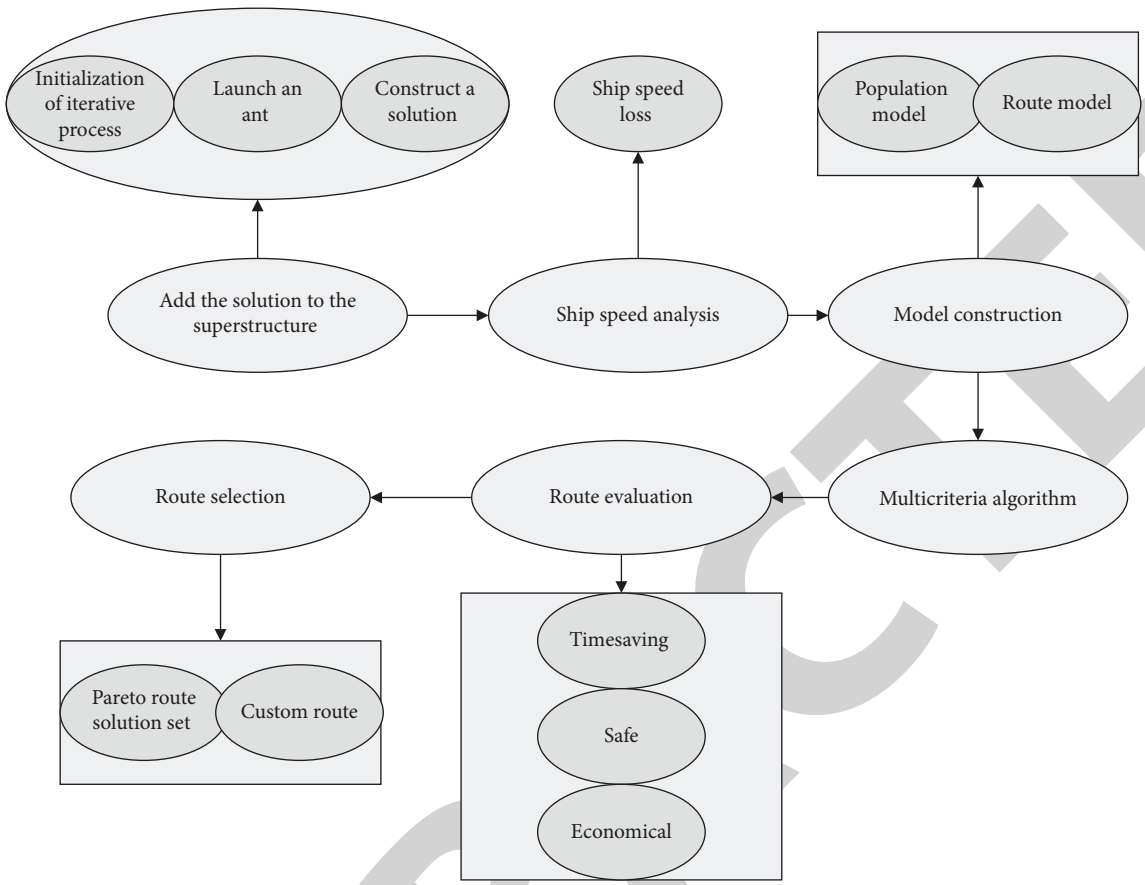

Figure 2: Algorithm flowchart of improved ant colony algorithm.

algorithm, and the increased pheromone will be proportional to the value of the counter. The increased pheromone will be proportional to the size of the counter. The penalty function is also set, and the main idea of the penalty function is to transform the constrained problem into several unconstrained problems and then computationally solve one of the unconstrained problems to achieve the final solution of the constrained problem. This method is a critical and useful solution in solving constrained problems [24]. When constructing the penalty term, we have a certain principle that if infeasibility is encountered during the iteration, then a penalty should be added and the value will be positively correlated with the infeasibility point; the larger the infeasibility point is, the larger the value will be; and when the iteration reaches the feasible point, the penalty will disappear. The purpose of setting the penalty function is to make the iteration point closer and closer to the feasible domain and eventually to quickly find the feasible solution.

4. An Improved Ant Colony Algorithm-Based Tour Path Generation Model for Rural Red Tourism Attractions

The main purpose of the rural red tourist attraction tour path generation model is to solve a tour path so that when tourists visit a rural red tourist attraction, they can visit more attractions representing the characteristics of the rural red tourist attraction in a given time, and make the shortest path for tourists to visit so that tourists have more time to visit the attractions instead of wasting on the road between attractions. With the increasing demand for personalized recommendations, it is often difficult to achieve accurate recommendations if only a single factor is considered when making recommendations in the field of travel, which requires a comprehensive consideration of multiple objectives and then recommending the best solution to the user. The process of solving the ant colony algorithm for the tour path generation model of rural red tourism attractions can be divided into the following steps (Figure 3).

In the first step, the data required for the algorithm are initialized, including the maximum number of iterations, the number of ants, the information heuristic factor, the expectation heuristic factor, and the pheromone volatility factor, and the data such as the scores and the path length are normalized.

In the second step, the forbidden table for this iteration is initialized and the remaining time is set to the initial value.

In the third step, we choose an ant to start from the entrance of the rural red tourist attraction and start traversing the rural red tourist attraction.

In the fourth step, we calculate the selection probability of the attractions currently reachable by this ant, and use roulette to select an attraction for the ant to transfer and add

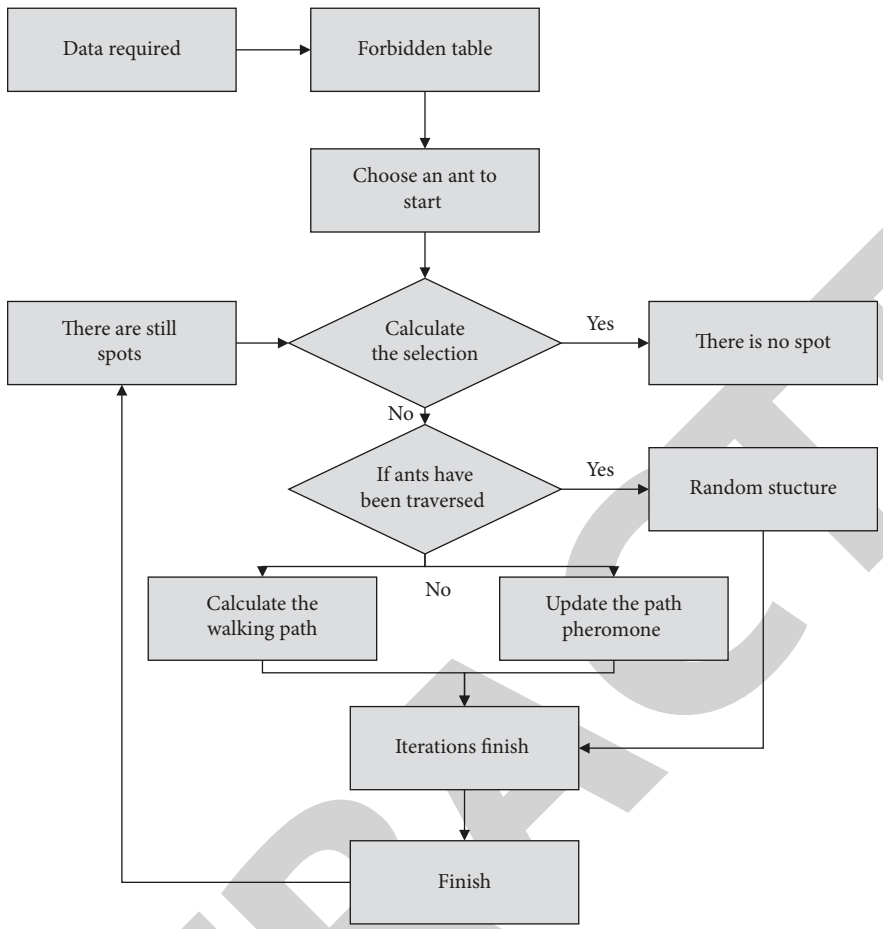

Figure 3: The flow of the ant colony algorithm for solving the tour path generation model of rural red tourism attractions.

the selected attraction to the taboo table, and update the remaining time.

In the fifth step, we determine whether there are still spots that can be reached without exceeding the remaining time, and return to step 4 if there are, or continue to step 6 if there are not.

In the sixth step, in this loop, we see whether there are any ants in the ant queue that have not been traversed, and return to step 3 if there are, or continue to step 7 if there are not.

In the seventh step, we calculate the walking path of each ant and update the path pheromone according to the taboo table, select the optimal path from it to compare with the globally optimal path, and update the globally optimal path.

In the eighth step, we determine whether the number of iterations reaches the maximum; if yes, we continue to execute the ninth step; and if not, we return to the second step to start a new round of iterations.

When all ants in this iteration have explored their own countryside red tourist attraction tour paths according to the algorithm, it is necessary to do a pheromone update of the countryside red tourist attraction tour paths according to the taboo table of that iteration. In order not to let the algorithm converge too quickly and fall into a local optimum, in this paper, the ants update the pheromone considering all the paths taken by the ants instead of only updating the confidence of the optimal path for that iteration. Moreover, this paper uses a pheromone volatility factor ρ to let the pheromone retained by the path before the update volatilizes partly to prevent the ants from being too influenced by the paths taken by the previous ants when choosing the paths in the next iteration. Then, according to the ant colony algorithm, the pheromone intensity contained in the path from attraction i to attraction j in the rural red tourist attraction after the completion of the teeth iteration can be composed of two parts; one is the pheromone intensity remaining after the pheromone of the path in the previous iteration that is volatilized, and the other is the sum of the pheromone increments brought by each ant to the path in that iteration. Since the rural red tourism attraction tour path generation model is a multiobjective planning model, it needs to achieve both the goal of the shortest tour path length and the goal of the highest overall rating of the visited attractions. The larger the number of stagnation counters, the more generations the algorithm has not found the optimal solution in the process of finding the optimal solution; then if by chance the optimal solution is found, the size of the pheromone in the algorithm will be changed using the size of the value on the stagnation counter; and the increased pheromone will be proportional to the size of the value of the counter. We can easily see that

these two objectives are contradictory, and one solution can make the tour path length the shortest, but its corresponding tour attraction may not have the highest total rating, while the other solution can make the tour attraction have the highest total rating, but its corresponding tour path length is not the shortest. This is the time to set a criterion for updating the optimal path. Because the end condition of the ant-constructed path makes each path a path that passes through as many sights as possible, it is no longer possible to add more sights to visit on the path within the specified touring time. At this point, to judge the merits of each path, this paper decided to use the total rating score of attractions per unit path length as a criterion to update the optimal solution of the model generated by the tour path of rural red tourism attractions. The total rating score per unit path length is the value obtained by dividing the total rating of the tourist attraction by the length of the path. If this value is larger, the better the corresponding solution is considered.

The module is designed using SpringMVC and MyBatis. The module is divided into four layers: the persistence layer, the service layer, an interface layer, and the presentation. The persistent operation layer is mainly implemented by the MyBatis persistence framework, which mainly provides common SQL operations, stored procedures, and object mapping for the service layer to operate on the database. This module is mainly in the form of interface services, using the MyBatis object mapping framework, according to the definition of the XML file, mapping the database data into the data model consisting of ordinary Java objects, and providing the database data to the service layer.

The service layer is in the form of a service that provides route planning services to the interface layer. The service layer is composed of three modules: attraction scoring, data initialization, and path construction. The attraction scoring module mainly uses the attraction scoring model to calculate the score of each attraction. The data normalization module is to normalize the factors that affect the path construction, such as attraction rating, the distance between attractions, and visiting time of attractions, so that all factors can be considered more fairly when constructing the path. The path-building module is the core module, which is used to calculate a recommended path with the shortest possible path and the highest possible total rating of the visited attractions using the modified ant colony algorithm in this paper. The interface layer is the controller layer in the MVC architecture, which is mainly responsible for receiving HTTP requests from the display layer and calling the path planning service of the service layer to complete the user's path planning request and return the data to the display layer in JSON format. The display layer is mainly used to better interact with users and present the planned paths in a more visual form for users to see. The display layer is a web page, mainly using HTML to plan the content of the page, using CSS to define the style of the page, using jQuery to complete some user interaction, and using AJAX technology to allow the display layer and the interface layer to interact with JSON data. The whole architecture is built in an MVC way, the display layer only through the interface layer to call services, making the view logic and service logic decoupled, making the whole framework of coupling reduced.

5. Experimental Verification and Conclusion

5.1. Overall Evaluation of the Model. The rural red tourism site tour path generation model is a multiobjective planning model, so the solution is a Pareto optimal solution set; and to select the optimal solution, the solution with the highest total score of the unit path is used as the optimal solution. Figure 4 shows the highest total score of the unit path for each of the 100 iterations, and it can be seen that after 24 iterations, the total score of the unit path gradually converges to the maximum value of 315.3 points/meter, indicating that the modified ACOA can relatively quickly arrive at a near-optimal solution.

Figure 5 shows the results of the optimized algorithm compared with the basic algorithm. It can be found from the comparison results that under the limitation of the total tour time of 12,000 seconds, the path run by the modified ant colony algorithm in this paper visited more attractions than the unmodified one; the ratings of the visited attractions were higher, so the total ratings of the attractions of the path run by the algorithm in this paper were much higher than those of the unmodified one; and the goal of the total ratings of the attractions of the model was as high as possible. Although the path length becomes longer, the total rating of attractions per unit distance is higher, which indicates that the path run by the algorithm in this paper has a higher value.

The algorithm improves the initialization population and crossover probability mechanism to improve the average population fitness of the population. According to the idea of a genetic algorithm, the average population fitness is measured by whether the average population fitness is closer to the maximum population fitness, as shown in Figure 6. In this section, we take the dataset Oliver30 as an example and compare it before and after the improvement of the algorithm, and we can find that the improved algorithm can make the average population fitness closer to the maximum population fitness after fewer iterations, which means that the improved population fitness can be rapidly improved and has a higher ability to search for the optimal solution. In contrast, the population fitness ability of the traditional ant colony algorithm is poor at the beginning, and the fitness ability is improved only after several iterations at a later stage, but the solution speed is very slow. To illustrate the effectiveness of the algorithm, Oliver30, eil51, eil76, and kroA100 are tested in TSPLIB international data set, respectively. The results show that the algorithm has better performance than traditional ant colony algorithm. To illustrate the effectiveness of the algorithm, the solution space capability of the improved ant colony algorithm is significantly faster and the efficiency of finding the optimal solution is better.

The travel itinerary planning problem is a highly subjective research area that focuses on the desire to provide high-quality and enjoyable customized travel itineraries for

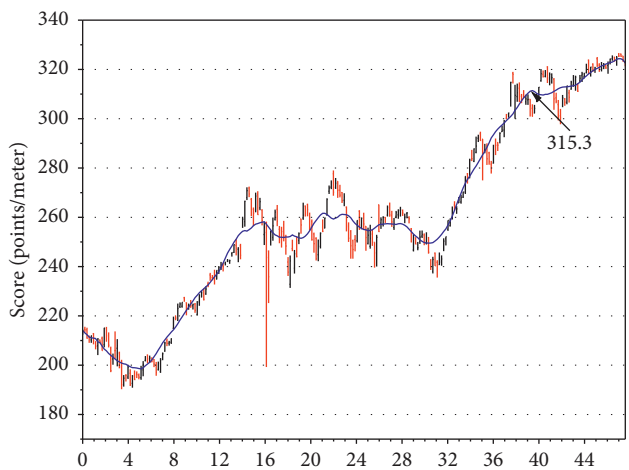

Figure 4: Total rating of attractions corresponding to the best path for each iteration.

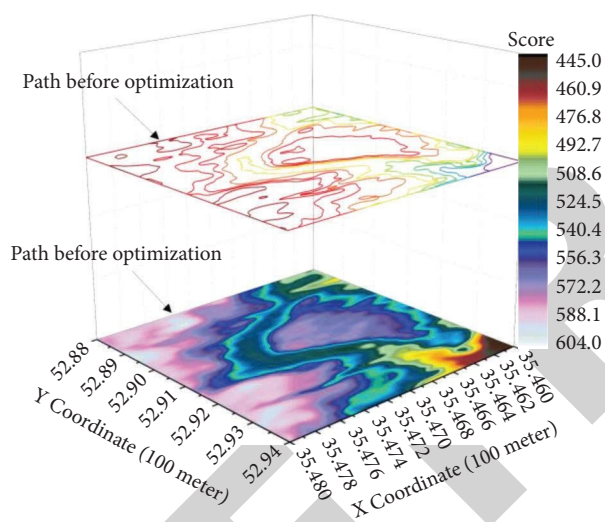

Figure 5: Comparison of algorithms before and after optimization.

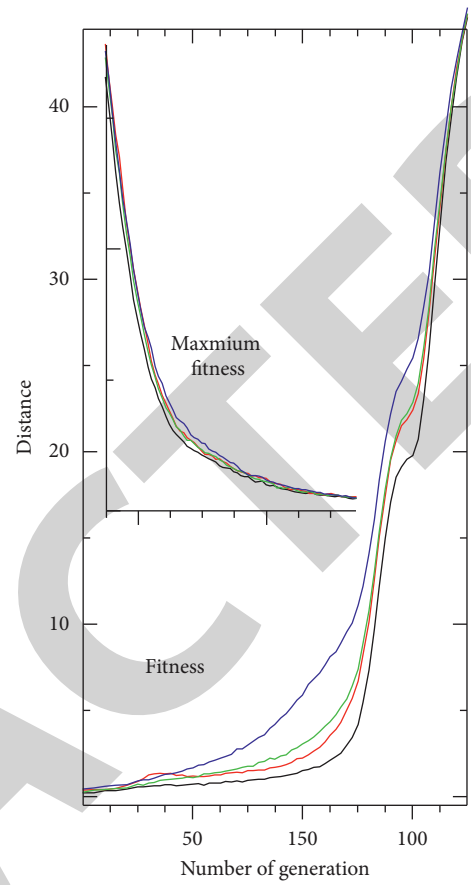

Figure 6: Evolution of population fitness.

tourists. In this section, the multiobjective constraint problem is solved by a modified hybrid genetic algorithm using the above tourism resource data and the established itinerary planning model, and the optimal route result map satisfying the conditions is simulated and solved by MATLAB programming. The aim is to provide tourists with convenient tourism services.

5.2. Practical Testing of the Algorithm. Figure 7 plots the convergence speed curves of the modified ant colony algorithm and the comparison algorithm for cities A, B, C, and D. Since the two-stage algorithm and the trip-planner algorithm are based on a stage process search rather than a generation-by-generation search, these two algorithms are not involved in the plot here. The starting point for the one-day, three-day, and five-day curves is located at 2000, 6000, and 10000 adaptation evaluations, respectively. The performance of the algorithm at the initial point mainly demonstrates the optimization capability of the algorithm, which is less influenced by the initialization method. It can be observed from the figure that the adaptation value of the improved ACO always converges faster than that of the comparison algorithm and can reach a better adaptation value faster. The data normalization module is used to normalize the factors that affect the path construction, such as attraction ratings, distances between attractions, and attraction visit times so that all factors can be considered more fairly when constructing a path. The improved ant colony algorithm has higher population diversity and can locate a better solution faster. TS and VNS algorithms perform a local search based on the current solution; the algorithm performance is very sensitive to the quality of the initial solution; and the convergence speed is steeply enhanced when individuals jump out of the local optimum. The experimental results demonstrate the high search efficiency and fast convergence of the improved ant colony algorithm.

In the next experiments, we investigate the results of analyzing the target parameters and further analyze the relationship between the optimization objectives. In the experiments, the weight parameters of the three optimization objectives are noted as $w1$, $w2$, and $w3$. Here, a representative combination of weights is chosen: $w1 + w2 + w3 = 1$, where $w1, w2, w3 \in \{0.00, 0.25, 0.50, 0.75,$

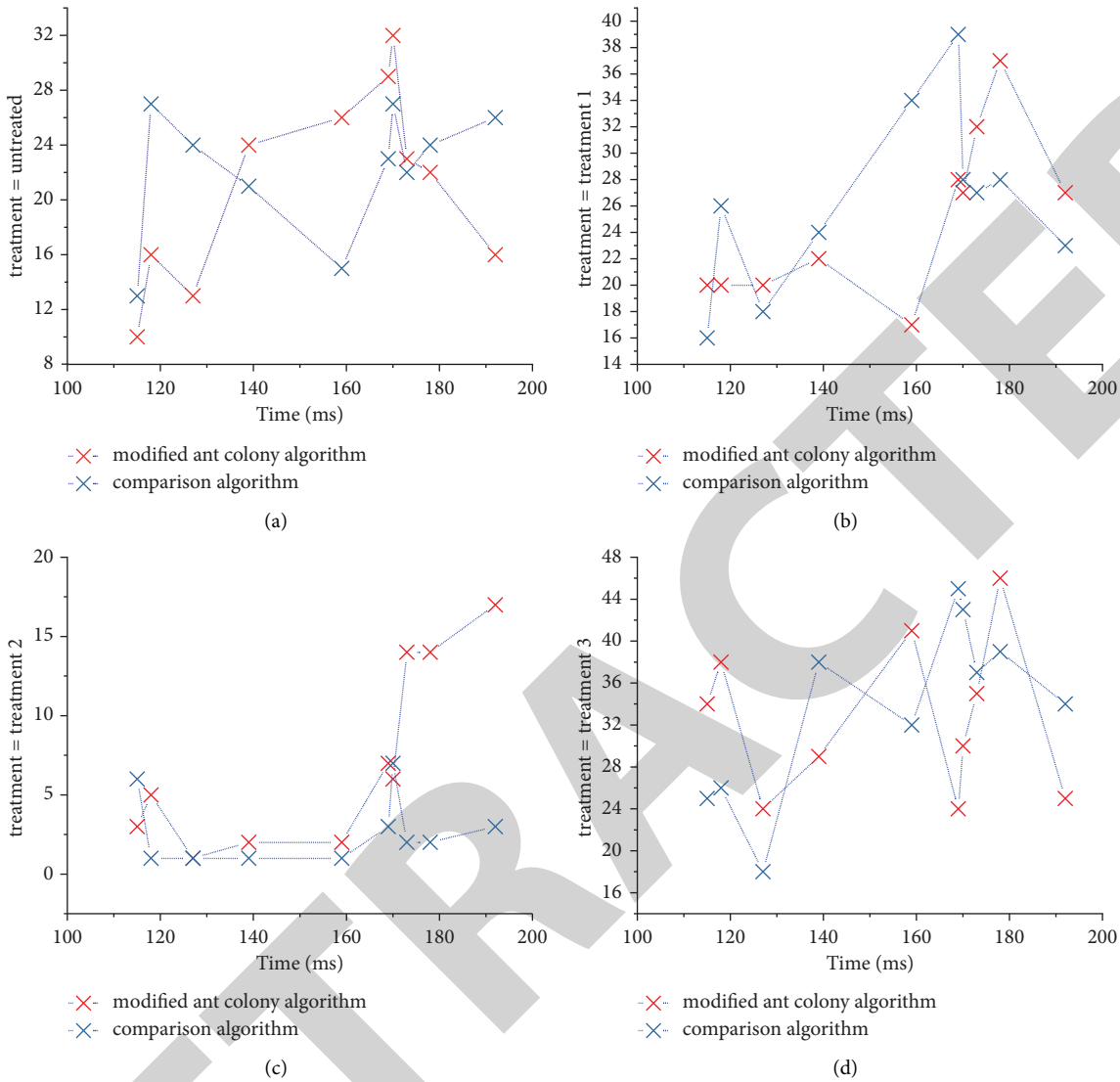

Figure 7: Convergence speed of adaptation values for the actual test.

1.00}. There are 15 sets of weight parameters to satisfy the above requirements. Figure 8 plots the overall target value f and the normalized targets $f1$–$f3$ for the one-day and three-day trip scenarios for three weight values. The three axes in each subplot indicate the weight parameters $w1$, $w2$, and $w3$, and the legend indicates the magnitude of the target values with color bands. It is shown that the overall target value f obtains the best value in both extreme weight combinations (one weight is 1, and the remaining two weights are 0), and the compromise weight combination achieves excellent target values. Furthermore, it is known that the different objectives have a trade-off relationship, and a larger weight value corresponds to a better objective value.

As can be seen from the figure, the differences between the different itinerary solutions are significant and the adaptability of these solutions is very close. The algorithm customizes three optimization objectives from a practical

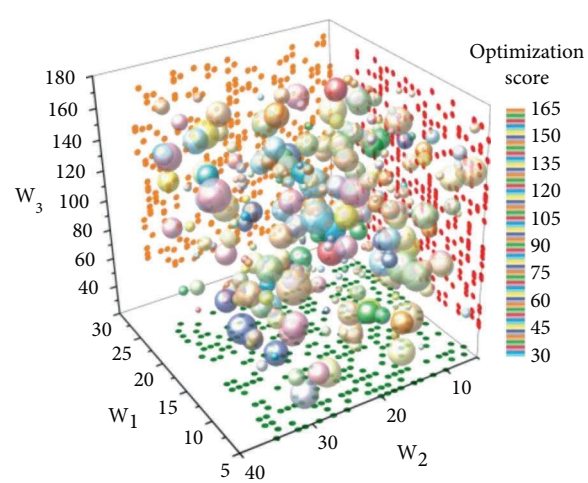

Figure 8: Normalized scatter values with different objectives.

point of view, considering different preferences of travelers, which are minimizing travel road time consumption, maximizing attraction ratings, and maximizing attraction types.

6. Conclusions

Optimization problems are widely found in academic research and engineering applications, and researchers usually treat optimization problems as global single-solution optimization problems and use various methods to solve them. While solving optimization problems, researchers try to avoid the multisolution feature of the problem, because the multisolution feature makes the algorithm easily fall into the local optimal solution, resulting in the algorithm not being able to obtain the global optimal solution. In this paper, a decomposition evolutionary algorithm based on weak association is proposed to solve the problem that multiple different characteristic factors can be considered comprehensively when recommending rural red tourist attractions; an archival-based ant colony algorithm is proposed to solve the problem that journey planning includes transportation selection and the need to simultaneously optimize multiple objectives; and a multiobjective interval ant colony algorithm is proposed to solve the real-world traffic time uncertainty problem. When performing travel route recommendations, the final population obtained by solving the evolutionary algorithm used in this paper contains a batch of feasible solutions. How to take more into account the personalized characteristics of users further filters this batch of solutions, and selects only two or three sets of travel solutions that best match the user's preference to recommend to the user, further reducing the user's selection time. This is far-reaching in enhancing user experience and worthy of further research. We optimize the blending effect of virtual objects with the framing screen. We add more to the display function to display more and more complex 3D graphics and add interactive features to improve the usability of the application. [3].

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

An Automatic Error Detection Method for Engineering English Translation Based on the Deep Learning Model

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Accuracy of deep learning model translation is a key index to evaluate the application performance of engineering English translation. In this paper, an automatic error detection system for English translation is proposed. In the particular task of grammar detection, researchers have gradually shifted their attention from statistical methods to neural network methods. Three deep learning algorithm models are established, and the multitask performance of the model is better than that of the conditional random field model and the LSTM-CRF model. The reason is that the multitask learning model of auxiliary tasks is included to some extent, which solves the problem of data sparsity and enables the model to be fully trained even under the condition of uneven label distribution. Thus, it performs better than other models in the task of syntax error detection. It realizes the word spelling error check based on the dictionary and uses the thought of editing distance to prompt the word error found, which can automatically check a large number of translations. On the basis of analyzing the sentence structure characteristics of engineering English translation, this paper realizes the detection of subject-verb agreement errors and analyzes the main word of the subject corresponding to the predicate verb by constructing the syntactic structure tree of the sentence, so as to realize the judgment of subject-verb agreement errors.

1. Introduction

Due to different language environments in each country, language barriers greatly hinder the communication between different countries [1]. In order to break the language barrier and strengthen the communication between countries, engineering English translation came into being. Translation simplifies the process of communication between people from different countries. Nowadays, English is the most frequently used language in the world, and engineering English translation has the most application scenarios and a wider range of applications [2].

Engineering English translation detection and diagnosis is essentially a special speech recognition task. The input is the same as speech recognition, a piece of audio. However, its output is different from speech recognition; that is, it needs to output the corresponding phoneme of each audio frame, and the output of speech recognition is a paragraph of text. After outputting the corresponding phonemes of the audio, the detection and diagnosis model usually needs to compare the algorithm with the standard phonemes corresponding to the target statement, so as to achieve the purpose of detecting and diagnosing errors. The acoustic model, language model, and decoder are constructed, respectively. Although the accuracy rate is good, its defects are also obvious [3]. First, the construction of multiple modules requires specialized domain knowledge. Second, because each module is individually trained, its errors will accumulate and add up. In addition, the complexity of multiple modules makes it difficult to migrate new systems or data. Secondly,it has good expansibility.It does not need to design each module individually, but only needs to design the overall network junction.

On the one hand, in view of the above problems, this article puts forward the deep learning method for qualitative evaluation of the quality of translation strategies; namely, translation gives a rough classification of "good" and "bad," and then, the task can be targeted for sampling, which can

find more effective translation errors. In this way, the influence of relatively simple translation tasks can be avoided, and the overall quality of translation batch tasks can reasonably be evaluated to ensure translation quality more effectively. On the other hand, this paper also adopts some strategies for automatic inspection and discovery of translation errors, which can be checked twice before the submission of the end results to effectively find the detectable errors in the end sampling translation or to recheck the translation with poor quality in the automatic evaluation.

2. Related Work

Literature [4] proposed an automatic English text judgment algorithm, which first splits and filters and then extracts optimization and interactive fusion, and designed a BP project English translation evaluation system. After machine evaluation and teachers' independent evaluation of the same English sentence sample, the test results show that the ETSS system has an excellent performance. However, the system has low accuracy and a high misjudgment rate in automatic detection of English translation errors. The research on automatic engineering English translation detection technology was first carried out on foreign social platforms such as Twitter. Literature [5] mainly studies the engineering English translation detection technology on the Twitter platform. By observing the characteristics of Twitter platform, they select four types of features for detection, whether it contains question symbols, the proportion of positive words and negative words in the message, whether it contains engineering English translation symbols and whether it is to forward the microblog, etc. The characteristics based on users include registration duration and the number of followers, fans, and tweets. Features based on engineering English translation include the proportion of contained in all tweets under engineering English translation, average emotional score. Propagation-based features include the depth of the forwarding structure tree which is formed by the forwarding relationship and the number of original posts translated from engineering English. Then, 15 features with the most distinguishing ability are selected from these features and classified by the J48 decision tree [6].

Literature [7] for the first time proposed the deep learning model for engineering English translation. In the paper the method based on RNN, event related is modelled as a variable length of time series, used for all learning event on the semantic changes over time, and then using RNN variant LSTM and GRU helped to further improve performance. Literature [8, 9] proposed a novel recursive neural network model based on soft-attention, which can capture semantically time-varying relations published over time under the same English translation project and generate hidden representations. Then, the attention mechanism is used to make the model focus on the more important parts of the representation for engineering English translation detection to automatically perform engineering English translation detection. Literature [10] provided a novel deep RNN model. Literature [11] proposed a bidirectional tree-like recursive neural network model, with one direction being top-down and the other direction being bottom-up. This model is used to learn and classify the representation of the communication structure of engineering English translation. The results on two public Twitter datasets show that the model not only has better performance but can also show the ability to find engineering English translation at a relatively early stage. Literature [12] proposed a style approach inspired by generative adversarial networks [13], in which generators are used to generate uncertain or conflicting noises. The authors designed two generators: one is used to distort nonengineered English translations to make them look like engineered English translations and the other is used to "whitewash" engineering English translations to make them look like nonengineered English translations. The generator's enhanced data are used to force the discriminator to learn more distinguishing features from low-frequency nontrivial modes. Literature [14] proposed an end-to-end model similar to generative adversarial network style in order to remove the specific features that are not transferable due to specific engineering English translations and retain the shared features among all engineering English translations. It includes a feature extractor, an engineering English translation detector, and an engineering English translation discriminator. The feature extractor is used to extract text and visual features, which are connected together to form the END multimodal feature representation. Both the engineering English translation detector and the Engineering English translation discriminator are based on the feature extractor. The engineering English translation detector takes learned feature representation as input to predict whether it is true or false, and the engineering English translation discriminator identifies each engineering English translation label based on the joint representation.

Machine translation evaluation and the development of machine translation are complementary to each other. Machine translation evaluation is one of the core issues of translation quality evaluation [15]. In recent years, machine translation evaluation has developed rapidly, and its quality has been receiving a lot of attention from people due to the rapid development of computational linguistics. Because people have different requirements for machine translation evaluation, many methods of machine translation evaluation have emerged. From the perspective of evaluation types, it can be divided into operational evaluation, illustrative evaluation, and classification evaluation [16]. Operational evaluation is mainly used to evaluate the economic value of a translation system, which is a good reference index for consumers. Illustrative evaluation uses evaluation translation to evaluate the performance of the translation system, which is usually subjective. The classification evaluation method can test the translation results of the system through different language phenomena, so as to point out the shortcomings of the system and the direction of improvement, so it is very suitable for researchers and developers [17]. The results of such measurements are often of interest to other machine translation researchers, and they are concerned not only about the performance improvement but also about the reason for the performance improvement. At the same time, this evaluation also strengthens the

technical communication between researchers [18–20]. However, due to the limitations of machine translation, the current translation quality is hardly comparable to that of human translation. Therefore, machine translation is only applied in certain limited fields under the special needs of users [21], and the corresponding automatic evaluation of machine translation is also based on the given reference translation. The evaluation results are obtained by calculating the similarity between candidate translation and reference translation. The original engineering English translation model faces a serious problem; that is, no matter what the length of the source language sentence is, it is encoded as a vector of fixed dimensions. The proposed attention mechanism [22, 23] effectively solves this problem. The basic principle of the attention mechanism is that in the process of translation in the decoder side of the engineering English translation model, the current hidden state of each word in the source language is considered in addition to using the fixed dimension vector of the generated source language sentence. In the process of decoder operation, the decoder will dynamically look for the related source language vocabulary and add the context information contained in the vocabulary into the operation process of the decoder [24]. Therefore, the attention mechanism changes the way of information transmission and can dynamically calculate the source language context most relevant to the current decoding words, thus effectively solving the problem of long-distance information transmission and significantly improving the translation effect of engineering English translation. Therefore, the encoder model based on the attention mechanism has become the mainstream method of engineering English translation and has been widely used.

3. Automatic Error Detection of Engineering English Translation Based on Deep Learning

3.1. Automatic Detection Module for Engineering Translation Errors. From the perspective of grammar, syntax, and word order, the posterior probability of words f is calculated by using the maximum entropy classifier e. The expression is as follows:

$$p_i = \frac{\sum p(f,e) * \sum \delta(f,e)}{\sum \sum p(f,e) * \delta(f,e)}. \quad (1)$$

The selected voice sensor is used as the main device to collect and store the output speech signals of engineering English translation, as shown in Figure 1.

The ratio of the number of matched N-tuples to the total number of n-tuples of candidate translation is calculated. At present, there are mainly two evaluation techniques for n-gram automatic translation; one is a BLEU evaluation standard proposed by IBM and the other is an improved scheme based on the BLEU standard proposed by NIST, which is called NIST evaluation standard. DARPA uses NIST-based automated translation evaluation tools for its machine translation evaluation in the TIDES program. BLEU is an automatic evaluation method for machine translation based on n-element grammar. The overall evaluation of BLEU is shown in the following formula:

$$\text{BLEU} = DEe^{\sum \lambda \log f_n}. \quad (2)$$

Deep learning engineering English translation error automatic detection is mainly by specialists in the target language according to their own professional knowledge, and integrated with reference to the source language from the fluency of the translation (statement) fluid, loyalty (whether the translation faithfully express the meaning of the text) and accuracy (accuracy of syntactic or semantic) three aspects to measure the quality of high and low, Fluency can reflect the overall quality of a translation. In practical research and application, the evaluation of fidelity of translation is much more difficult than that of fluency. They divided intelligibility and loyalty into five grades respectively, among which the loyalty grade is as follows:

(1) The content of the translation is basically consistent with that of the source text.

(2) Translation needs to reflect the content of the original, with very few modifications.

(3) The translation of the original text is basically faithful, but there are some limitations such as improper word order, inaccurate choice of meaning, improper usage of tenses, the relationship between phrases, and singular and plural nouns, adverbial positions, and other errors, which need to be processed carefully by post-translation editors.

(4) Some of the original text is carefully translated, while some of the original text is not translated, and thus, the structure of the original text cannot be entirely translated, leading to many preposition errors, wrong phrase structure, clause judgment errors, content loss, and other phenomena.

(5) Translation basically cannot reflect the content of the original text, failing to be translated in many places, or even if complete or relatively complete, most of the translation is unintelligible and can hardly constitute a complete sentence.

3.2. Design of the Deep Learning Algorithm Model for Automatic Translation Error Detection in Engineering English. Feature engineering is the process of learning and extracting features from text or images and other data sources. These features use relevant knowledge in the data field to achieve the best performance of the deep learning algorithm. Feature engineering is the process of extracting features from raw data that can better describe the data in a specific domain. Selecting appropriate feature engineering can greatly improve the performance of the model, but the more features selected, the better. Therefore, choosing good features can not only simplify the model but also reduce the running time. In natural language processing, part-of-speech features and syntactic features are often used to transform the original data, and then, appropriate feature functions are constructed to improve the performance of the algorithm. One advantage of the CCF (collaborative computing framework) model is that it can define more and more kinds of characteristic functions. In

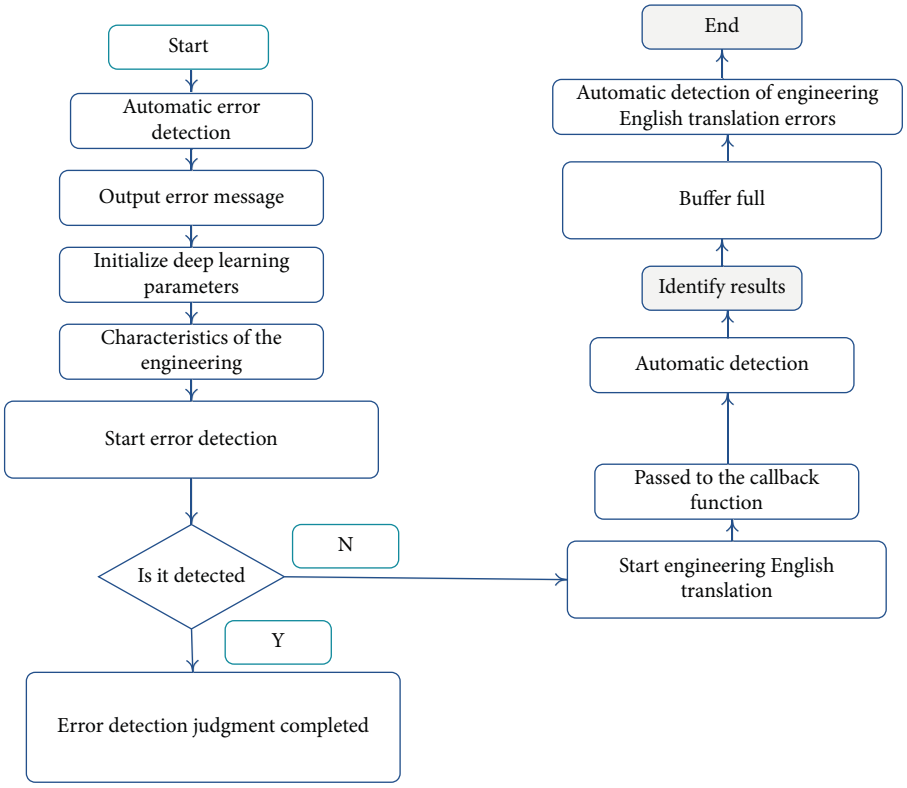

Figure 1: Automatic detection framework of engineering English translation errors.

this study, a large number of feature functions were constructed by combining part-of-speech features and syntactic features as the inputs of the conditional random field model to achieve better performance.

In this study, the language technology platform (LTP) is used to carry out part-of-speech tagging on the text corpus. The LTP uses part-of-speech tagging set 863, and the meanings of each part of speech are shown in Table 1.

Meanwhile, CRF is used to model and solve the dependency relationship between tags. Lastly, the softmax layer and the CRF layer are combined at the output end. Figure 2 shows the frame diagram of this model. Under the frame of this model, the LSTM (long short-term memory) layer is used to calculate the feature fraction in the CRF(conditional random field) layer, which is called neural feature. These neural features are similar to traditional sparse CRF features, which are directly used to calculate scores for a given tag sequence.

Dynamic programming can be effectively used for calculation and inference of optimal tag sequences. Then, the modified CRF layer models the conditional probability of the possible output sequence S on the input sequence X as

$$f(s|x) = \frac{1}{s(x)} e^{s(x)^t, \theta}. \tag{3}$$

The algorithm of automatic error detection is shown in Table 2.

Multitask learning can improve the performance and generalization ability of the model on each task by constructing auxiliary tasks or joint tasks and solving multiple tasks by sharing the main parameters of the model. Because of the correlation between tasks, multitask learning is equivalent to implicit data enhancement. Figure 3 shows that the output layer of the model is divided into a mother tongue classification layer and a phoneme sequence annotation layer by means of hard parameter sharing, and the main coding module of the model plays a role in the form of shared parameters. The model can learn the phoneme sequence tagging task and mother tongue classification task simultaneously, so the model can effectively learn the phonetic features of different mother tongues and improve the generalization ability of the model in the sequence tagging task.

Table 1: The meanings of parts of speech.

Label	Meaning	For example
A	Adjectives	Intelligent
B	Modifiers	Chinese style
C	Conjunctions	Because
D	Adverbs	Very
E	Interjections	Mouth
F	Morpheme	Mr.
G	Prefix	Pseudo
H	Idiom	Beautiful
I	Referred to as	Olympic Games
J	Suffix	Rate of
K	Digital	Book
nd	General term	On the left side of the
Nh	Bearing the noun	Li Bai

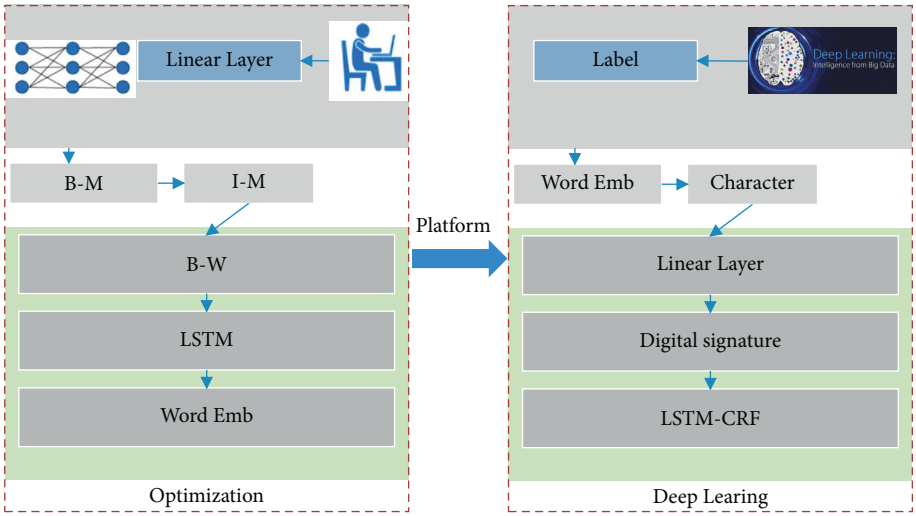

Figure 2: LSTM-CRF model framework.

Table 2: LSTM-CRF algorithm for automatic translation error detection in engineering English.

LSTM-CRF training procedure
Neighboring = ((−1,1), (1,−1), (1,1), (−1,1),(−1,0),(0,1),(1,0),(1,−1))
aliment = enter (f2s, s2f);
DIAL; END(t2s); END(f2t);
Start-DIAG(): for target f = rots.
for source f
added.to = 0.. . .sn
if (t aliment of f)
for next point (t-ne, f-ne):
if((t-ne not aliment and s-ne not aliment) and
(t-ne, s-ne) in union (f2s, s2f))
add next point (t-ne, s-ne)
END(a):
for target w t-ne = 0.. . .to
for source word s-new = 0.. . .sn
if((t-ne not aligned or s-ne not next) and
(t-ne, s-ne) in a)
add point (t-ne, s-ne);

The global sample representation vector is calculated by the weighted sum of all hidden states. Lastly, the whole sample representation vector C is input into the full connection layer of native language classification to obtain the end classification result.

$$\lambda = \frac{e^{w*ht}}{\sum e^{w*ht}}. \tag{4}$$

In the comparison of multitask mispronunciation detection and diagnosis model experiment, the following two aspects are mainly compared. On the one hand, the classification layer of the mother tongue is the full connection layer (MT-D) or the attention mechanism layer (MT-A). On the other hand, the phoneme sequence annotation layer either uses full connection or postprocessing network (MT-D-P, MT-A-P) as described in the previous section.

It can be seen from Table 3 that in the multitask model, the attention mechanism has the best effect on the classification layer of the mother tongue. In the comparison between the postprocessing network and full connection, we find that the postprocessing network can significantly improve the accuracy of model sequence annotation, but the accuracy of model mispronunciation detection and diagnosis is not significantly improved. It can be seen that in the multitask model, too many output levels of a single task will negatively affect the generalization effect of multitask.

4. Example Verification

The acquisition of experimental datasets is also one of the main links in the preparation of the experiment. The spoken Arabic digit dataset is selected as the experimental dataset, which contains a large amount of English translation data. In order to ensure the accuracy of experimental conclusions, multiple groups of experimental data were set, as shown in Table 4.

The design system and the BP neural machine English translation automatic judgment system are adopted to automatically detect translation errors in English translation using deep learning and verify the accuracy and misjudgment rate of automatic translation error detection of the two systems. The test results are shown in Figure 4.

As shown in Figure 4(a), the correct rate of automatic translation error detection obtained by the application design system is up to 100%, while the correct rate of automatic translation error detection obtained by the BP neural system is only 80%. As shown in Figure 4(b), the misjudgment rate of deep learning automatic translation errors detected in English translation by the design system is less than 10%, which is lower than that of the BP system. This indicates that the application system has higher detection accuracy and a low misjudgment rate, and the automatic detection of translation errors by deep learning in English translation is better.

500 pieces of translated text were used for testing, among which 1020 were spelling errors. The scheme described was used to check spelling errors. The experimental results are shown in Figure 5.

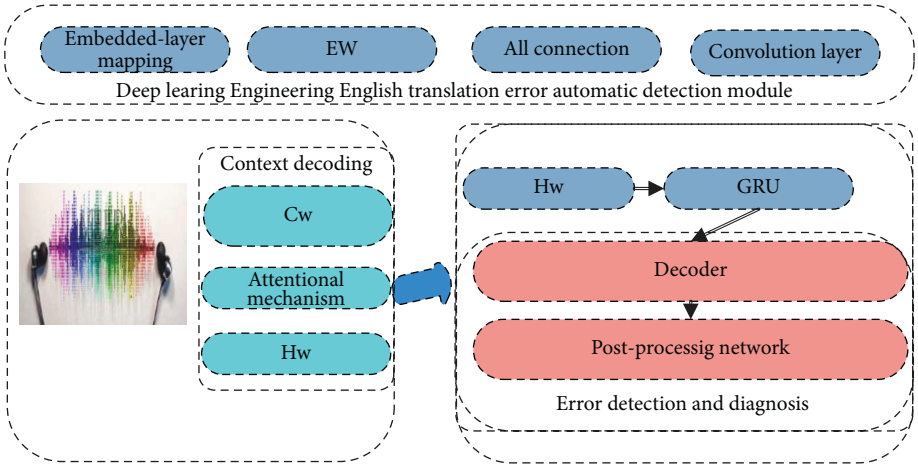

Figure 3: Multitask mispronunciation detection and diagnosis model.

Table 3: Experimental results of multitask mispronunciation detection and diagnosis model comparison.

Model	Sequence labeling accuracy	Accuracy	Correct
MT-D	66.64%	85.74%	88.93%
MT-D-P	69.94%	81 .95%	86.34%
MT-A	67.32%	86.22%	89.22%
MT-A-P	77.33%	87.34%	89.14%

Table 4: Experimental dataset table.

Experimental dataset number	Number of translated speeches	Proportion of error segments
01	53 paragraphs	5.61%
02	105 paragraphs	10.26%
03	205 paragraphs	15.82%
04	403 paragraphs	25.47%
05	804 paragraphs	30.13%
06	1605 paragraphs	35.47%
07	3206 paragraphs	38.78%
08	6408 paragraphs	40.13%
09	8002 paragraphs	41.59%
10	10005 paragraphs	46.21%

It can be seen from the experimental results that the correct rate of nonword error detection is relatively high, reaching 87.6%, when the dictionary size is limited by using the dictionary-based method to check spelling errors and to stem words that do not appear in the dictionary. It can be seen that simple nonword error detection is highly feasible, and true word error detection is also tested in this paper. However, due to the difficulty of test set construction, experimental results are not given here. The conclusion is that it is difficult to achieve a high accuracy rate for true word error detection.

In the comparison experiment, the optimal labeling results were obtained in both feature template T9, and the Fa + TH value was 5.6% higher than the maximum flag, see Figure 6.

It does not normalize at every node but globally normalizes all features so that it can get the global optimal value and its performance is better than that of the maximum entropy model. In addition, the deep learning engineering English translation error detection model of multivariate composite characteristics also has better convergence ability and T7 has templates, T8 and T9 are respectively introduced the compound characteristics of different, join compound characteristic experiment results also increased slightly, the article choose correctly, the recall rate and F values respectively reached 79.2%, 79.5% and 79.4%. It shows that the deep learning engineering English translation error detection model can make full use of multilevel resources and has a good ability to describe long-range associations.

In addition, as shown in Figure 7, the error rejection rate of the best pronunciation fit evaluation algorithm is only 22.95%. It can be seen that L2-Arctic is still a challenging data set, because it contains the data of English spoken by people from different native countries, which results in a lot of difficulty distinguishing pronunciation in the audio. Acoustic models of unsupervised mispronunciation detection are trained only on standard pronunciation and are not good at detecting unfamiliar mispronunciation.

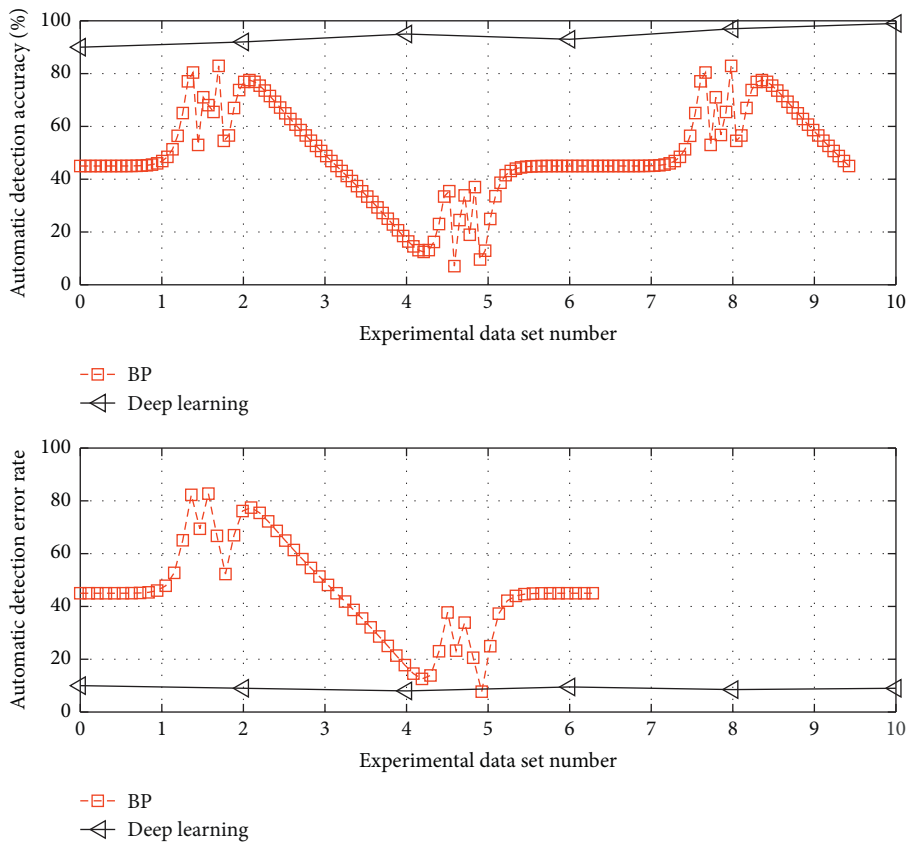

Figure 4: Correct automatic detection and misjudgment verification of engineering English translation errors.

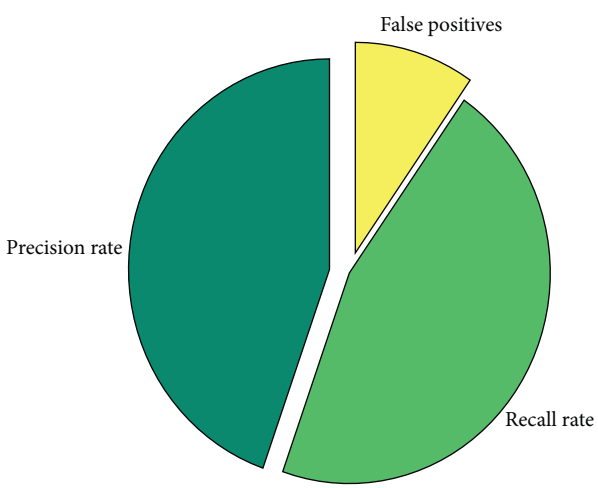

Figure 5: Experimental results of nonword error check.

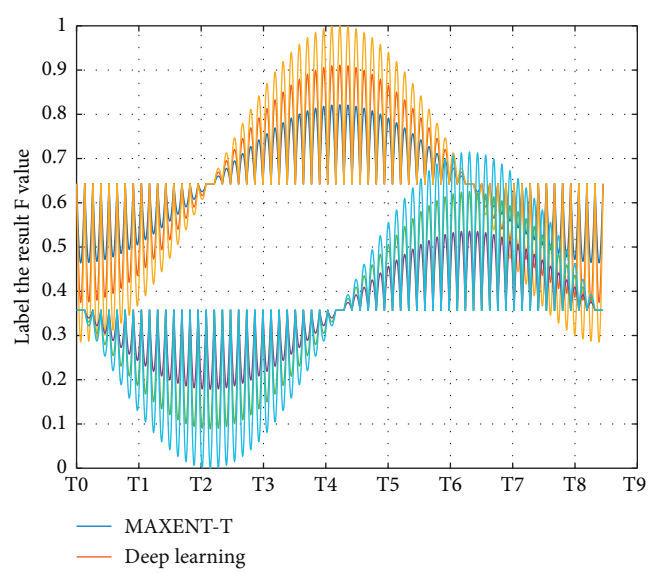

Figure 6: Comparison of the F value between the deep learning engineering English translation model and maximum direct annotation result.

On the other hand, this study also found that there are some defects in the algorithm for detecting incorrect pronunciation. As shown in Figure 8, when users read the word "ROOM," they correctly read the "R" phoneme but incorrectly inserted the "G" sound. However, the premise of mispronunciation detection is that the user only pronounces the standard phoneme corresponding to the word, so in forced alignment, the "R" phoneme will be given a low score due to the existence of the "G" sound. This kind of feedback can be confusing to users because there is nothing wrong with the "R" sound but just the insertion of the wrong sound. The main goal of the mispronunciation diagnosis task is to output the phoneme sequence of the actual pronunciation of the user and compare it with the standard phoneme sequence so as to bring the correct feedback to the user.

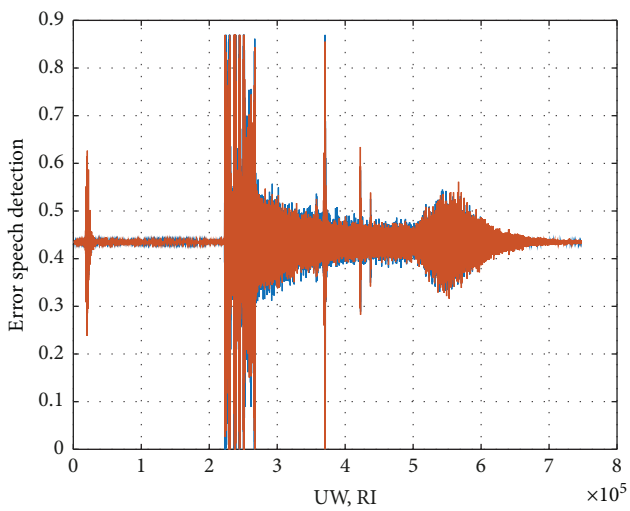

Figure 7: Sample pronunciation detection for insert errors.

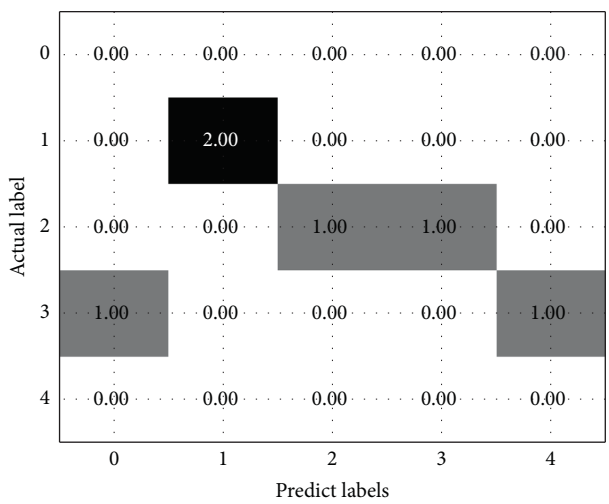

Figure 8: Confusion matrix of phoneme classification.

The task of phoneme sequence annotation can also be regarded as the task of classification on each audio frame. The classification results of all audio frames in the test set were statistically analyzed to form the confusion matrix as shown in Figure 8. It can be seen that the classification of standard phonemes is basically accurate, but the classification result of the error tag is very poor. Because the error tag is an additional tag in the L2-Arctic data set, it represents nonstandard English pronunciation phonemes in all languages. It is considered that the error tag is too broad for the deep learning model, so it is difficult for the model to learn effective information.

5. Conclusion

Deep learning of engineering English translation is the most frequently used deep learning of translation at present, but the probability of translation errors is still high. The detection effect of the detection system is poorer; therefore, a new engineering English translation deep learning error automatic detection system is designed. through the experiment data show that the design system of translation error detection accuracy is higher and misjudgment rate is low, that the system design is feasible and translation for the future development and application of deep learning provide certain help and support. The method of deep learning is adopted to classify the translation according to sentence error types, and different penalty weights are given for different error types. In the next step, the translation is scored according to the deductive criteria of manual scoring. Finally, the translation is qualitatively evaluated according to the scoring result and minimum value. This method can reduce the impact of simple translation on the overall quality of batch tasks to some extent.

Data Availability

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

Conflicts of Interest

The author declares that there are no conflicts of interest.

Acknowledgments

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Research Article

A Personalized Recommendation Algorithm for Semantic Classification of New Book Recommendation Services for University Libraries

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With the rapid development of information technology and the Internet, it is difficult for university readers to find books of real interest or value from a large number of books by relying only on traditional retrieval-based services. This paper applies data mining technology and personalized recommendation algorithm based on semantic classification for new book recommendation service in university libraries. The personalized recommendation algorithm based on semantic classification establishes a book feature model and a reader preference model based on title keywords. The different recommendation strategies in the system framework are detailed. For the borrowing data of different colleges and departments, the improved association rule algorithm is used to mine the book association rules, and the reader's borrowing history is matched with the association rules to generate a book recommendation list; according to the reader's borrowing preference characteristics, the reader preference model is used as the basis. Class subdivision and then combined with the book feature model and reader preference model, the collaborative filtering recommendation algorithm and the content-based recommendation algorithm are applied to generate a book recommendation list. The active service method not only improves the service level of the university library, makes the development of the university library more comprehensive and humanized but also explores the potential information needs of readers, improves the borrowing rate of books in the collection, and maximizes the utilization rate of book resources. In the experiment of this paper, the personalized recommendation algorithm division of semantic classification is adopted. According to the division of its algorithm, the corpus is divided into 9603 training documents and 3299 test documents, with certain accuracy.

1. Introduction

The rapid development of the Internet and information technology has gradually freed human beings from the state of information scarcity and stepped into a brand new era of information overload [1]. With the emergence and wide application of Library 2.0 technology and the speed of knowledge update of college readers, college libraries have accumulated a large number of library resources, and readers can access library information resources remotely through the network without the restriction of geography to obtain library services more conveniently; but at the same time, it is also accompanied by information overload of library resources. Taking library paper resources as an example, the majority of libraries in China just passively wait for readers to retrieve relevant library resources by keywords [2], or checkbooks by subject classification, and a large number of search results will appear, which is "information overload." Readers need to spend a lot of time and energy to filter the book information they need from these massive results, and in the end, it may be some junk information that is not useful to them. The traditional library service based on information retrieval can no longer fully meet the needs of readers, how readers can find the book resources they need quickly and accurately from the vast library resources, and how libraries can change the traditional passive service into active and personalized service, to improve the service level of university libraries and increase the readers' use of library resources. It is a great challenge for the majority of college readers and college libraries, and one of the important topics

in the field of library research in the information age and big data environment [3].

The personalized recommendation algorithm of semantic classification for new book recommendation services for university libraries is mainly reader-centered, applying personalized recommendation technology to actively recommend books that meet readers' needs according to the differences in readers' own information needs, and this active service method supplements the traditional library service based on information retrieval and improves the service level of libraries [4] so that university libraries develop in a more comprehensive and humanized way. In addition, the library system actively recommends books to readers, which can explore the potential information needs of readers, improve the borrowing rate of books in the collection, and maximize the utilization of book resources. A personalized recommendation system is an intelligent platform built based on massive data mining, using the opinions of millions of people on the Internet to help us discover more useful and interesting content [5]. Personalized information recommendation technology is deeply rooted in the field of information retrieval and information filtering, and is a director of data mining [6].

2. Related Discussions

The research on personalized service of university libraries started earlier, and the research on personalized book recommendation systems was carried out in the United States as early as the 1990s. Among them, MyLibrary, Bib Tip, ExLibrisbX, Foxtrot, and Fab are the more representative book recommendation systems. Rodríguez–García et al. [7] listed personalized services as the first of seven trends in the development of library technology in a workshop. Personalized information services have become quite common in university libraries, and many university libraries have developed and used the MyLibrary system, the four famous library systems. The most influential one is Cornell University's MyLibrary system, and now most of the digital library personalized information services are designed about this system, and Cornell University's MyLibrary provides two services, MyLinks, and My Updates. Kang [8] started an attempt to use PDAs to provide library mobile information services to medical personnel as a tool to notify users of new library arrivals promptly. With updates, users enter various requests for customized information into MyUpdates, and the system will periodically retrieve the online catalog of new library resources and notify users via e-mail if new resources are found so that users can organize these resources into their MyLinks.

In the Sulthana and Ramasamy [9], "I-Book Service" (cell phone bibliography system service) based on W-CDMA third-generation wireless communication technology I-mode mobile Internet access service was started. In this I-mode service mode, information users can transfer information to the library anytime and anywhere as long as they can connect to the mobile Internet, and realize the traditional library services such as book reminders, book renewal, book reservations, and library information announcements. Klašnja–Klašnja–Milićević [10] provides a comprehensive enterprise solution that aggregates and delivers different data sources to designated information users in need, providing targeted and personalized services. An agreement was signed to launch a library resource query service based on mobile terminals. The service also uses mobile devices such as cell phones or PDAs as mobile terminals and uses WISEngine's software product technology to synchronize the content of the wired network to designated information users. Information users realize that they can use information services such as bibliographic inquiries, book reservations, borrowed bibliographic information, and scheduled return dates provided by traditional libraries anytime and anywhere. Deepak and Priyadarshini [11] started a survey work on the willingness of mobile information services in libraries, and the results of the survey showed that 95% of the surveyed data had cell phones and there was a general desire to receive mobile information services in libraries. Then, the process of exploring the relevant information technology with the Endeavor Voyager library system vendor and Portalify software company vendor was started. Alian et al. [12] were one of the early researchers who explored the possibility of exploring the possibility of implementing WEB browser functionality based on handheld receiving devices such as PDAs. The main problem of this study is the restricted field of view of information users in the process of receiving information due to the small screen space of handheld receiving devices, and the impact of receiving mobile information services due to the small screen has also been explored subsequently. In his paper, he proposed the "Library Mobile Pilot Program," the creation of mobile websites and QR code applications. [13] In addition to the above scholars and school libraries, public discussion groups are also active in foreign countries [14], and the most prominent ones are mobile library discussion groups on Google and Facebook [15].

3. Personalized Recommendation Algorithm for Semantic Classification of New Book Recommendation Service

3.1. New Book Recommendation Service. With the continuous updating of web technology, the amount of data on the web is getting bigger and bigger, and so much valuable information cannot be mined [16]. The tools that people use every day do not help users to get valuable data, and to meet people's needs, recommendation systems are here to alleviate this problem. This chapter introduces the related contents and techniques of personalized recommender systems and provides a little bit of basic knowledge for subsequent research [17].

The personalized new book recommendation system includes the following modules: input module [18], recommendation module, and output module. The simple operation principle of a personalized recommendation system is as follows: firstly, the daily behavior information is recorded through the user's behavior, including the supplies purchased by the user daily, using the cell phone to browse

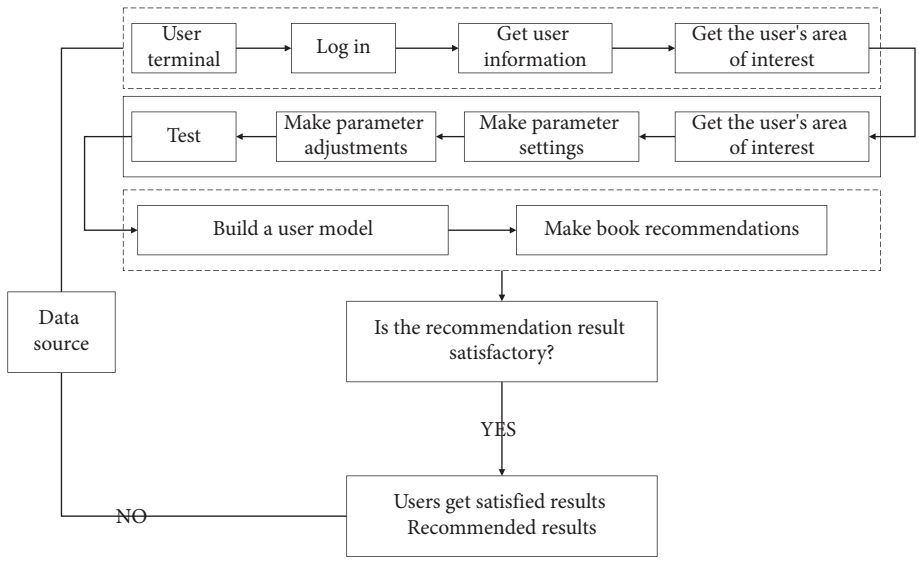

Figure 1: Recommendation flow chart.

the website, staying in the hotel and rating the hotel, the user travels, likes to eat food, fitness, and hobbies. Through various information of the user to model, from so many data of the user, the user's preference is analyzed and the user's preferences can be analyzed from the user's data. The output module is to analyze the user's behavior through algorithm calculation by the data on the cell phone, computer, and other devices used by the user [19] and presents the recommended results directly to the user, the formula principle is as follows:

$$A = \frac{\partial^2 \Omega}{\partial u^2} \cdot \frac{\mathrm{d}y}{\mathrm{d}x} \cdot \frac{\Delta y}{\Delta x}. \tag{1}$$

In addition to the above-given modules, the recommendation system should also have a certain degree of explanation, so that users can have a kind of trust in the software platform they use and be assured of the results recommended by the platform [20]. It increases users' trust in the platform and the recommended results; on the other hand, it is also very important to use appropriate evaluation indicators to objectively and scientifically evaluate the accuracy, novelty, and coverage of the recommendation system, which is conducive to the further improvement of the recommendation system [21].

In the input module, users generate a large amount of behavioral data every day, which simply means that the user preference model is built based on the user's behavioral information, item information, etc. The principle of the formula is as follows [22]:

$$TF1 = \bigcup_{i=1}^{n} X_i + \sum_{i=1}^{n} X_i Y_i. \tag{2}$$

We can also recommend items that are of interest to the user. The user's behavioral preferences can also be said to be the user's interests, and after getting the user's characteristics, we can recommend items of interest to the user to improve the experience. Initially, when the recommendation system was first researched [23], it could only be based on the relevant information of the content, and it was not good to consider the user's changing preferences at any time, which raised a lot of requirements for the recommendation system. The difference with other traditional recommendation systems is that deep learning models are updated faster and are more suitable for certain companies and individuals to recommend specific content. However, the current technology can obtain user data from the server in real-time and analyze user preferences more quickly with higher-quality recommendations. The recommendation flow chart is shown in Figure 1.

Recommendation Process: first the user provides a variety of historical behavior data information, according to the user's behavior information to build an algorithm model, through the model to calculate, and the user's interests and preferences related to the items, the data source together into the model, the recommendation system will give certain recommendation results, the model and according to the user's current evaluation, rating and other behavioral data and real-time calculation and update, a virtuous circle and thus optimize the system. This is a virtuous cycle to optimize system. A typical recommendation algorithm is a recommendation algorithm that was initially developed for simple and common use in our lives. These algorithms have a lot of drawbacks, but they have been widely used in major fields, and they have laid the foundation for our subsequent research on recommendation systems. The main traditional recommendation algorithms and their classification are shown in Figure 2.

3.2. Personalized Recommendation Algorithm for Semantic Classification. The study of semantic classes reveals that semantics as a whole can be divided into two categories, namely, static semantic classes and dynamic semantic classes. Static semantic classes describe the relationships and properties of things; dynamic semantic classes change the

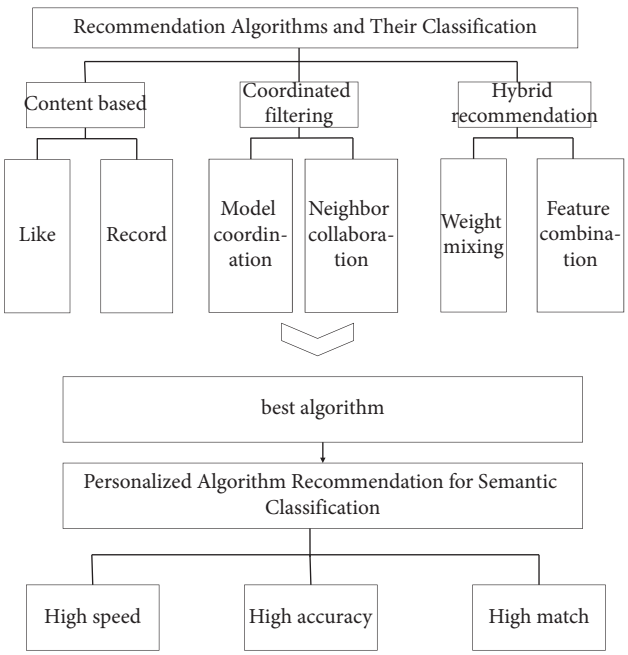

Figure 2: Major recommendation algorithms and classification.

relationships and properties of things. Thus, we first divide the semantic classes into "event" semantic classes ("event") and "state" semantic classes ("state") using the dichotomy. "). The semantic classes are subsequently subdivided into a personalized recommendation technology to solve the cold start problem, we first introduce the extraction of the user's feature information about the item keywords, which are the main features that can represent the item. Then, we combine the modeling with a long and short-term memory network, arranged according to the sequence of users' consumption behavior, which presents the intrinsic characteristics of users over some time and is static or slowly changing over time. After comparing several experiments, it has been improved in terms of recall, or accuracy. The personalized recommendation algorithm for semantic classification focuses on uncovering the main feature information in a sentence that expresses the main content of this text. The word frequency, i.e., the number of words that appear in the information in this paper is the most important. In preprocessing, the redundant words are filtered out and the words that best represent the text are left, whose expression is

$$M = \sum_{i=1}^{n} X_i Y_i + \frac{1}{n}\frac{\Delta y}{\Delta x},$$
$$Y = \begin{pmatrix} 1 & 0 & 2 \\ 0 & 3 & 0 \\ 4 & 0 & 5 \end{pmatrix}. \tag{3}$$

In a corpus, the word frequency reflects the importance of the word in the textual information, which is somewhat localized. If a word appears repeatedly in a corpus, then the word may not seem so important in the corpus. To determine the importance of a word, we introduced IDF to calculate the importance of the word. Keyword extraction is the feature extraction of the target object content, and the degree of feature attributes expressed by words in text content is also different in the text, which requires a comprehensive evaluation of the attribute weights of words in the text in many aspects. The weights are divided into subjective weights and objective weights, in this paper there is only objective weighting method, in this paper information added to the subjective weighting method, comprehensive weight calculation, more complete keyword extraction, and G1 weighting method is currently one of the most effective methods, the formula principle is as follows:

$$B = \frac{n!}{r!\,(n-r)!}.\sum_{i=1}^{n} X_i Y_i. \tag{4}$$

Therefore, to achieve the best recommendation, we have to find out the data content of users' past consumption for analysis, find the content or evaluate books related to their corresponding feature attributes, and then use the personalized recommendation algorithm of semantic classification and weighted comprehensive evaluation to extract the features of book keywords. Finally, an improved LSTM model is input to find the size of users' interest and preference for ranking by calculation, to recommend the best books to users. The user's consumption record is relatively small, and there is also a user's nearest neighbor family to calculate the items consumed to extract the features of relevant attributes and get the preference experience of the user's consumption behavior to make the best recommendation. The algorithmic flow of the personalized recommendation algorithm for semantic classification is shown in Figure 3.

4. Experimental Design

The experiment of a personalized recommendation algorithm for semantic classification of new book recommendation services for university libraries first requires preprocessing of data, which is the process of converting the original text into a text format that can be processed by the text classification system. Since the storage formats of various types of text are very different and the completeness of the text content is different, it must go through a series of preprocessing processes to meet the input requirements of the text classification system. The text preprocessing process generally includes steps such as extracting valid text content, removing illegal characters, letter format conversion, filtering deactivated words, word stemming processing, or Chinese word separation processing.

In the experiments of this paper, a complete text classification system is constructed from the previous section, and a dichotomous classifier on categories is constructed using a personalized recommendation algorithm for semantic classification. As with common classifiers, there is a problem with determining the threshold value in the classifier, i.e., new incoming documents can be computed by the model to obtain a value that predicts that the components of

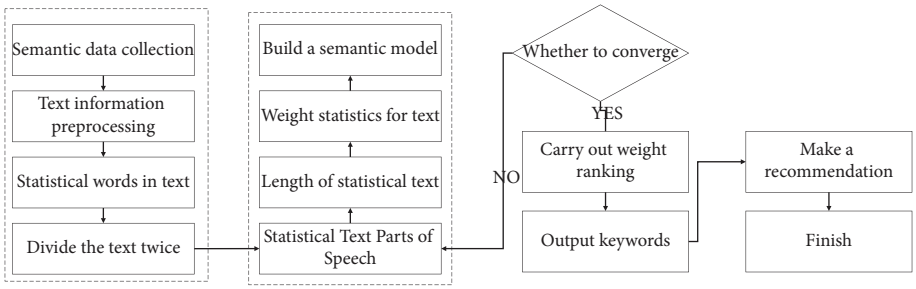

Figure 3: Algorithm flow of personalized recommendation algorithm for semantic classification.

the category vector are distributed between 0 and 1. The choice of this threshold value affects the classification performance of the system. In the experimental process of this paper, this threshold is set as follows: after the training is completed, the training sample set is brought back to the model for testing, and the threshold that results in the best $F1$ value for the final classification result is selected. In this way, a relatively optimal threshold can be set for each category.

5. Analysis of Results

5.1. Analysis of the Selection Results of the Corpus. In the study of text classification models, the choice of the corpus in experiments is of great importance. The performance of the same text classification model on different corpora may vary significantly, and the experimental results are generally not comparable with each other. If we want to compare the performance of two classification models, we usually compare the experimental results on the same corpus, and the results are more convincing. In this paper, the personalized recommendation algorithm division of semantic classification is used in the experiments. According to the algorithm, the corpus is divided into 9603 training documents and 3299 test documents, but after the category filtering (i.e., only the categories with at least 2 positive documents in the training set and 1 positive document in the test set are retained) and the removal of documents with missing information (e.g., missing document body), 8894 training documents and 3472 test documents are finally retained. The corpus analysis divided by the personalized recommendation algorithm for semantic classification is significantly more efficient than the traditional corpus analysis, and its experimental results are plotted in Figure 4.

In summary, this paper concludes that, compared with other classification methods, although the personalized recommendation algorithm for semantic classification does not show superior performance on large-scale categories, it performs better than other classification methods on small- and medium-scale categories, especially rare categories. It indicates that the potential semantic space obtained after adding document category information to the personalized recommendation algorithm for semantic classification retains features that are highly beneficial for classification tasks, especially for rare categories, allowing the new classification method to improve the classification performance

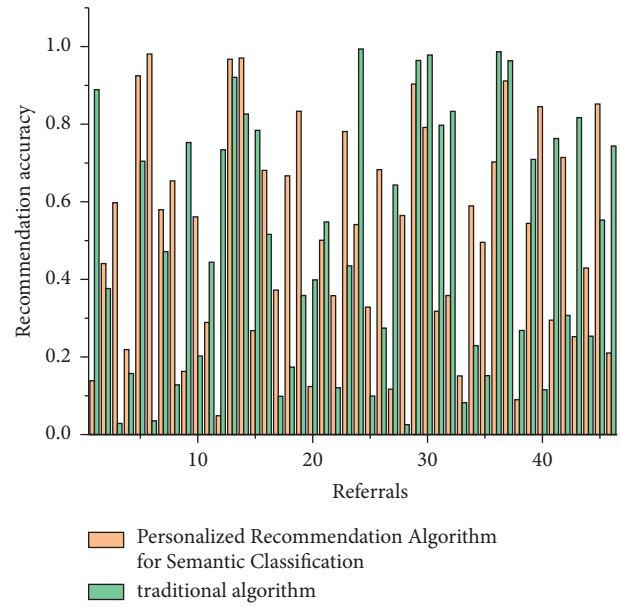

Figure 4: Comparison of corpus selection efficiency results between personalized recommendation algorithms for semantic classification and traditional algorithms.

for rare categories while maintaining better classification results for common categories.

The MAE is a more commonly used quality evaluation of recommendation performance, which is calculated by summing up the differences between the predicted and actual ratings of selected users and then averaging them. The MAE value is inversely proportional to the accuracy of the recommendation, and a smaller MAE value should be chosen for better recommendation results. To validate the local characterization experiment, we randomly select two users or items to calculate the similarity between them, and to verify the similarity criteria between them, we use the Euclidean distance and Pearson's correlation coefficient as tools to do a comparison experiment with the MovieLens dataset and the Netflix dataset, and the results are shown in Figure 5.

From the experiments, we can see that the Pearson correlation coefficients of local characterization in the MovieLens dataset are higher than those of Euclidean distance and CNN local similarity prediction when the sparsity is between 0.2 and 0.5; the data of all three methods are similar when the sparsity is between 0.7 and 0.9. CNN local

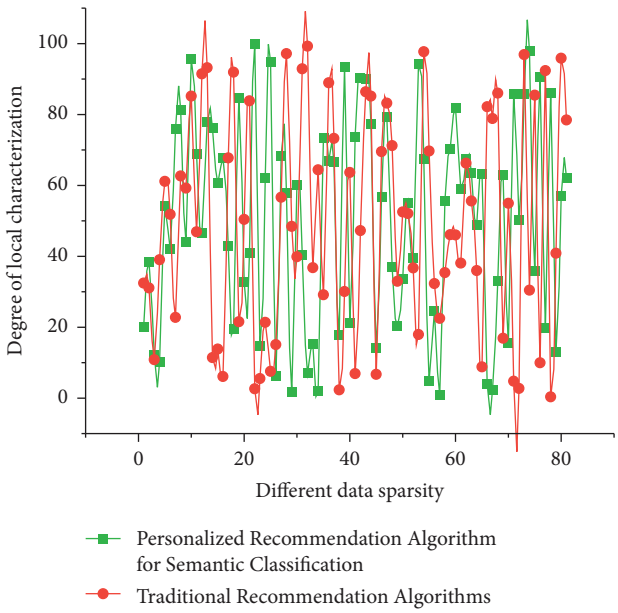

Figure 5: Experimental results of the movieLens dataset.

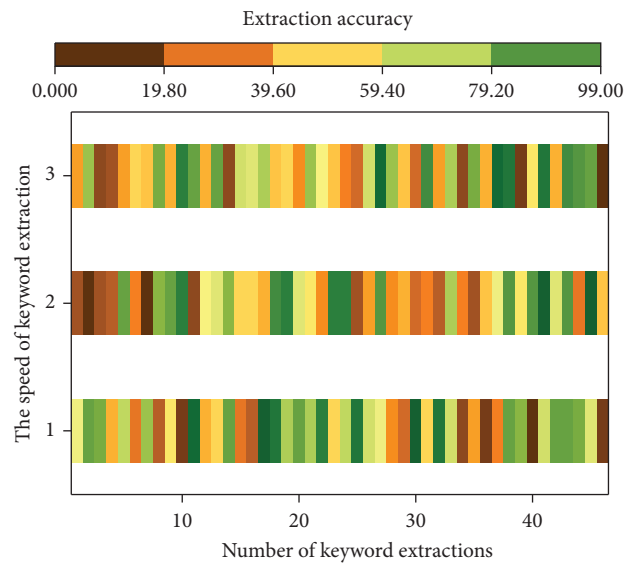

Figure 6: The efficiency of personalized recommendation algorithms for semantic classification compared with traditional algorithms for keyword extraction.

similarity prediction is higher than the other two methods. Therefore, the personalized recommendation algorithm of semantic classification has obvious advantages.

5.2. Extraction Analysis of Keywords. In recommender systems, the keyword extraction algorithm extracts textual information by analyzing the content of the items in a process. Which is further divided into learning given a learning task and direct training learning according to the need for training samples. Supervised learning is for humans to extract the needed information words first, set certain rules for the subsequent use, first train Key, then set the rules of the feature words to train classification, from the output in the classification of keywords. Unsupervised learning does not require a training sample set, and feature words are extracted based on a set threshold range of scoring rules. The algorithm used differs according to different objects so that the most desired feature words are obtained. So keywords are also very important to research work. The extraction of keywords can better help users find the books they need, thereby improving efficiency. The personalized recommendation algorithm using semantic classification is more efficient than the traditional algorithm. The experimental results are shown in Figure 6.

5.3. Analysis of the Accuracy of New Book Recommendation Services in University Libraries. The data sparsity that exists in personalized recommendation systems is prevalent, and for this problem, a personalized recommendation algorithm with semantic classification is proposed to improve the inaccuracy problem of the recommendation system to some extent. In many e-commerce platforms, users' behaviors on this e-commerce platform account for only a little of all items. The user behavior data is too little compared with the item rating data, and such little data affects the quality of recommendation system recommendations, and it is necessary to use the principle of good deep learning to solve these problems in this case.

In the field of information retrieval, synonymy and polysemy have plagued traditional word-matching methods. The phenomenon of synonymy refers to multiple different words expressing the same concept, which may cause the document to be missed when the keywords expressing a specific meaning in the user's query do not match with the relevant words in the relevant document. A similar problem exists in the text classification task. To a certain extent, keyword matching can affect the accuracy of the recommendation, and the personalized recommendation algorithm using semantic classification can match the keywords more accurately. Figure 7 shows the comparison between the personalized recommendation algorithm of semantic classification and the traditional algorithm in the recommendation accuracy experiment results.

By decomposing the document vector-matrix into singular values, the latent semantic indexing method generates a lower-dimensional concept space with several orthogonal factors, which is consistent with the feature information expressed in the original document vector matrix and also reflects the semantic structure of the whole document set, reflecting the main relevant patterns of lexical information in the document set, thus eliminating the problem of lexical noise caused by the variability of specific wording in The problem of lexical noise caused by the variability of specific words is eliminated. Latent semantic indexing has been proved to be an improvement to the traditional vector space technique, which can achieve the purpose of dimensionality reduction of the document vector by eliminating the word-to-word correlation. Information retrieval or filtering by latent semantic indexing is not based on word frequency information in the document set but the latent semantic structure, its performance is much higher than that of

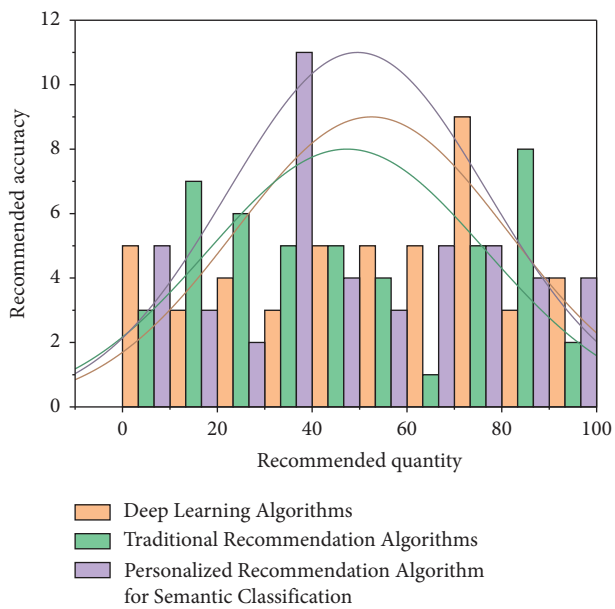

Figure 7: Experimental results of personalized recommendation algorithms with semantic classification compared with traditional algorithms in terms of accuracy of recommendations.

keyword matching methods and has achieved good results in the field of information retrieval. The personalized recommendation algorithm with semantic classification has obvious advantages over traditional algorithms in keyword matching.

6. Conclusion

In this era of information intelligence, with the development of Internet technology, the amount of data on the Internet has developed in a spurt. At the same time, the "information overload" brought by the massive amount of information has two sides, the advantageous side is to be able to discover valuable information from this data, and the other side is that a large amount of data caused the complexity of information, can not well pick out the valuable information from the data. To solve this situation, all the methods used are recommendation systems, which are now widely used in various industries. This paper describes the research of a personalized recommendation algorithm for semantic classification on recommendation systems in the publishing industry. The traditional recommendation system has data sparsity and cold start problems, and then the local similarity is proposed to alleviate the data sparsity of the recommendation system, which further improves its performance of the recommendation system. Secondly, merchants are difficult to be recommended with high quality without ratings due to the frequent increase of information and the emergence of new books. In this paper, we propose the extraction of textual feature values and fusion of long and short-term memory neural networks to take users' usual preference behaviors into account to construct an improved personalized recommendation algorithm with semantic classification for integrating users' short-term and long-term preferences and implementing personalized recommendations with high accuracy.

For the personalized recommendation algorithm of semantic classification for the new book recommendation service of university libraries, the next thing to improve is the extraction speed of the algorithm for keywords and the accuracy of matching, so as to better carry out the efficient new book recommendation service.

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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Hindawi
Mathematical Problems in Engineering
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Retraction

Retracted: Interactive Teaching Based on Artificial Intelligence and Its Application in Improving National Music Appreciation Ability

Mathematical Problems in Engineering

Received 13 September 2023; Accepted 13 September 2023; Published 14 September 2023

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

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

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

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

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

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

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[1] Z. Zhang, "Interactive Teaching Based on Artificial Intelligence and Its Application in Improving National Music Appreciation Ability," *Mathematical Problems in Engineering*, vol. 2022, Article ID 5363782, 10 pages, 2022.

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Mathematical Problems in Engineering
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Research Article

Interactive Teaching Based on Artificial Intelligence and Its Application in Improving National Music Appreciation Ability

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The limitations of the traditional interactive teaching model are gradually becoming apparent in the current music teaching process. Based on the interactive teaching theory of artificial intelligence, this paper constructs an evaluation model of ethnic music appreciation ability and conducts research by using a novel method of fusion of long- and short-term audio features. The model proposes the classical features describing the sound quality and the beat histogram as the feature of the long-term rhythm of the music to form a mixed feature; secondly, the representation method of the song style vector is proposed, and the quantitative problem of music teaching is solved. During the simulation process, the model adopts the popular Model-View-Controller (MVC) design pattern and Unified Modeling Language (UML) and is developed with the Java 2 Platform Enterprise Edition (J2EE) architecture. It realized the user login function of three identities of students, teachers, and system administrators, and the subsystem can complete the management of students' personal information, browse related courseware information and other resource information, and download courseware and tutorials. The experimental results show that the average value of the students' evaluation is 0.606; the average value of case is 0.5852; it also reduces the workload of later maintenance of the system.

1. Introduction

Music has become a new form of online music characterized by being massive, disordered, and scattered, which also makes the study of music information retrieval for searching and browsing massive network music (database) resources. Technology has become a hot topic [1]. The demand for the computational and intelligent application of music theory to assist the original teaching and creation methods is also increasing [2], so that the research on music theory-based music intelligent computing technology has urgency [3–5]. A common key core research problem of the above two technologies is how to intelligently analyze and obtain various elements of audio music content (the basic music elements that constitute the music structure and the formal music elements that constitute the music expression) [6].

With the development of information technology and computer network technology, the traditional music teaching mode can no longer meet the needs of modern teaching, music online teaching has been popularized and developed, and a new learning mode that is different from the traditional one and is not limited by time and place is constructed [7]. Arranging harmony for melody is a key part of music creation, and it is also an extremely difficult job [8–10]. Only a few professional musicians can do this job, using artificial intelligence technology to analyze music and learn complex harmony theory, and finally automatically [11]. It can not only save a lot of labor costs, but also provide a reference for the composer, or even a new creative inspiration [12].

Aiming at the current research status and practical needs of music teaching, this paper constructs an evaluation model of ethnic music appreciation ability. At the theoretical level, this paper proposes an analysis method of music connotation, which divides music connotation into three dimensions, that is, sound attribute, rational cognitive attribute, and irrational cognitive attribute, and explains the theoretical basis of the music computing system from this

structure. At the method level, this paper further divides the music elements involved in the research methods into three levels, combines the music connotation analysis method to classify the research methods involved in music computing into eight categories, and points out the key research methods in this paper. The major application directions are presented, and the key technologies involved in these two directions are expounded.

2. Related Work

Judging from previous research results, it is impossible to achieve breakthroughs in music element analysis by relying solely on signal processing technology and classical statistical pattern recognition methods or simple quantitative music theory models [13].

Wei et al. [14] improved PreFEst by considering the melody line as a collection of melody fragments composed of F0, where the melody fragment refers to the region that exhibits stable and obvious F0 characteristics. Then, this method divides the detected F0 candidates into melody segment groups and then uses the clustering method to generate melody lines. Wang et al. [15] identified the melody line as a sequence of notes at the Musical Instrument Digital Interface (MIDI) levelfirst, the correlation graph was used to detect the candidates of F0, the frequency of the candidate was quantized into its closest MIDI note symbol, and the candidate melody line was formed. Xu [16] believed that the primary function of the multimedia film management system based on the digital campus is to realize the effective management of multimedia information, and the key is the realization of the user module. It mainly involves the uploading of multimedia files. In the uploading process, Asynchronous JavaScript and XML (AJAX) is mainly used; when compressing files, the Zipstream class provided by framework is used. The advantages are as followsspeeding up file uploading and multithreaded mode that realizes asynchronous operation, which saves the user's time and enhances the sense of experience.

Williams et al. [17] proposed a feature representation-based music summarization algorithm, and an algorithm for extracting choruses in music was proposed earlier, and they achieved good results in the typical music structure. The detection rate of chorus on the self-built test set has achieved an 80% detection rate, but this work is limited to its analysis [18]. On the basis of subtraction, the candidate fundamental frequency is extracted from the harmonic product spectrum, and the overlapping harmonics are separated by harmonic reset [19]. The peak area and nonpeak area in the spectrum are modeled, and the maximum likelihood probability method is used to perform multibase frequency modeling frequency estimation [20–22]; the researchers take the Mel cepstral coefficients based on the spectral envelope as features and express the spectral features of the signal to be measured as the weighted sum of the spectral features of each note through the least squares method [23], and finally the subdiagonals of the matrix were processed by image processing to find similar segments [24].

3. Model Construction of Interactive Teaching Based on Artificial Intelligence and Its Ability to Improve Ethnic Music Appreciation

3.1. Artificial Intelligence Network. It is not feasible to use the characteristics of each sound as an input parameter $f(x)$, and all these individual sounds have a lot of redundant information $f(k)$ from the factors that affect the performance $\exp(2/k)$. According to music theory, the factors that affect the performance effect $f(x)$ should also be summarized as rhythm, beat, chord, melody tone, and other factors, so these factors should be used as the parameters of the artificial intelligence network evaluation model. According to it, the harmonic frequencies corresponding to the musical tones differing from a pure fourth differ by an integer multiple of fX/3.

$$F(x) = \{f(x), 2f(x), 3f(x), \ldots, (n-1)f(x), nf(x)\},$$
$$\frac{f(k)}{\min f(k/2)} = \min \exp(2/k). \tag{1}$$

The function will represent the difference between the training target output and the actual output in the form of entropy and accumulate it in all time periods and all output layer units under different network conditions, indicating the possible overall error of the network output. From the perspective of training efficiency, the function $q(a, b)$ has a unique global minimum point, and the gradient $f(a/k)$ descent method is used for fast calculation $w(n, k)$, which are all advantages of using it as a training objective function for network weight modification $x[n-1]$. According to the said classical theory, the ratio of the fundamental frequencies of two musical tones separated by a certain interval is n/m

$$q(a,b) = \begin{cases} f(2\exp(1/b) - 1), \\ \dfrac{f(a/k)}{f(b/k)}. \end{cases} \tag{2}$$

$$\sum w(n,k)x[n] - w(n-1,k-1)x[n-1] = 1.$$

When the error sensitivity $x[k-1, n-1]$ of a neuron in the output layer is determined by calculating the partial derivative of the training objective function, the correlation term is only related to the target and actual output of this neuron under different network conditions, which can greatly simplify the solution process. In this way, through the calculation simplification of the above formula, it can be known that the error sensitivity of the output layer neuron is only related to the actual output of this neuron; in this way, the weight correction value $n[k]$ of the output layer is very easy to obtain.

$$x[n-k] - x[k-1, n-1] = \frac{1}{n(k)},$$
$$\frac{x[n-k]\exp(2\text{pin}/x(n))}{x[n]\exp(2/x(n-1))} < 1. \tag{3}$$

After designing the database table, what needs to be considered is how to optimize the database table. In the process of optimization, the table design should be checked with reference to the third normal form to see if it satisfies these conditions. Among them, the requirement of 3NF is as followsa database table does not contain nonprimary keys that have been included in other tables, word information. For example, there is such an information table file, in which each file has the information of FileID, FileName, and Description, and after the file number is listed in other data tables, FileID, FileName, Description, etc. can no longer be associated with the file. The relevant information is added to the file information table. If it does not exist, it should also be constructed according to 3NF; otherwise, it will cause data redundancy.

$$\begin{cases} |x[t-1,k-1]|>1, \\ \exp\left(\dfrac{2n}{x(n)}\right)-\exp\left(\dfrac{2n}{x(n-1)}\right)>1. \end{cases} \tag{4}$$

The human ear perceives frequency on the Mel scale. When filtering, a filter bank with equal width on the Mel scale is used, so on the real frequency scale, the filter bandwidth of the low frequency part is narrow, and the filter bandwidth gradually increases with the increase of frequency. In addition, in order to improve the robustness of the feature, its cepstrum form is adopted. The Meier Cepstral Coefficient (MFCC) can describe the sound quality characteristics of music sound to a certain extent, which complements the pitch characteristics and rhythm characteristics of music.

Here, we will mention the FileUploadAJAX control. Using the control in Figure 1, the upload function without refresh function can be encapsulated into a control, which can well meet the future use. The distance of each semitone interval can be more accurately divided into 100 cents, and the frequency ratio of two notes with the same name differing by 1 octave is 2 : 1.

Not only that, its various functions are also very powerful. Using FileUploadAJAX, the following functions can be well realizedit can select the maximum number of uploaded files, realize multifile upload, delete uploaded files, define scripts, configure prompt files, and allow no refresh upload effect. When a user requests a file, the page processes the request through a page handler. Custom Hyper Text Transport Protocol (HTTP) handlers can be created to render custom output to the browser.

3.2. Music Signal Transformation. Compared with ASP.NET to operate music signals, it is much more difficult to operate audio and video files with ASP.NET. In this article, the files will be generated in format on the server side, then

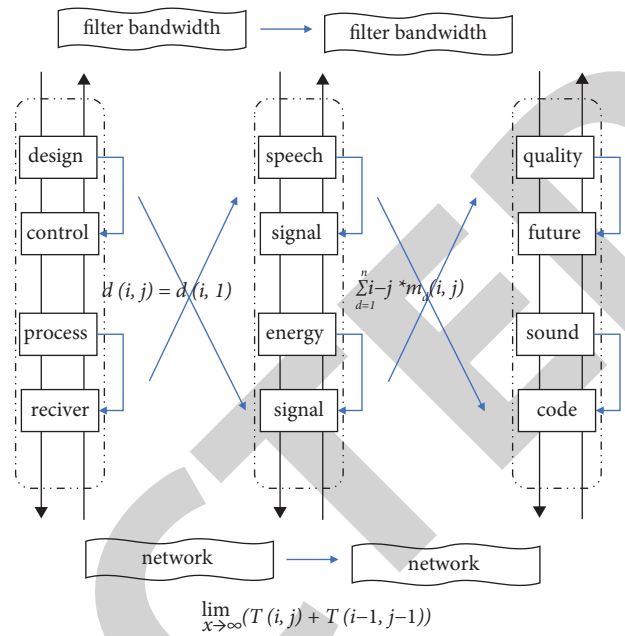

Figure 1: Artificial intelligence network topology.

compressed, and then transmitted through the network. According to the type of multimedia information $A(x)$ resources, they are divided into four partstext, video, audio, and picture animation; they are divided into smaller functional blocks according to the user's access rights and the technical characteristics of the type of information resources, so that the corresponding information resources can be centralized.

$$d(i,j)=d(i,1)+i-j\sum_{d=1}^{n} i-j*m_d(i,j),$$

$$\frac{\partial A(x)\bullet a(y)\bullet x_w}{\partial A(x)-\sum s_w*A(x)}=f(x-i). \tag{5}$$

And the set of all the semitones in the octave with $s(w,x)$ as the sound name is the sound level $f(x-i)$, and the same is true for other sound levels, so we get 12 sound levels. If the energies of all the semitones in the same octave are added together, it becomes the energy of this scale. According to this, we can get a 12-dimensional vector, which represents the energy distribution of 12 tone levels, which is Primary Control Program (PCP). The calculation method and structure of PCP are similar to those of MFCC, both of which describe the sound quality of music, but PCP uses the sound level structure instead of the Mel scale $\sin(t-k)$, so its description is closer to music theory, and it is more reasonable to process music.

$$\begin{cases} 2\sin(t-k,t)<1, \\ \cos\left(2\pi wt^2\right)e^{-\left(t^2/tt^2\right)-y\left(1-\left(1-t^2/tt^2\right)\right)-x\left(t^2-1/tt^2-1\right)}\in T, \\ \text{median}\left(df(t-1,1),df(t-1,2),\ldots,df(t-1,t),df(t-1,t+1)\right)\subseteq \text{DF}(t). \end{cases} \tag{6}$$

The fine temporal spectral structure median (f) in the different frequency bands of the music signal $df(t-1,\ t)$ is estimated by calculating the modulation amplitudes in the mid- and high-spectral bands. The spectral flow characteristic can be expressed as a two-dimensional matrix with the frequency band as the row and the modulation frequency $T(x, y, t)$ as the column, and its elements represent the power change rate $P(x,\ y)$ of the spectral band.

$$T(x, y, t)_i (i, j = 0; t < 1, k < 1) | f(i-k, j-k) \in P(x, y),$$

$$\frac{P(u(i), u(j), \ldots, u(k)|u(t))}{u(i)u(j)} - \frac{1}{1-\sqrt{u(i,j)}} \sim St(n-1, n). \tag{7}$$

The goal of Onset Detection $u(i)u(j)$ is to identify the sounding onset $St(n-1,\ n)$ of each note (overlay) in a continuous piece of music. At present, there are three types of effective methods in this directionbased on the difference of the amplitude spectrum $X(B(x,\ n),\ A(x,\ n))$ of the adjacent time points, based on the difference of the phase spectrum of the adjacent time points, and the complex detection method based on the mixture $St(n+1,\ n-1)$ of the first two methods.

$$\overline{X(B(x,n)|A(x,n))} - St(n-1, n) = St(n+1, n-1). \tag{8}$$

Compared with the starting point information, the tempo is the rate/time information that is closer to the music theory, and its relationship with the rhythm is easier to understand and perceive. Beat information is often used in conjunction with other features to locate the temporal position of other features. It is indicated in the score that the duration of the notes is fixed, and they have a strict proportional relationship. For example, in a 2/4 beat rhythm, a denominator of 4 means that a quarter note is defined as one beat; a numerator of 2 means that each measure has two beats, and each measure in the score is also the smallest unit that characterizes the rhythm of music.

The value is obtained by counting the distribution of subband spectral values in the experiment. Table 1 randomly and repeatedly examines from the most significant subband (such as the subband where the root note is located) to the insignificant subband (it is not significant in itself and has no adjacent significant subbands); in each case, consider the spectral mean of the two most obvious local maxima (peaks) in the subband and their surrounding 10 spectral lines, and compare this local mean with the subband spectral mean. The interference reduction factor set in this paper is intended to control the variation difference brought by different observation data to the posterior distribution in the process of calculating the distribution parameters of the time serieswhen $h = 1$, it means that the new observation data has obvious fundamental frequency characteristics, and the posterior distribution parameters are greatly affected by the observed data; and when $h = 6$, it means that the observed data has a large disturbance factor ($h = 6.67$ when $a > 100$, the standard deviation disturbance range is larger than the halftone band range).

Table 1: Music signal transformation properties.

Music signal	Subband value	Beat value	Spectral value	Spectral value
Rhythm 1	87.17	90.88	20.57	40.18
Rhythm 2	66.71	44.61	33.26	86.30
Rhythm 3	86.77	98.35	64.35	59.34
Rhythm 4	24.80	26.52	5.35	27.40
Rhythm 5	26.74	97.92	21.82	67.34
Rhythm 6	33.62	20.12	25.07	50.83

3.3. Interactive Teaching Analysis. Interactive teaching considers all possible frequencies of F0 in the preset frequency region (mid-high range, that is, the possible region where the melody of a general musical work appears) at each moment and assumes the input mixed sound to be analyzed. In this case, the PreFEst method represents the sound of the mixture to be analyzed using a weighted probability density function that represents a weighted mixture of the probability density functions (sound models) of all possible values of F0. When the server returns the information, the user does not need to refresh, and the returned information will automatically appear in the corresponding position of the page.

Since the distribution of scale frequencies in music is a geometric series, this makes the frequency components not completely matched when using DFT to describe music signals. Then, this method uses the maximum a posteriori probability estimation method (MAP) and the expectation maximization algorithm (EM) to estimate the weight of each possible value of F0 and its probability density function and select the possible value of F0 with the largest weight as the most significant value at this moment. Finally, the method of Figure 2 also presents an algorithm for smoothing F0 so that it is continuous in time.

Therefore, the user has to wait for a long time after completing the upload operation. In order to optimize this problem, the author has taken certain measures through analysis; that is, the position of the upload control is placed in the front, and the user can upload the file first. If the upload fails, the data will not be submitted. In order to obtain the relevant data results accurately, the experiment also needs to process the relevant values of pitch, sound intensity, and sound length through accurate calculation. Once the wrong pitch occurs, the corresponding error value is 1, and the value in the other case is 0.5, and then the related chord calculation is performed, and relevant parameters are input and correspond to each input neuron. There is still some content that needs to be discussed; that is, the sum of the relevant differences is obtained by calculation, which is used as the basis for the strength and weakness of the chord, and the relevant input and output of the relevant duration are carried out.

3.4. Quantification of Music Appreciation Ability. The characteristics of music appreciation belong to the basic elements and formal elements in music. When designing the system management class diagram structure, the system management interface class diagram object is provided, which includes different subordinates such as user

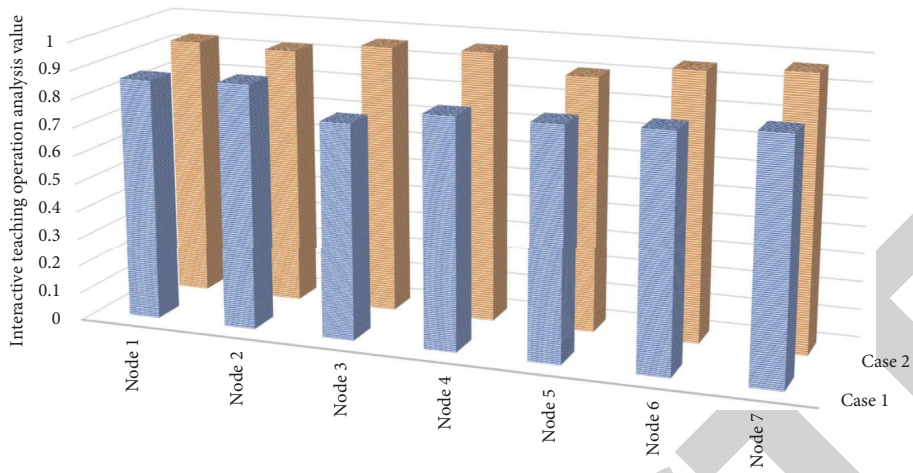

Figure 2: Analysis of interactive teaching operations.

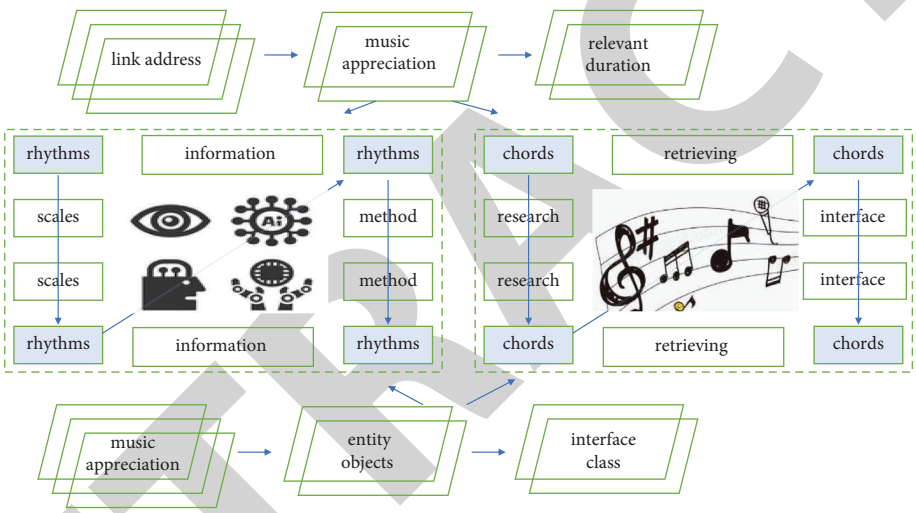

Figure 3: Distribution process of music appreciation.

management interface class, role management interface class, and menu management interface class object, and at design time, user management provides user interface objects including user ID, user password, user name, as well as getting users, adding users, editing users, and deleting users, retrieving roles, updating roles, and deleting roles including role interface objects; Figure 3 provides menu information entity objects including menu ID, menu name, link address, and alias.

In order to make note pitch identification not erroneous due to the pitch shift of the instrument, it is necessary to use the pitch calibration techniques proposed in this section on the resulting spectrum of the signal transformation. The basic idea of pitch calibration technology is to estimate the overall pitch offset of all musical tones by obtaining the statistical characteristics of the pitch offsets of all instruments in the target music in the spectrum, and to correct the spectrum accordingly.

The above problems all make the spectral characteristics of music signals cannot be effectively expressed in the frequency domain space through DFT. Due to the harmonic structure of tones in real music and the effects of overlapping notes in the case of chords, it is difficult to determine the fundamental frequency of each note and calculate its pitch offset, so we need to find some spectral nodes. Quick search supports single-item and multicondition search, you can select the search term matching mode, and quick search also supports searching in the results. This search method is fast and simple. In general, these local maximal candidates will contain some harmonic components in addition to the fundamental frequency, and if selected properly, most of these candidates will have the same pitch offset. Here, a normal distribution is introduced to estimate all the candidate offsets, and the parameters of the normal distribution represent the maximum possibility of the offset distribution.

4. Application and Analysis of Interactive Teaching Based on Artificial Intelligence and Its Model for Improving Ethnic Music Appreciation Ability

4.1. Artificial Intelligence Feature Recognition. Taking the case where the maximum accuracy of the pitch offset is 10 cents as an example, the scale of $b = 120$ is selected for the

artificial intelligence feature transformation spectral line per 10 cents, and then the commonly used in this paper is the scale of $b = 120$. There are a total of 630 spectral lines in the frequency range. There are four beats in each measure, and each beat is a quarter note. When recording the intensity, it is the intensity of the quarter note; that is to say, the number of beats in each measure is determined, and the recorded intensity is the number of beats. The weight is relatively heavy, and for real music in which the vocal intervals differ by at least one semitone, this accuracy can basically meet the correction requirements. Of course, the processing method for the case where the maximum accuracy of the pitch offset is 1 cent is similar to the method in Figure 4.

Most of the previous starting point detection methods did not consider the prior knowledge of the pitch of the musical instrument. If the musical sound features are integrated into the detection method and combined with the specific pitch distribution information, the effect of the starting point detection is bound to be improved. The delay mechanism that is relied upon is to make the time series in one time period input into the network at the same time, and the adjacent time periods are overlapped and sequentially input, which ensures that the time sequence and continuity of the input sequence will not be destroyed; but only relying on delay, time information retained in the sequence may not be fully utilized, and it is somewhat difficult to determine the size of the overlap caused by overlapping inputs.

4.2. The Saliency Analysis of Interactive Teaching. The test database contains 7,000 phrases, and the interactive teaching selects 100 phrases in 10 styles as query samples and requires to retrieve the 5 most similar songs from the 7,000 phrases corresponding to each sample (not the samples themselves, not by the same artist). The evaluation of the results is based on manual scoring. In order to avoid these problems, the method research under the framework of music computing in this paper is all based on the note as the processing primitive.

This system uses two types of featuresrhythmic features and timbre features. The extraction of rhythm features is based on the wave pattern; the sound quality features are based on MFCC and spectral contrast features and are represented by a single Gaussian model. The final distance measure based on the two features is calculated separately and then fused to obtain the final distance measure of similarity. The values that the players get when they play are 98, 75, 80, and 70. Then, the value that this subsection grasps for the beat is $2 + 5 + 10 + 0 = 17$.

As can be seen from Figure 5, after the spectrum of the music signal passes through the temperament filter bank, 88 energy outputs can be obtained. The energy output represents the energy component contained in the music signal corresponding to the fundamental frequency. In the process of determining the parameters of the rhythm feature, the parameters representing the grasp of the rhythm need 6 neurons in the input layer to correspond to them. To sum up, the important musical rhythm of a piece of music is an important feature used to describe the length and shortness of the sound, and it is also an important means. In the score

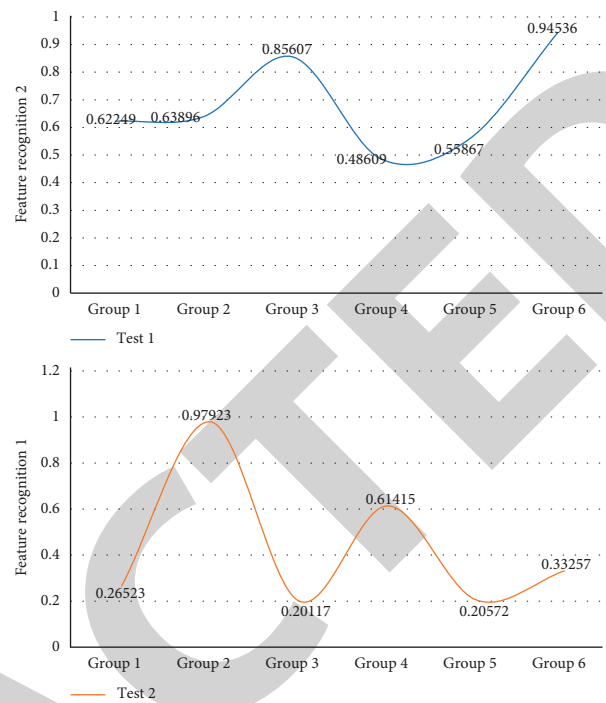

Figure 4: Artificial intelligence feature recognition distribution.

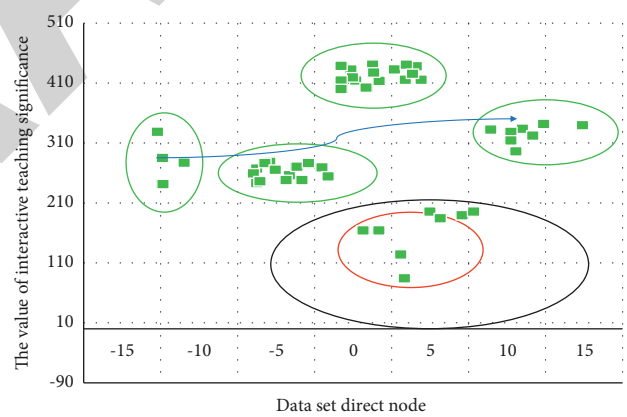

Figure 5: The significance analysis of interactive teaching.

of the music piece, the indicated time will appear corresponding to it. During the performance of any performer, the speed will be different, but this difference will not significantly affect the result. The core problem of this method is the construction of the detection function, and the detection function should use a lower sampling rate in the calculation to reduce the amount of calculation and give a peak value when the starting point is encountered in the detection.

Here, we also need to grasp the meaning of the pitch period. It is the reciprocal line of the pitch frequency. It usually refers to the time each time the vocal cords are opened, and the vocal cords are closed each time. Since the pitch period is a very important concept, its role in speech signals cannot be ignored, and the changing pattern of the pitch is usually called pitch.

4.3. Simulation of Music Appreciation Ability. At present, the data access method of the main music appreciation system is as followsusers enter the system through the browser page, and because the system can automatically translate the request sent by the user to the server operation, you can see the processing results delivered by the server in the mode. The artificial intelligence network is a general function approximator, which means that only one hidden layer can achieve the approximation of any function. In practical applications, the most difficult thing to determine in the network structure in Table 2 is the number of neurons in the hidden layer. If the frequency is correspondingly large, the pitch will be high, and vice versa.

Among all the note starting points, the interval between some of them may be very small. Considering the influence of human factors and the structure of national musical instruments, even if multiple keys are pressed at the same time, the occurrence times of multiple notes will not be exactly the same, so it is necessary to postprocess the note origin. Taking into account the auditory characteristics of the human ear and the sound effect of harmony, this paper sets a fixed time threshold of 50 ms and merges all the notes whose starting point interval is less than 50 ms.

One of the most prominent problems in doing so is to sacrifice the descriptive characteristics of CQT for music to accommodate the implementation of the FFT algorithm, which is obviously not desirable. The method first uses a scoring function to traverse all possible polyphonic combinations and evaluates them according to energy residuals and spectral smoothness. The frame estimates the fundamental frequency and then uses the maximum likelihood estimation-based voice tracking algorithm to select the active fundamental frequency; the above system still performs well in task 2; and task 3 only has one team participating, so it is impossible to compare the effects horizontally.

The module of Figure 6 is to complete the student authentication function. If the user passes the test, the system considers the user to be a legitimate user, and the student can log into the system to use the functions; if the user fails the test, the relevant warning messages remind users to log in again. The amplitude of the note increases rapidly in the attack phase, reaches the peak, then goes through the decay phase, and then gradually disappears after being held for a period of time in the sustain phase. Among them, preprocessing is generally a simple process of the original music signal to make the subsequent detection performance better, signal reduction refers to extracting a series of features that can represent the original signal from the signal, and peak extraction is performed by a specific peak detection function.

4.4. Example Application and Analysis. The folk music teaching management system adopts SQL Server 2020 relational database, which supports hundreds of users log-in at the same time, and the music teaching management systems can not interfere with each other at the same time, and the system will not slow down due to the increase in the number of users. All administrators and individual users within the system can use the system normally. The powerful logical computing capabilities of the SQL Server 2020 relational database ensure the stability of the entire system. The system can run around the clock and can store information in a safe module when a hardware failure occurs. A total of 3 important related tables have been designed in the experiment, that is, the music file database, the feature information database, and the system audio manager information database. In this audio database, various important relevant pieces of information about the administrator are stored. Once a qualified user logs into the software, the comparison

Table 2: Music appreciation ability algorithm.

Ability algorithm code	Music appreciation network
To get distance between two point	Input neuron to $S(j)$
Double dist($pt\ a$, $pt\ b$)	Method of the main $w(t)$
{Int double get_sum($pt\ p0$, int n)	Users enter the system
Return sqrt(sqr($a.x - b.x$) $+a$);	The data access $u(i, j)$
For(int $i =$; $i < n$; $++i$)	Through the browser $x(t)$
Ret $+=$ dist($p0$, $p[i]$);	Music appreciation system
Int main	According to the $St(n-1, n)$
$X += (p[i].x - x0)/\text{dist}((pt)\{x0, y0\}, p[i])$;	In the output layer $d(i, 1)$
$Y += (p[i].x - y0)/\text{dist}((pt)\{x0, y0\}, p[i])$;	Used in music $B(x, n)$
$F\{x0 + x^*\text{temp}, y0 + y^*\text{temp}\}, n)$;	Performance evaluation
Double tmp = get_sum((pt)	Input parameters $m_d(i, j)$
Sqr($a.y - b.y$)	Mentioned above $d(i, j)$
Z(ans−temp)/temp)	Delivered by the server
Else if(math.exp(>random())	Corresponding to two output

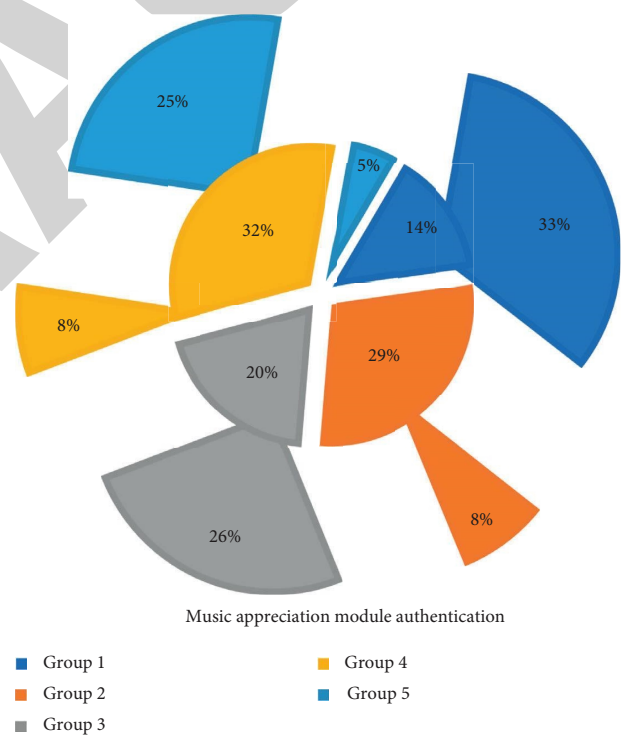

Figure 6: Music appreciation module authentication.

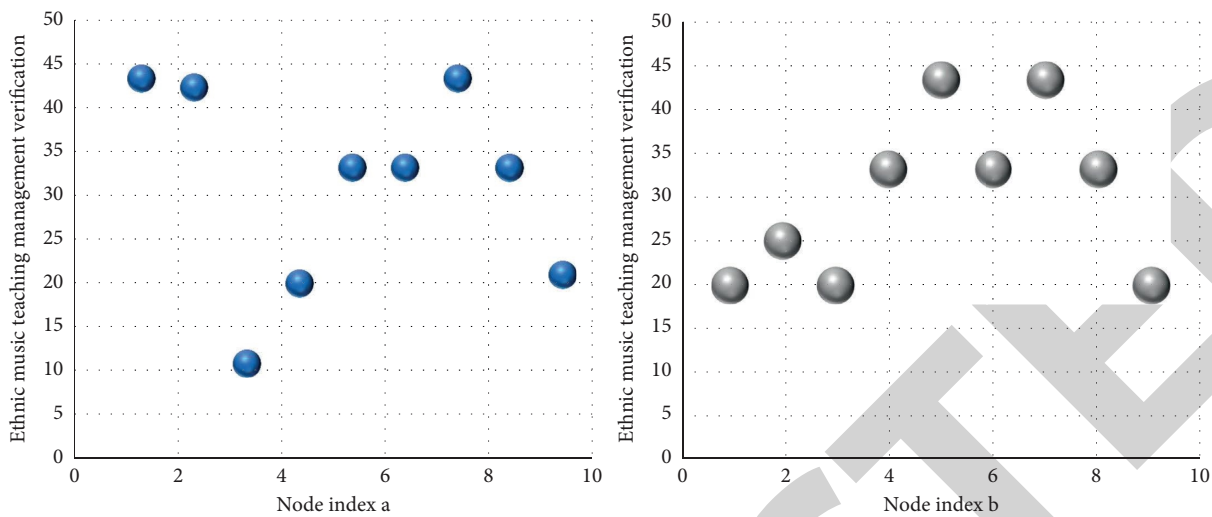

Figure 7: Verification of ethnic music teaching management.

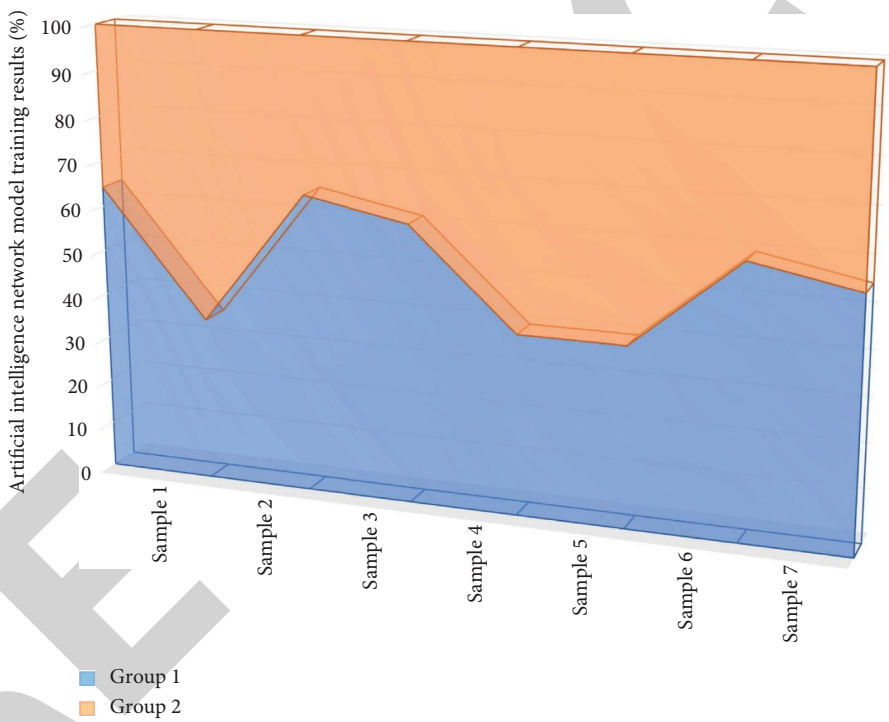

Figure 8: Training results of artificial intelligence network model.

with the database in Figure 7 can be realized. If the comparison is the same, the verification of the software is passed; otherwise, the verification cannot be passed.

First of all, the first point is to effectively obtain relevant files, then obtain important standard values by the performance teacher of the musical instrument, and finally determine the input characteristics of the data through the performance of the relevant national musical instruments. The idea based on cognitive distributed music features believes that listeners (who have received professional music training) store in their auditory cognitive mechanisms standard listening templates for various musical elements based on pitch distribution.

In the example, the input of relevant data must first be completed through the artificial intelligence network model, so that a comprehensive evaluation can be made from the overall effect of the music performance, the rhythm of the music, and the artistic expression of the work. The input value remains between 0 and 1 once the data about the parameter is present. The experiment requires a total of nearly 10 samples for example training in Figure 8.

Through learning, it is found that, in the MIDI signal, 127 keys are corresponding to 127 kinds of pitches. MIDI input devices generate related signals when there are multiple keys that generate corresponding signals. There is only a 0.1 millisecond signal difference, which has no effect on the

polyphony of the song. The important characteristics of the extracted sound are then analyzed; if it is derived from a MIDI signal, each key and release are paired, and each action produces two different signals. If there is a time difference between the two signals, the length of the tone will be obtained. In the MIDI signal, the first data is the pitch, and the resulting quantization range is within 127. One difference interval corresponds to the corresponding semitone, and one semitone corresponds to the keys of the piano, which can fully meet the requirements. In the MIDI signal, its second data is expressed as the strength of the button, and the resulting quantization range is the strength within a certain range. During the operation of the system, some users may need to delete the user due to the resignation of the employee or no longer have the login authority of the music teaching management system. After the user is registered, if the user information changes, such as the user's contact information, the department to which the user belongs, the user's responsibilities and permissions, the administrator or user with the user's modification authority can be allowed to modify the user information.

5. Conclusion

According to the research results of artificial intelligence theory and cognitive psychology on human perception of music, this paper proposes a set of methods for measuring the salient part of music teaching based on artificial intelligence cognitive theory and proposes the characteristics of acoustic auditory saliency, which is based on the establishment. The model describes the three-dimensional eigenvectors of musical subband structural differences and timing differences. In the scoring, mode, and key judgment part, if the tonic and mode type are all correct, a full score of 100 points will be awarded. If the tonic is wrong, the score is 0; if the tonic is correct, the score is 50, and only if the tonic is correct will it be considered whether the tonality is correct. Starting from the contextual relevance and harmonic structure characteristics of music, this paper proposes the auditory saliency feature of music theory, which complements the previous acoustic auditory saliency feature and confirms the musical connotation analysis theory proposed in this paper. Finally, we use the full auditory saliency feature to synthesize the techniques (constant Q transform, pitch correction, etc.), tools (time integration network, etc.), and conclusions (mode and chord recognition results) involved in this paper and add a variety of music theory rules. For the results of the melody analysis, this paper proposes a melody flow that is closer to the actual listening sense and perception target of human beings. In addition, the use of this system will play a significant role in promoting school teaching reform, improving students' autonomy in learning, improving teaching effectiveness, and reducing teachers' workload.

Data Availability

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

Conflicts of Interest

The author declares there are no conflicts of interest or personal relationships that could have appeared to influence the work reported in this paper.

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Research Article

Construction and Application of Music Style Intelligent Learning System Based on Situational Awareness

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Contextual representation recommendation directly uses contextual prefiltering technology when processing user contextual data, which is not the integration of context and model in the true sense. To this end, this paper proposes a context-aware recommendation model based on probability matrix factorization. We design a music genre style recognition and generation network. In this network, all the sub-networks of music genres share the explanation layer, which can greatly reduce the learning of model parameters and improve the learning efficiency. Each music genre sub-network analyzes music of different genres, realizing the effect of multitasking simultaneous processing. In this paper, a music style recognition method using a combination of independent recurrent neural network and scattering transform is proposed. The relevant characteristics of traditional audio processing methods are analyzed, and their suitable application scenarios and inapplicability in this task scenario are expounded. Starting from the principle of scattering transform, the superiority and rationality of using scattering transform in this task are explained. This paper proposes a music style recognition method combining two strategies of scattering transform and independent recurrent neural network. In the case that the incremental data set is all labeled, this paper introduces the solution of the convex hull vector, which reduces the training time of the initial sample. According to the error push strategy, an incremental learning algorithm based on convex hull vector and error push strategy is proposed, which can effectively filter historical useful information and at the same time eliminate useless information in new samples. Experiments show that this method improves the accuracy of music style recognition to a certain extent. Music style recognition based on independent recurrent neural network can achieve better performance.

1. Introduction

Music is an indispensable part of modern life and can assist the expression of emotions in different situations. Music is composed of many elements, the basic elements of which include rhythm, melody, harmony, and timber [1–3]. These four elements are the basic considerations for composers when creating, and only with a certain professional understanding of these complex rhythms, melody, harmony, and timber can we have a more accurate understanding of the content and theme of music. The most direct grasp of music by ordinary nonprofessionals can be summarized in two aspects: style and rhythm [4, 5]. Style is the overall grasp of music, and it is the first intuitive feeling that people have when listening to songs. Many music playback software recommends music through songs of the style that users often listen to. Whether the music recommendation is accurate has become the application of choice for many users today [6, 7].

Now, music information retrieval has also become an emerging category, and a large number of researchers have invested in this field. Since some users are only very interested in a certain genre of music, the music recognition and classification system can classify music into different genres of music. In this way, it is convenient for users to retrieve and efficiently manage music in different time periods such as exercise and rest. When the same song is sung by different people, because of the range of each one, the difference in timber, and the playing of various instruments, the songs are all made different. Various reasons make it very

difficult for people to extract music features, resulting in the inefficiency of classification and identification of music genres. With the deepening of a large number of researchers, it is believed that the problems of music genre classification and generation will gradually develop in a better direction.

Considering that context representation recommendation is not the fusion of context and model in the true sense, this paper aims to establish model-based context-aware recommendation. In order to deal with the multidimensional "user-situation-item" model, this paper cleverly regards "situation-item" as an item in the "user-item" model, and uses probability matrix decomposition to propose a situational sense based on probability matrix decomposition. This paper introduces the overall design of music style recognition and generation model, and introduces the preprocessing method and operation process of music data, including the separation of audio tracks, the quantification of data, and the extraction of music features. At the same time, the design of the input matrix and output matrix of the network is also introduced. Through the design of the input and output matrix, the features to be learned can be expressed in the form of vectors. The paper also introduces the design of an analytical model for musical genres and musical styles. Four small music genre analysis models are included in the music style analysis model. The model belongs to a multitask operation model and can handle multiple different music genres at the same time, which increases the learning efficiency of the model.

The classification task of musical style is implemented using a variant of recurrent neural network, IndRNN. The experimental results show that the new IndRNN performs well in the classification task of music style, and the experiments show that its average classification accuracy can reach 96%. IndRNN is still significantly better than other networks in terms of model training time and final classification accuracy. Compared with the current popular models, the experimental effect of this strategy is still very competitive. Introducing the solution of the convex hull vector can discard a large part of useless information when training the initial sample, which reduces the training time. Then, combined with the error push strategy, an incremental learning algorithm based on convex hull vector and error push strategy is proposed, which is applied to the music style classification system. In the marked scenario, it can shorten the model establishment time, and at the same time, it can effectively mine the hidden information of the historical training set, eliminate the useless information in the newly added samples, and maintain excellent performance.

2. Related Work

The deep neural network has the ability of automatic feature extraction, so the above two problems can be combined into one. For example, in the audio recognition task, related scholars believe that the low-level network of deep neural network can extract features similar to speakers, while the high-level network extracts discriminative information between categories [8, 9]. In the past few decades, traditional models such as Mel spectrum and Mel cepstrum have often appeared in audio analysis tasks [10]. These audio features can also be processed and utilized by computing statistics such as the mean and variance between these frame-level features, clustering, quantizing, and finally predicting with classifiers such as K-NN or support vector machines. In the field of neural networks in recent years, MLP, CNN, RNN, and their variants are commonly used to analyze sound.

On the one hand, convolutional neural networks have achieved good results in the audio domain. On the other hand, recurrent neural networks are also playing their part in this field. For time series signals such as music, recurrent neural networks have certain advantages. Recurrent neural networks are mainly modeled according to long and short time correlations (dependencies) on time frames [11–13]. Recurrent neural network has a good effect on sequence data with strong temporal correlation. For example, the time before and after the logic of speech carries very important feature information. Relatively speaking, it is more suitable to use recurrent neural network [14].

For MLP, generally one-dimensional coefficient vectors, such as flattened MFCC features, can be used as input to the corresponding network, and each learning of MLP is for the global features of the input; for convolutional neural networks, a two-dimensional spectrogram is input, and two-dimensional CNN is used for learning [15–17].

Deep convolutional neural networks can learn deep behavioral features, combining feature extraction and classification operations to provide classification accuracy and model robustness [18]. Convolutional neural networks have performed well in speech recognition and music segmentation after being introduced into the audio domain. Related scholars selected eight musical features from three main musical dimensions (dynamics, timber, and pitch) as the input of CNN [19, 20].

3. Methods

3.1. Probabilistic Matrix Decomposition Based on Context Awareness. Probabilistic matrix decomposition assumes that the latent feature matrices of users and items obey the same distribution. Through model training, the large "user-item" matrix can be decomposed into small-scale user latent feature matrices and item latent feature matrices. Finally, the product of the two is used to predict the user's recommendation probability for unrated items.

Through the product of the user feature vector U_u and the item feature vector V_v, the user's rating prediction R_{uv} for the item can be calculated. The learning process of probability matrix factorization finds the best user latent feature matrix by training the model.

$$g(x) = 1 + \frac{1 - e^x}{\sqrt{1 + e^x}}. \tag{1}$$

The probability matrix decomposition uses probability as the recommendation basis, so the first step of probability matrix decomposition is to convert the rating value in the "user-item" matrix into the corresponding probability value.

The expression formula of probability matrix decomposition is as follows:

$$p\left(R|U,V,\sigma^2\right)=\sum_{u=1}^{N}\sum_{v=1}^{M}I_{uv}\ln\left[N\left(R_{uv}|\frac{U_{u+1}^{T-1}}{V},\sigma^{-2}\right)\right]. \quad (2)$$

Among them, I_{uv} is a Boolean function, $I_{uv}=1$ indicates that the user u has a scoring record for item v, and $I_{uv}=0$ indicates that no scoring behavior has occurred. Using this function, it is easy to distinguish between user-rated items and unrated items.

$$\begin{aligned} p\left(U|\sigma_U^2\right)&=\sum_{u=1}^{M}NI_u\left(U_u|I\sigma,\frac{\sigma^2}{I}\right),\\ p\left(V|\sigma_V^2\right)&=\sum_{v=1}^{N}NI_u\left(V_u|\frac{\sigma}{I_{uv}},I\sigma^2\right). \end{aligned} \quad (3)$$

Based on the above expressions, the calculation formula of the posterior probability of the eigenvectors U and V is as follows:

$$\begin{aligned} p\left(U,V|R,\sigma,\sigma_u^2,\sigma_v^3\right)&\propto p\left(U,V|R,\sigma\right)\frac{p\left(U,V|\sigma_u^2,\sigma_v^3\right)}{p\left(U,V|\sigma_v^3\right)}\\ &=\frac{\sum_{v=1}^{M}R\left(U|V,\sigma_u^2\right)}{\sum_{u=1}^{N}N\left(V|U,\sigma_v^3\right)}\times\frac{1}{2}\left(\prod_{v=1}^{M}\frac{1}{I_{uv}}N\left(U_{uv}|UV,\sigma,\sigma_u^2,\sigma_v^3\right)\right). \end{aligned} \quad (4)$$

Taking the logarithm of both sides of the above equation can be obtained:

$$\log_2 p\left(U,V|R,\sigma,\sigma_u^2,\sigma_v^3\right)=C\cdot 4\sigma^{-2}\prod_{u=1}^{M}\sqrt{I_{uv}\left(R_{uv}+\frac{U_u^v}{T}-1\right)}-2\sigma^{-2}\prod_{v=1}^{n}\sqrt{I_{uv}\left(R_{uv}-\frac{V_u^v}{T}-\frac{1}{2}\right)}+\frac{3}{4}\left(\left(\prod_{v=1}^{M}\frac{1}{I_{uv}}\right)\log_2\sigma-\frac{N\log_2\sigma_v+1}{M\log_2\sigma_u+1}\right). \quad (5)$$

Since C is a constant that does not depend on the parameters U and V, the left part of the above equation is minimized, denoted as

$$\begin{aligned} E&=\frac{3}{4}\prod_{v=1}^{M}\sqrt{\left(R+U_u^vT-2\right)^{I_{uv}}}-\frac{\lambda_U+1}{\lambda_V-1}\prod_{u=1}^{N}\left(\sqrt{\frac{\|U_v\|}{\|V_u\|}}+1\right),\\ \lambda_U&=\sqrt{\sigma\left(\sigma_U^2+\sigma^{-2}-1\right)},\\ \lambda_v&=\sqrt{\sigma\left(\sigma_v^2+\sigma^{-2}+1\right)}. \end{aligned} \quad (6)$$

The maximum likelihood estimates of the final parameters U and V can be solved using the Markov chain Monte Carlo algorithm or the expectation maximum algorithm.

The posterior distribution of the user feature vector is

$$p\left(U|T,\sigma_U^2,\sigma_T^3\right)\propto\frac{p\left(U|\sigma_U^2,\sigma_T^3\right)}{p\left(U|T,\sigma_U^2,\sigma_T^3\right)}=\frac{\sum_{u=1}^{N}NI\left(U|T,\sigma_U^2,\sigma_T^3\right)}{\sum_{v=1}^{M}(N/I)\left(U|0,\prod_{v\in M_u}\sigma_U^2\sigma_T^3\right)}. \quad (7)$$

3.2. Dimensionality Reduction in Multidimensional Scenarios. For context-aware matrix factorization, tensor factorization has been widely used in multidimensional scenarios. However, the high algorithm complexity limits its development in large-scale data processing. As an effective means of matrix decomposition, probability matrix decomposition can only be applied to the two-dimensional rating recommendation of "user-item" and cannot handle the multidimensional recommendation requirements of "user-scenario-item." In order to reasonably introduce context information and take into account the complexity of the algorithm, this paper proposes a context dimensionality reduction method, which maps the "scenario-item" combination in the multidimensional "user-scenario-item" model to the two-dimensional "user-item" model. In the "item", the advantages of the traditional two-dimensional scoring recommendation are rationally utilized, so as to realize the situation-aware recommendation based on the probability matrix decomposition.

In the implicit score conversion in this paper, contextual dimensionality reduction maps the user's scattered time series music records in different contexts to the corresponding scores in each context. At the same time, the user's rating for the same piece of music in the rating matrix will be different due to different situations. The scoring information under different scenarios exists in the scoring matrix as independent scoring items. The context-aware recommendation method based on probability matrix decomposition has the same principle as the recommendation method of probability matrix decomposition, but it can handle multidimensional contextual recommendation requirements because it distinguishes different scoring records in different scenarios.

The purpose of track separation is to distinguish single-track music from multitrack music. In order to better train music and obtain the characteristics of music, single-track music will be selected here. Because multitrack music contains many different instruments and chords, at the current level, it is difficult to use computers to generate such complex music.

Model training here is mainly to adjust the value of the parameters so that the values of the parameters can be

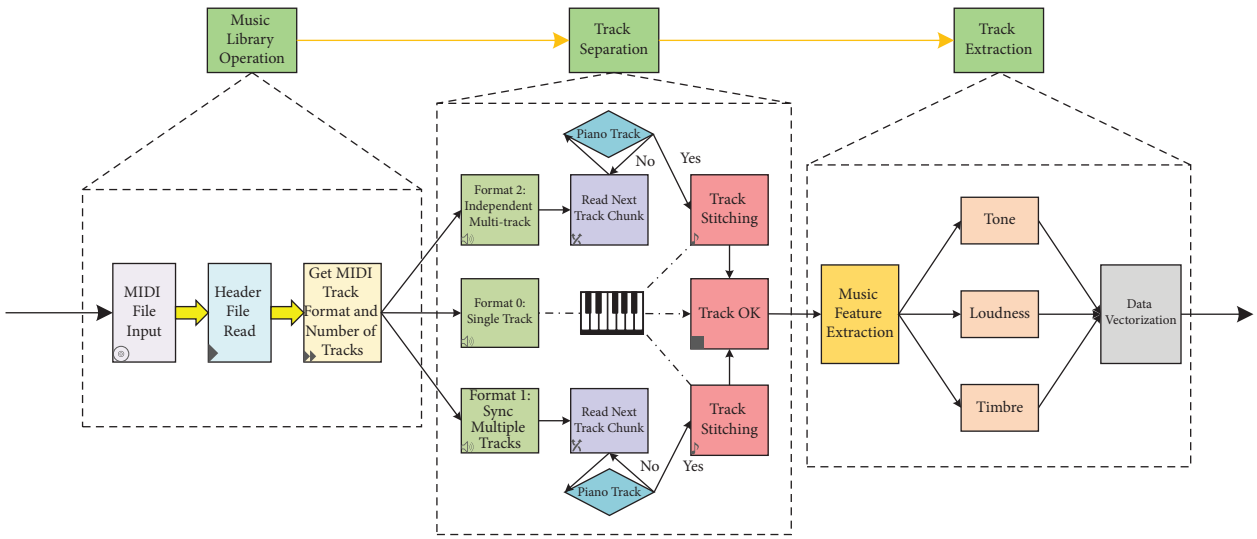

Figure 1: Flowchart of extracting audio tracks.

optimal. There are mainly two network models here: one is used to learn the characteristics of music genres, which can be called the genre model (GenereModel), which is divided into a bidirectional LSTM layer and a linear layer.

Another network model is the style model (StyleModel), which mainly consists of the explanation layer and the GenereModel sub-network mentioned above.

The main task of music generation is to convert a matrix containing musical features into playable music. Since the network finally generates a matrix containing the loudness, the matrix can be regarded as a time series, and the feature matrix needs to be converted into different genres of music through the inverse of the matrix.

3.3. Track Separation. The MIDI music data in the music library contain three formats, namely, 0, 1, and 2. Each format represents how to handle the time series in the file. In MIDI, each track is a time series, and the time series records the content of the entire piece of music.

0 means that there is only one track, and then all the tones are included in this track. Multitrack music is music that has many tracks. Multitrack music is more complex than single track, so when extracting or separating tracks, it is relatively complicated.

When playing MIDI music with format 1, multiple tracks will start playing at the same time sequence and the same beat. 2 means that multiple tracks can be selected without starting at the same time, which is the biggest difference from format 1.

In the MIDI music file in the music library, open any song in a genre, and you can find that the music contains many instruments. Each instrument is a separate track stored in the MIDI file; in this article, the main need is the piano track. Since multiple tracks of multiple instruments are calculated, vectorizing the music data will make the model too computationally expensive and will not be able to get the best results. Therefore, for the music in the music library, it is necessary to convert the multitrack data into single-track data, and select the piano track in the multitrack. The process of separating audio tracks is shown in Figure 1.

Since the audio tracks are independent, it is only necessary to traverse the header files of the audio tracks in turn. Since there are categories in the track headers that describe the instruments, it is easy to isolate the piano tracks. For music in format 1, since all the audio tracks are synchronized, it is relatively troublesome to separate them, so the audio tracks need to be spliced.

Since each track can be regarded as a complete time series, the time series is composed of multiple time increments (delta time). Delta time not only has the ability to express different time intervals, but also allows stored information to preserve time series. So when doing track splicing, the scattered delta times with interval time can be spliced together to form a complete time series.

Each delta time is composed of 4 bytes, so the maximum value can be 228-1. During the splicing process, the bits are carried from the lowest order of the 4 bytes to the high order. When the lowest order of a byte reaches 7FH, it will start to carry forward. By splicing similar to delta time, it is possible to separate out the piano track in the synchronized multitrack in format 1. Table 1 shows the conversion of variable lengths to real values.

3.4. Acquisition of Music Features. Music features are usually divided into two categories: one is physical features, including pitch, timber, and duration. Another feature is the time domain feature, which cannot be felt by the human ear and can only be displayed by specific instruments, such as short-term energy, short-term average zero-crossing rate, and short-term autocorrelation coefficient.

In order to make the training model more accurate and effective, the optimal features need to be selected when extracting music features. However, some of the MIDI music contained in the music library is derived from software synthesis, and some is generated from recordings of real

Table 1: The conversion of variable length to real value.

True value	3FFFH	100000H	7FH	4000H
Variable length (hex)	FFH7FH	C0H80H00H	7FH	81H80H00H
Variable length (binary)	11111111B01111111B	11000000B10000000B00000000B	01111111B	10000001B10000000B00000000B

performances. MIDI music synthesized by software has a characteristic, the music is very monotonous, and it is difficult to obtain the loudness characteristics of the music, or it can be simply understood that the types of a different loudness of the music are too few.

3.5. Quantification of Data. To solve this problem, then all music data will be selected in 4/4 time, while the timestamp is approximated to the 1/16th note. That is to say, 1/16 note is a beat, and each measure has four beats. The method of modifying the timestamp is relatively simple. It only needs to change the denominator of the message in each track read from 4 to 16.

Since time is a continuous concept, the score matrix of each delta time is discrete. A MIDI music can be regarded as a complete time sequence, which contains several delta times.

In order to represent all the information of all the notes of a song with a feature matrix, then it is necessary to combine the note information with the corresponding time; otherwise, there will be a situation where some note information cannot be obtained.

At the same time, since the music feature information is not continuous, but discrete, one-hot encoding is adopted during vectorization.

Before using hot-unique encoding, categorical values are first mapped to integer values, and then each integer value is represented as a binary vector, which is 0 except for the index of the integer and 1 for the rest. Encoding values in this way can efficiently express many situations and are often used in vector encoding design.

3.6. MIDI Content Coding Design. Before training the model, the MIDI content information needs to be converted into a valid vector, which needs to contain the pitch, intensity, start time, and end time of the score and other related information. After the key of the current score is played, it is necessary to know what the next key is to play.

When the next note is the same as the previous note, the note still needs to be represented by a new parameter, which makes more useless or redundant information added to the vector.

This model designs a relatively simple representation method to encrypt the pitch state information into a vector. Here, the representation method of binary vector is used to encrypt the pitch state information. The first parameter of the binary vector represents whether the tone is played in the time series, and the second parameter represents whether the tone is the same as the previous tone. Then when there is a tone that needs to be played, if the tone is different from the previous tone, use [1, 1] to represent it in the matrix, and use [0, 1] to represent the same tone as the previous tone, but use [0, 0] to represent when you do not need to play. By encrypting the pitch state information using a binary vector approach, model learning can be made relatively easy.

The design of the output matrix is very similar to the design of the input matrix above. The ordinate of the output matrix still represents the time series, and the abscissa represents the pitch value. The only difference here is that the dimension of the pitch value is 88 dimensions, while the dimension of the input matrix is 176 dimensions.

Here, the strength and weakness features of the pitch are expressed in the form of vectors in the matrix. In order to make learning relatively easier, the dimension of the vector is reduced, and the matrix design is carried out in the form of [pitch, time series].

3.7. Music Genre Analysis Model Design. The algorithm is mainly composed of two models, the music genre analysis model and the music style generation model. The music genre analysis model divides the learning problem into two parts. The first part is used to learn the musical features in the score and converted into feature vectors, and the second part is to obtain the range of musical intensity.

In order to learn a specific musical style, it can be learned by combining a specific musical genre. In piano performance, the loudness of a note can be achieved by hitting the keyboard lightly and hard, and the strength and weakness of these notes have their own emotional expression.

In the deep neural network, when selecting parameters to update the method or optimization algorithm, such as gradient disappearance in the update process, it will seriously affect the effect of the experiment.

But when training the model, especially when the model uses back-propagation for parameter update, gradient descent will seriously affect the weight update. In the current RNN, two adjacent time steps share the same weight. When the value of the weight is less than 1, after a series of steps, the gradient will disappear. So for a long-term sequence like music, when two adjacent notes have a great influence at the same time, insisting on using RNN will make the effect unsatisfactory. You should consider the variant LSTM network of this network.

Since MIDI music is a long-term sequence, the effect of using RNN cannot meet the requirements. However, there is currently a network that has a good effect in dealing with long-term sequence problems, that is, the bidirectional LSTM network. Bidirectional LSTM is more complicated than unidirectional LSTM, mainly in the process of value propagation. At the same time, bidirectional neural network requires more training times to optimize the parameters, while unidirectional LSTM does not require many training times. However, the accuracy of the training results of the bidirectional LSTM network is much higher

Figure 2: Design of the musical style analysis model.

than that of the unidirectional LSTM after many times of training.

The activation function of bidirectional recurrent neural network is usually a simple tanh function, through which the weight value of the current state cell is determined, and the output value will become part of the input value of the next cell. However, due to the relatively simple design and the problem of gradient descent, only a small portion of previous input values can be retained. Then as the time step increases, the previous input value has less and less influence on the subsequent input value.

The reasons for choosing a bidirectional long- and short-term memory network can be roughly summarized as follows:

(1) The bidirectional long- and short-term memory network has a better processing effect on the problem of gradient descent.

(2) Since the processing of MIDI music data belongs to a long-term sequence problem, the special design structure of the LSTM network can optimally retain or remove the unnecessary parts.

(3) Since the ordinary recurrent neural network cannot know what the next note needs to be played through the musical score, the bidirectional recurrent long short-term memory network has a forward propagation layer and a back-propagation layer. The back-propagation layer can reverse the time series, so it can achieve a role similar to a person reading a musical score to adjust the model and make the training more accurate.

The role of the bidirectional cyclic long short-term memory network layer in the entire model is to provide memory for the learned music features, so that the model can take future information into account when learning.

After passing through the bidirectional LSTM layer of the previous layer, since the activation function of the hidden layer of the bidirectional LSTM is tanh, the value range of the current output data belongs to [−1, 1]. Because the range of the performance intensity is a continuous larger range, it is necessary to convert the output value into a music intensity value, so it is necessary to change the range of the output value through a linear layer.

3.8. Design of Music Style Analysis Model. The music style analysis model mainly studies whether computers can learn

and generate different styles of music like humans. How to learn the information of the whole score is the task that the music genre network needs to complete, and the main task of the music style analysis model is to predict and generate different styles of music according to different music genres. In this model, it mainly includes two parts, namely, the interpretation layer and the sub-network of the music genre analysis network. The model structure design is shown in Figure 2.

The music genre analysis sub-network in the analysis model is mainly used to learn the music style of a specific genre, and an explanation layer is included in the upper design, which can be shared by the music genre analysis network. This greatly reduces the learned parameters, and the music style analysis network is like a tool that can convert music into different styles.

Based on this situation, some scholars have proposed the use of a neural network called Siamese, which is a similarity measurement method, which maps the input to the target space through a function and uses Euclidean distance in the target space for similarity degree comparison. The network shares the same weight, and Network1 and Network2 can represent the same network or different networks. The two neural networks are trained to represent the new output in a new space and finally use the loss function to calculate the similarity of the two inputs.

Based on the use of this network, different genres of music can be used as different inputs; for example, input1 can input pop music, and input2 can input jazz music.

In music style analysis, since music has different genres, in order to better learn different music styles, in this music style analysis model, it is necessary to design multiple music genre analysis sub-network units.

Each sub-network is connected to the interpretation layer, and the output of the interpretation layer is used as the input of the sub-network unit. The sub-network unit consists of a bidirectional LSTM layer and a linear layer. Each different music genre is a small sub-network. Therefore, a total of four sub-networks are set in the music style analysis model, namely, classical, jazz, rock, and popular music.

The output of the interpretation layer in each sub-network unit contains the state and input, then contains the 2-layer bidirectional LSTM network, and finally connects the thread layer. The role of the bidirectional LSTM layer is to read the score, learn the relevant parameters, and then modify the performance. When reading an article or a piece of music, the human eye can know what the current next word is, so as to think. The four-layer bidirectional LSTM in this subnet is mainly used to learn parameters, similar to the process of thinking, and adjust parameters through forward propagation and back-propagation.

The role of the interpretation layer is the process of reading music of different genres into a computer-recognized score. To put it simply, it is the process of entering a musical score into the neural network. Since music has different genres, the same method can be used for this entry process.

If each genre of music needs to use a separate input, this will increase the parameters learned by the model, making the model less efficient.

Therefore, when designing, the output of the interpretation layer is used as the input of the music style analysis network. When there are multiple music genre analysis networks, multitask learning can be performed at the same time.

4. Results and Analysis

4.1. Analysis of Simulation Results of Independent Recurrent Neural Network. In the process of completing this project, starting from the RNN, we tried the application of LSTM and GRU network in the project. During the experiment, it was found that the sigmoid function and the hyperbolic tangent tanh function in these two variants of RNN may cause gradient decay in deep networks, especially for inputs such as musical style fragments that require long-term sequences. In order to solve practical problems in practical music style classification applications, this topic attempts to solve them with emerging RNN variants. The independent recurrent neural network (IndRNN) can learn longer time-dependent contexts than LSTM and GRU, so the network is more suitable for the music style recognition task in this paper.

That is, at time t, each neuron only accepts the input at the moment and its own hidden state at time $t-1$ as input information. In traditional RNN, each neuron at the current moment needs to take the state of all neurons at the previous moment as input. This allows each neuron in an IndRNN to process its temporal and spatial models independently, making it easier to visualize. The cyclic processing process is represented by recurrent + ReLU, and the activation function uses the ReLU function. As an important step in the current neural network learning, the BN layer is mainly used to adjust the data distribution, speed up the network learning rate, and alleviate the problem of gradient disappearance to a certain extent.

Compared with traditional RNN, IndRNN has many advantages in long-term sequence task scenarios. Based on the calculation method of Hadamard product, IndRNN can effectively alleviate the gradient disappearance and gradient explosion problems that often occur in the model training process by specifically adjusting the parameters of gradient back-propagation.

Figures 3 and 4 correspond to the zero-order and first-order scattering coefficient distributions, respectively. As the order increases, more and more high-frequency features are recovered.

The feature data obtained by the scattering transformation are sent to the network for training. It can be seen from Figure 5 that after 500 epochs of IndRNN training, it converges to a fairly high accuracy. Figures 6 and 7 show the training results of the GTZAN data set based on other typical networks in recent years. This paper compares and analyzes the network performance based on training time and classification accuracy. Although the training time of each epoch is very short, the classification accuracy of the RNN is at a disadvantage. In terms of both training time and classification accuracy, the IndRNN used in this paper performs the best.

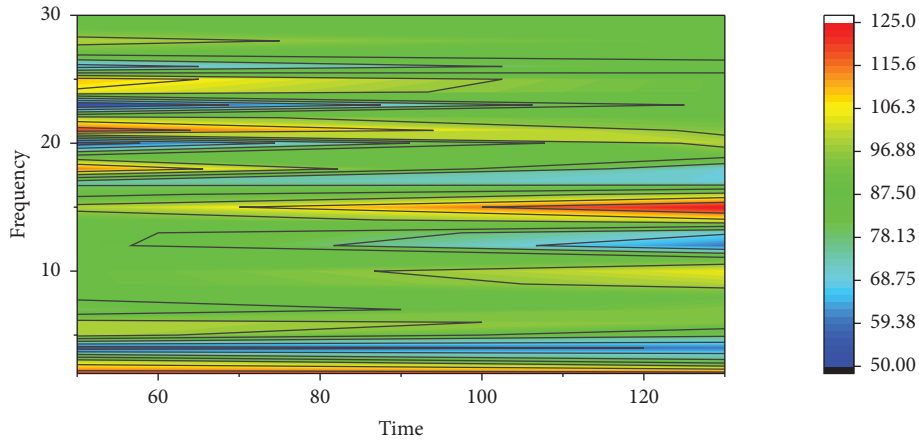

Figure 3: Distribution of zero-order scattering coefficients.

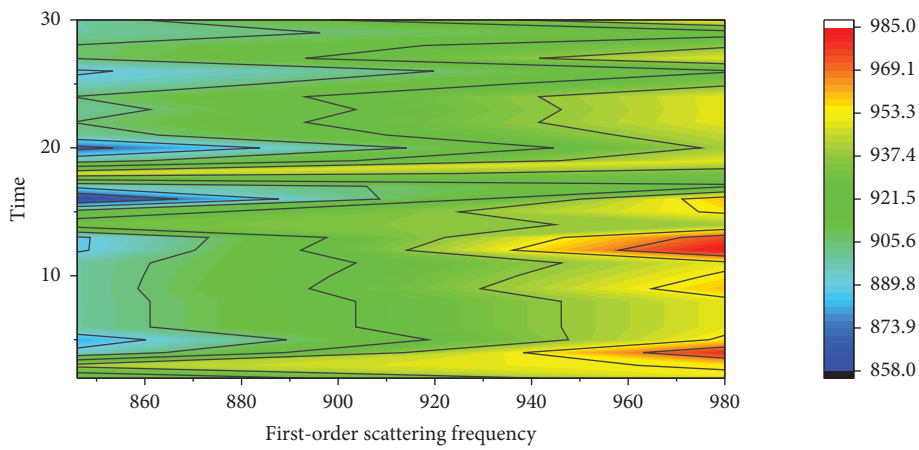

Figure 4: Distribution of first-order scattering coefficients.

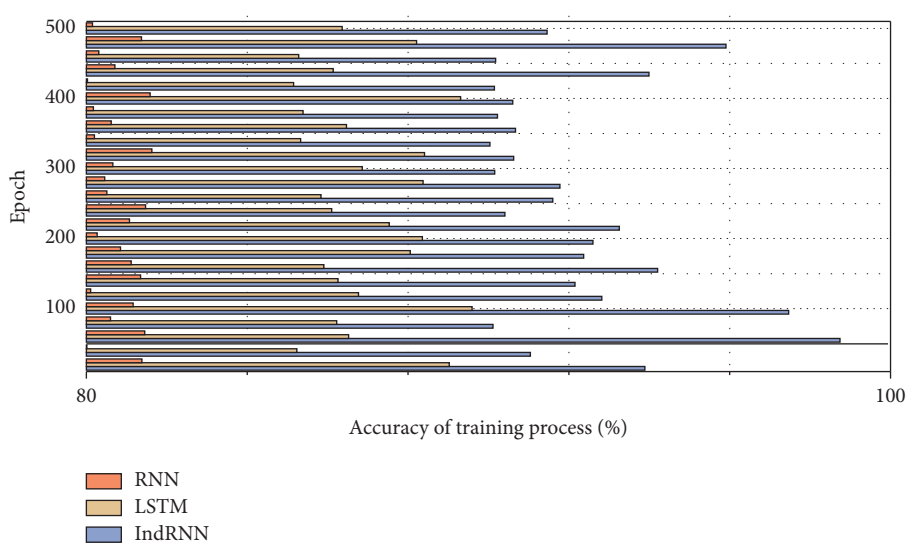

Figure 5: IndRNN, LSTM, and RNN training process accuracy.

4.2. Intelligent Learning System Music Classifier Experimental Simulation and Analysis. There are 6 corresponding test sets in total, each test set includes 200 songs of different styles and 40 samples for each type, and each song can only be used once. Figure 8 lists the comparison of the classification accuracy of the traditional incremental learning algorithm

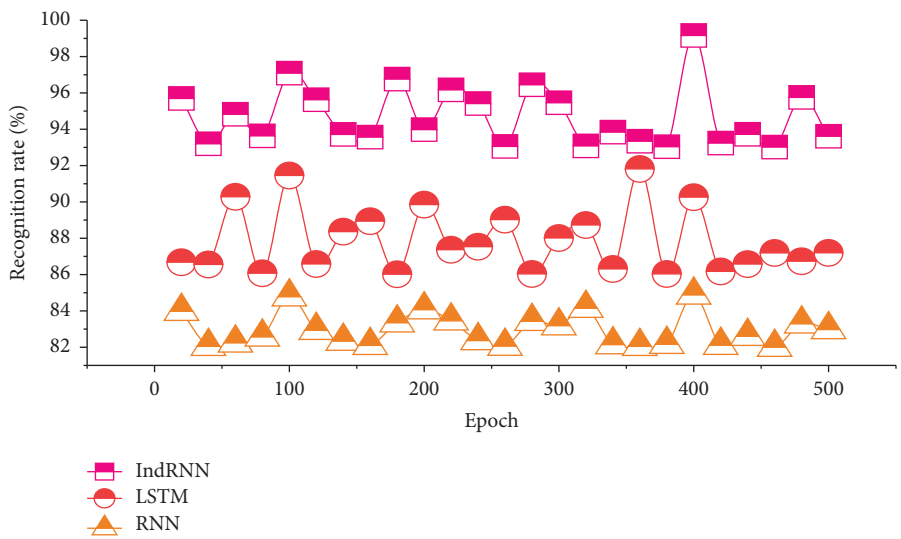

Figure 6: IndRNN, LSTM, and RNN recognition rate comparison.

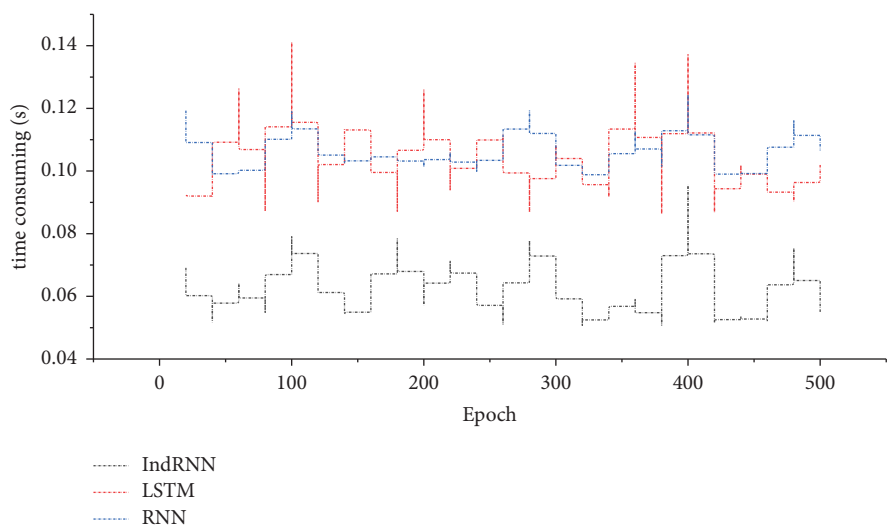

Figure 7: IndRNN, LSTM, and RNN time performance comparison.

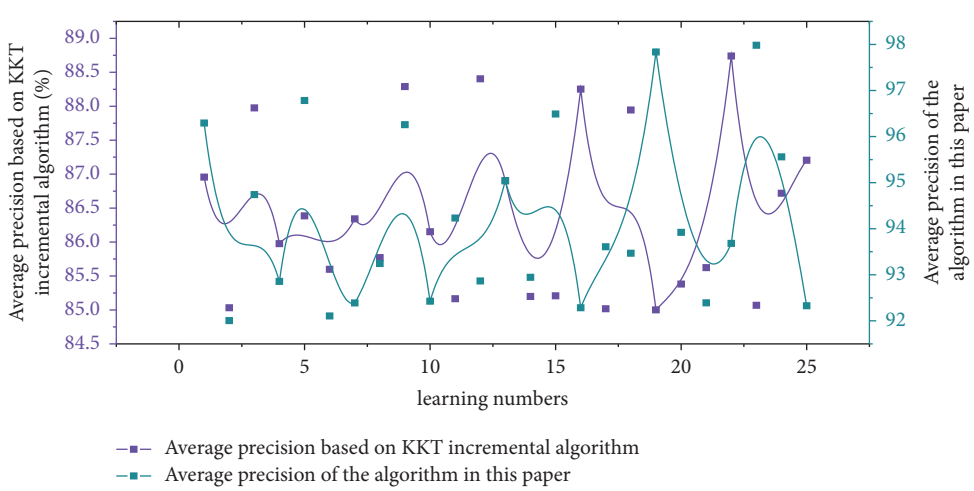

Figure 8: Classification accuracy comparison.

based on KKT condition and the incremental learning algorithm of this paper.

When the learning number is 1, there is only the initial training process. Although the accuracy of the initial classification model established by the algorithm in this paper is slightly smaller than the classification model established by the traditional incremental algorithm based on KKT conditions, the training time is shortened by about 1 min.

This is because the information of the initial sample set cannot reflect the overall information of all samples. The model established by the training is not sufficient, the generalization ability is weak, and the accuracy of the classification model is small. With continuous incremental training, the accuracy of the classifier is getting higher and higher.

For the music classification system built according to the traditional KKT conditional incremental algorithm, although the SV set in the last training set and the new sample set will be considered before establishing a new classification model, those nSV sets will be the same in each incremental training which are excluded, but these nSV sets may have sample data that will be converted to SV after the next incremental training. Therefore, with the increase of the number of subsequent incremental trainings, errors continue to accumulate, and it is difficult for the accuracy of the classification model to increase rapidly.

For the incremental learning algorithm in this paper, combined with the advantages of traditional incremental learning, the convex hull vector and error push strategy are introduced. This algorithm is obviously better than the incremental music style classifier based on the traditional KKT condition, and the classification accuracy has reached 90%.

5. Conclusion

Considering that the context filtering recommendation will directly filter out most of the scoring data sets that are not related to the current context, this recommendation cannot achieve the integration of context and model in the true sense. A context-aware recommendation method based on probability matrix decomposition is proposed. The method maps the multidimensional "user-context-item" model to a two-dimensional "user-item" model, so as to make model-based context-aware recommendations by using traditional probability matrix factorization. Based on the LSTM network, the music genre style recognition and generation network is redesigned. In this network, all the sub-networks of music genres share the explanation layer, which can greatly reduce the learning of model parameters and improve the learning efficiency. Each sub-network of music genres analyzes music of different genres and realizes the effect of multitasking and processing at the same time. In this paper, a music style recognition method using a combination of independent recurrent neural network and scattering transform is proposed. Starting from the principle of scattering transform, the superiority and rationality of using scattering transform in this task are explained. Based on the application scenarios of this topic, the application effects of recurrent neural networks and their variants on this task are compared and analyzed. This paper proposes a music style recognition method combining scattering transformation and independent recurrent neural network strategies. Experiments show that this method improves the accuracy of music style recognition to a certain extent. In the case that the incremental data set is all labeled, this paper introduces the solution of the convex hull vector, which reduces the training time of the initial sample. Combined with the error push strategy, an incremental learning algorithm based on the convex hull vector and the error push strategy is proposed, which can effectively filter historical useful information and at the same time eliminate useless information in new samples, reduce the training time of incremental learning, and maintain good performance.

Data Availability

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

Conflicts of Interest

The author declares no conflicts of interest.

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Research Article

Design of Asynchronous Motor Controller Based on Controlled Lagrangians Method

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Asynchronous motor system has the characteristics of high order, strong coupling, and nonlinearity. From the dynamical model, it is the underactuated mechanical system, which means that the dimension of its input space is fewer than the degree of freedom. Following this perspective, the energy based nonlinear control technology-CL (controlled Lagrangians) method is used to solve the control problem in this paper. Based on the expected controlled energy and its derivative with respect to time, controlled Lagrangians and generalized force are constructed, and they produce the controlled equations. In order to ensure the complete matching between the controlled equation and the original equation, the gyroscopic forces containing the first-order term of velocity are innovatively introduced into the generalized force, and the matching conditions are obtained. By solving the matching conditions composed of some partial differential equations, the nonlinear smooth feedback control law can realize the global asymptotic stabilization of not only velocity but also position. Finally, the controlled energy is selected as the Lyapunov function, and the stability is proved according to the LaSalle invariant theorem. The effectiveness of the designed control law is demonstrated in the results of the simulation.

1. Introduction

With the advantages of low price, simple structure, convenient maintenance, and reliable operation, the asynchronous motor has always been in a leading position in today's social industrial production. Under the concept of advocating production environmental protection and low-carbon economy, the research on the control performance of the asynchronous motor has important theoretical significance and practical value [1].

The asynchronous motor is a nonlinear system. However, the traditional linear control method cannot reveal its nonlinear nature. Therefore, the research on the control method of nonlinear theory is of great significance to improve the dynamic and static performance of the AC asynchronous motor. At present, the nonlinear control methods applied to the asynchronous motor mainly include feedback linearization control [2], backstepping control [3], sliding mode control [4], active disturbance rejection control [5, 6], and passive control theory [7, 8]. The control performance of the system has been significantly improved for application of the above method.

Sun developed chopping control and energy-saving controller of a three-phase AC asynchronous motor [2]. Yu et al. designed the nonlinear adaptive controller of the asynchronous motor system by using the subsystem separation method and backstepping technology to ensure the stability of the system [3]. Lekhchine et al. designed a renewable energy storage electrical system for asynchronous motors. In this system, the motor is driven by sliding mode control, which can overcome the chattering phenomenon through the sliding surface based on fuzzy logic [4]. Li et al. proposed a second-order ADRC and AC excitation control system based on stator flux oriented control to control the active and reactive power of the variable-speed pumped storage unit [5, 6]. Wu et al. discussed the problem of asynchronous passive control of Markov jump systems and obtained three equivalent sufficient conditions to ensure the

random passivity of hidden Markov jump systems by using matrix inequality technology. Based on the established conditions, an asynchronous controller is designed [7–9]. Yu et al. studied the tracking control of the underactuated dynamic system and proposed a six-step motion strategy of the pendulum driven vehicle rod system [10, 11]. By implementing feedback and other measures, the asymptotic stability of the control Hamiltonian system can be realized. The literature [12–15] reports some new results about the control of underactuated dynamic systems.

In terms of mathematical equivalence, some studies analyze the controlled Lagrange (CL) method [16–19]. Compared with PBC, the CL method has a simpler mathematical form and clearer physical meaning, which is easy to understand. Usoro et al. described a Lagrangian method for solving nonlinear constrained optimization problems in set theory control problems. By introducing the matrix Lagrange multiplier, the problem is simplified to solve a set of nonlinear simultaneous matrix equations [16]. Műller et al. proved the possibility of maximizing the torque without exceeding the limit value of magnetic flux and stator current, which is independent of the number of revolutions of an asynchronous motor [17]. Lindgren et al. gave the exact slope distribution and other characteristic distributions of symmetric and asymmetric Lagrangian spatiotemporal waves at level crossings [18, 19]. In addition, some studies are extended to the general PBC method from the perspective of robust control and optimal control of general PCH systems [20–26]. These results have been proved to be expressed in a Lagrangian form.

This paper applys CL method to analyze the asynchronous motor system from the perspective of an underdrive mechanical system. We will use the electromagnetic energy generated by the stator and rotor windings and the mechanical energy generated by the rotor to construct a controlled energy controller [12]. The controlled system maintains the Lagrangian mechanical structure in form, obtains the smooth nonlinear feedback control law, has a large convergence range, and helps to realize the CL method robust control and optimal control [14]. Compared with the port controlled dissipative Hamiltonian system, the nonlinear smooth feedback control law obtained in this paper can realize the global asymptotic stabilization of position and velocity at the same time.

2. Mathematical Model

For the convenience of writing, we will indicate the independent variables of the functions and matrices that appear, which will be omitted when they appear below. $l, m, n \in N$, and $N_i = \{1, \cdots, i\}$, N_{n} means a collection consisting of the first n quantity of natural numbers. Let $z(\mathbf{e})$ represents the function of the vector $\mathbf{e} = [e_1, \cdots, e_5]^{\mathrm{T}}$, Y_{kj} corresponds to the element at the kth row and the jth column of the function matrix vector $\mathbf{Y}(\mathbf{e})$, x_i denotes the ith element of function vector $\mathbf{X}(\mathbf{e})$: $R^5 \longrightarrow R^5$, where $i \in N_5$, $\mathbf{I}$ means the five-order identity matrix. Besides, some notations as given below:

$$z_{,i} = \frac{\partial z(\mathbf{e})}{\partial e_i}, Y_{,i} = \begin{bmatrix} Y_{11,i} & \cdots & Y_{1m,i} \\ \vdots & & \vdots \\ Y_{l1,i} & \cdots & Y_{lm,i} \end{bmatrix}$$
$$\partial_{\mathbf{e}} z = \begin{bmatrix} z_{,1} \\ \vdots \\ z_{,n} \end{bmatrix}, \partial_{\mathbf{e}^{\mathrm{T}}} X = \begin{bmatrix} x_{1,1} & \cdots & x_{1,n} \\ \vdots & & \vdots \\ x_{m1} & \cdots & x_{m,n} \end{bmatrix}. \tag{1}$$

The generalized coordinate variables of the AC asynchronous motor is $\mathbf{q} = [q_1, \ldots, q_5]^{\mathrm{T}}$, where q_1, q_2, q_3, q_4 are the components of stator inductance charge and rotor inductance charge on $d-q$ axis, and q_5 is the angular position of motor rotor. $\mathbf{u} = [u_1, \ldots, u_4, 0]^{\mathrm{T}}$ is the original control input, where u_1, u_2, u_3, u_4 are the elements of the stator voltage and rotor voltage on the $d-q$ axis. In addition, $\mathbf{u} = \mathbf{O}(\mathbf{q})\mathbf{v}$, where the input coupling matrix $\mathbf{O} = [I_{01}, I_{02}, I_{03}, I_{04}]$, and $\mathbf{v} \in R^4$.

In view of the mathematic model of a three-phase asynchronous motor, the following assumptions are expressed as follows [9]:

(1) The spatial harmonic and the spatial difference between three-phase windings are ignored. Meanwhile, it is assumed that the generated magnetomotive force is distributed sinusoidally along the circumference of the air gap.

(2) Magnetic circuit saturation and core loss are ignored. At the same time, it is assumed that the inductance parameters of every phase winding, not only self-inductance but also mutual one, are constant.

(3) It is not considered of the influence of frequency and temperature changes on the variation of winding resistance.

According to the above assumptions for the AC asynchronous motor, its mathematical model in the $d-q$ coordinate system can be obtained by

$$\begin{bmatrix} L_{11} & 0 & L_{13} & 0 & 0 \\ 0 & L_{11} & 0 & L_{13} & 0 \\ L_{13} & 0 & L_{33} & 0 & 0 \\ 0 & L_{13} & 0 & L_{33} & 0 \\ 0 & 0 & 0 & 0 & J/n_{\mathrm{p}} \end{bmatrix} \begin{bmatrix} \ddot{q}_1 \\ \ddot{q}_2 \\ \ddot{q}_3 \\ \ddot{q}_4 \\ \ddot{q}_5 \end{bmatrix}$$
$$+ \begin{bmatrix} 0 & L_{11}\dot{q}_5 & 0 & L_{13}\dot{q}_5 & -n_{\mathrm{p}}\psi_{\mathrm{sq}} \\ -L_{11}\dot{q}_5 & 0 & -L_{13}\dot{q}_5 & 0 & n_{\mathrm{p}}\psi_{\mathrm{sd}} \\ 0 & L_{13}\dot{q}_5 & 0 & L_{33}\dot{q}_5 & 0 \\ -L_{13}\dot{q}_5 & 0 & -L_{33}\dot{q}_5 & 0 & 0 \\ n_{\mathrm{p}}\psi_{\mathrm{sq}} & -n_{\mathrm{p}}\psi_{\mathrm{sd}} & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} \dot{q}_1 \\ \dot{q}_2 \\ \dot{q}_3 \\ \dot{q}_4 \\ \dot{q}_5 \end{bmatrix}$$
$$+ \begin{bmatrix} R_1 & -\omega_1 L_{11} & 0 & -\omega_1 L_{13} & 0 \\ \omega_1 L_{11} & R_1 & \omega_1 L_{13} & 0 & 0 \\ 0 & -\omega_1 L_{13} & R_2 & -\omega_1 L_{33} & 0 \\ \omega_1 L_{13} & 0 & \omega_1 L_{33} & R_2 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} \dot{q}_1 \\ \dot{q}_2 \\ \dot{q}_3 \\ \dot{q}_4 \\ \dot{q}_5 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ T_{\mathrm{L}} \end{bmatrix} = \begin{bmatrix} u_1 \\ u_2 \\ u_3 \\ u_4 \\ 0 \end{bmatrix}. \tag{2}$$

In (2), $\psi_{sd} = L_{11}\dot{q}_1 + L_{13}\dot{q}_3$, $\psi_{sq} = L_{11}\dot{q}_2 + L_{13}\dot{q}_4$, L_{11}, and L_{33} denote the equivalent self-inductance of the stator and rotor phase windings, respectively. And L_{13} is the equivalent mutual inductance of the stator and rotor phase windings. The load torque is denoted by T_L, and $T_L = T_1 + T_L^{'}$, where T_1 includes no-load torque and the external one, and $T_L' = Hq_5$ denotes the torsional torque generated when the motor and the mechanical load are connected with a relatively long shaft, where H is the deformation coefficient. The equation (2) is abbreviated as

$$M\ddot{q} + C(q,\dot{q})\dot{q} + C_0\dot{q} + \partial_q E_p = u, \tag{3}$$

where $(\mathbf{q}^{\mathrm{T}}, \dot{q}^{\mathrm{T}}) = (\mathbf{q}_{\mathrm{d}}^{\mathrm{t}}, 0^{\mathrm{T}})$ is the equilibrium point, and its input must satisfy $\overline{O}\mathbf{u} = 0$, where $\overline{O} \in (\mathbf{O}^{\perp})^{\mathrm{T}}$ and $(\mathbf{O}^{\perp})^{\mathrm{T}}\mathbf{O} = 0$, so $\overline{O} = [0,0,0,0,1]$.

3. Design of Asynchronous Motor Controller Based on CL Method

3.1. Construction of Controlled Energy and Generalized Force. According to (3), the controlled kinetic energy of the controlled system is $\overline{E}_{\mathrm{k}}(\mathbf{q},\dot{q}) = (1/2)\dot{q}^T\overline{M}\dot{q}$. The controlled kinetic energy matrix satisfies $\overline{M}: R^5 \longrightarrow R^{5\times5}, \overline{M} = \overline{M}^T$ and $|\overline{M}| \neq 0$.

Take the controlled potential energy as $\overline{E}_{\mathrm{p}}: R^5 \longrightarrow R$, and generalized force $\overline{u} \in R^5$, then controlled Lagrangian function $\overline{L}(\mathbf{q},\dot{q})$ and controlled energy $\overline{E}(\mathbf{q},\dot{q})$ of the system are as follows:

$$\begin{cases} \overline{L} = \overline{E}_k - \overline{E}_p, \\ \overline{E} = \overline{E}_k + \overline{E}_p. \end{cases} \tag{4}$$

Sometimes, the controlled energy has physical meaning, such as controlled kinetic energy or controlled potential energy, and maybe it has only a mathematical meaning which is sufficient and necessary. According to $\overline{L}$ and $\overline{u}$, we obtain the controlled equations of the system as follows:

$$\overline{u} = \overline{M}\ddot{q} + \partial_{\mathbf{q}^{\mathrm{T}}}(\overline{M}\dot{q})\dot{q} - \frac{1}{2}\partial_{\mathbf{q}}\left(\dot{q}^{\mathrm{T}}\overline{M}\dot{q}\right) + \partial_{\mathbf{q}}\overline{E}_{\mathrm{p}}. \tag{5}$$

Using (4) and (5), we get

$$\dot{\overline{E}} = \dot{q}^{\mathrm{T}}\left[\frac{d}{dt}\partial_{\dot{q}}\overline{L} - \partial_{\mathbf{q}}\overline{L}\right] = \dot{q}^{\mathrm{T}}\overline{u}. \tag{6}$$

The generalized force of the system consists of two parts, namely gyroscopic forces $\mathbf{G}(\mathbf{q},\dot{q})\dot{q}$ and dissipation force $-\mathbf{D}(\mathbf{q})\dot{q}$, where gyroscopic forces matrix is $\mathbf{G} = -\mathbf{G}^{\mathrm{T}} = \sum_{i\in N_5}\mathbf{I}_{oi}\mathbf{G}_{io} = \sum_{i,j\in N_5}\mathbf{I}_{oi}\dot{q}^{\mathrm{T}}\mathbf{g}_{io}(\mathbf{q}) + \mathbf{G}^0$.

Furthermore, $g_{ij}^{(k)}(\mathbf{q})$ represents the element at the kth row and jth column of function matrix $\mathbf{g}_{io}$, and for $i,j,k \in N_5$, $g_{ij}^{(k)}$ is the kth component function of the element G_{ij} of the gyroscopic forces matrix.

Since the gyroscopic forces matrix is an anti-symmetric one, there is $g_{ij}^{(k)} = -g_{ji}^{(k)}$. Similarly, the constant elements of the gyroscopic forces matrix $\mathbf{G}$ also satisfy $\mathbf{G}_{ij}^0 = -\mathbf{G}_{ji}^0$.

Remark 1. Since there is $\mathbf{C}_0\dot{q}$ term in the original system, constant term $\mathbf{G}^0$ is introduced into the matrix $\mathbf{G}$ to construct the gyroscopic forces consisting of the first term of the velocity, which matches $\mathbf{C}_0\dot{q}$ of the original system. Maybe these forces do not exist in real world, and only mathematical meaning is necessary for them. As we know, this introduction is for the first time.

When generalized force $\overline{u} = (\mathbf{G} - \mathbf{D})\dot{q}$, we obtain from (5) that

$$\dot{\overline{E}} = \dot{q}^{\mathrm{T}}(\mathbf{G} - \mathbf{D})\dot{q} \leq 0, \tag{7}$$

which indicates that the energy of the closed system is decreasing. Multiplying $\mathbf{M}\overline{M} = \mathrm{N}(\mathbf{q}) - \mathrm{N}(\mathrm{q})$ at the two sides of (4) at the same time, we obtain

$$\mathbf{N}\overline{u} = \mathbf{M}\ddot{q} + \mathbf{N}\left[\partial_{\mathbf{q}^{\mathrm{T}}}(\overline{M}\dot{q})\dot{q} - \frac{1}{2}\partial_{\mathbf{q}}\left(\dot{q}^{\mathrm{T}}\overline{M}\dot{q}\right) + \partial_{\mathbf{q}}\overline{E}_{\mathrm{p}}\right]. \tag{8}$$

According to (2) and (7), the original control input u and the control input $\overline{u}$ of the controlled system are obtained. The relationship between them can be given as

$$\begin{aligned} u = {} & (C + C_{\mathbf{0}})\dot{q} - N\partial_{\mathbf{q}}\overline{E}_p + \partial_{\mathbf{q}}E_{\mathrm{p}} + N\overline{u} \\ & -N\left[\partial_{\mathbf{q}^{\mathrm{T}}}(\overline{M}\dot{q})\dot{q} - \frac{1}{2}\partial_{\mathbf{q}}\left(\dot{q}^T\overline{M}\dot{q}\right)\right] \end{aligned}. \tag{9}$$

According to (9)–(14) in [14] and (8) in this article, we obtain

$$\begin{aligned} u = {} & (C + C_{\mathbf{0}})\dot{q} + \partial_{\mathbf{q}}E_{\mathrm{p}} - N\partial_{\mathbf{q}}\overline{E}_p \\ & - \sum_{i\in N_5}\frac{1}{2}NI_{oi}\dot{q}^{\mathrm{T}}T^{(i)}\dot{q} + N(\overline{u} - \overline{G}\dot{q}). \end{aligned} \tag{10}$$

The deduction of (9) is tedious, so we borrow the similar process in literature [12] for abbreviation.

3.2. Determination of the Matching Conditions. If the controlled equation (5) matches the original (3), the control input determined by (9) is true; that is, $u_5 = 0$ is true for any point $(\mathbf{q},\dot{q})$.

In the same form as gyroscopic forces matrix $\mathbf{G}$, matrix $\widehat{G}(\mathbf{q},\dot{q})$ is given as follows:

$$\widehat{G}(\mathbf{q},\dot{q}) = \mathbf{G}(\mathbf{q},\dot{q}) - \overline{G}(\mathbf{q},\dot{q}), \tag{11}$$

where $\widehat{G}$ gives out functions $\widehat{g}_{ji}^{(k)}(\mathbf{q})$ and $\widehat{g}_{ij}$ similar to $g_{ji}^{(k)}(\mathbf{q})$ and g_{ij}. Substituting $\overline{u} = (\mathbf{G} - \mathbf{D})\dot{q}$ and (11) into (10), we get

$$\begin{aligned} u = {} & -\sum_{i\in N_5}\frac{1}{2}NI_{oi}\dot{q}^{\mathrm{T}}T^{(i)}\dot{q} + (C + C_{\mathbf{0}})\dot{q} \\ & + N(\widehat{G} - D)\dot{q} - N\partial_{\mathbf{q}}\overline{E}_p + \partial_{\mathbf{q}}E_{\mathrm{p}}. \end{aligned} \tag{12}$$

Let $\overline{N} = \overline{O}\mathbf{N}$, multiplying the line vector $\overline{O}$ from the left to (12) and taking the obtained left side zero constantly, we acquire the matching conditions as follows (13)–(16):

$$0 = \sum_{i\in N_5} \overline{N}_i T_{jj}^{(i)} + \sum_{i\neq j} 2\overline{N}_i g_{ji}^{(i)}, \tag{13}$$

where $j \in N_5$ and each j represents an equation, and

$$0 = \sum_{i\in N_5} \overline{N}_i \left(T_{fj}^{(i)} + g_{ji}^{(f)} + g_{fi}^{(j)} \right) + hn_{\mathrm{p}} L_{13}. \tag{14}$$

In equation (14), each pair of (j, f) corresponds to an equation. Otherwise, $j, f \in N_5$ and $j > f$, When $f + j \neq 5$, $h = 0$; then $h = (-1)f$.

$$0 = \sum_{i\in N_5} \overline{N}_i D_{ij} + \sum_{i\neq j} \overline{N}_i \widehat{g}_{ji}, \tag{15}$$

where $j \in N_5$, and each j corresponds to an equation.

$$0 = \sum_{i\in N_5} \overline{N}_i \overline{E}_{\mathrm{p},i} - E_{\mathrm{p},5}. \tag{16}$$

Multiplying (13) by $\overline{N}_1^2, \cdots, \overline{N}_5^2$, and multiplying (14) by $2\overline{N}_1\overline{N}_2$, $2\overline{N}_1\overline{N}_3$, $2\overline{N}_1\overline{N}_4$, $2\overline{N}_1\overline{N}_5$, $2\overline{N}_2\overline{N}_3$, $2\overline{N}_2\overline{N}_4$, $2\overline{N}_2\overline{N}_5$, $2\overline{N}_3\overline{N}_4$, $2\overline{N}_3\overline{N}_5$, and $2\overline{N}_4\overline{N}_5$, then the sum to obtain a equation has nothing to do with gyroscopic forces:

$$2n_{\mathrm{p}} L_{13} \left(\overline{N}_2\overline{N}_3 - \overline{N}_1\overline{N}_4 \right) = \sum_{i\in N_5} \overline{ON}_i \mathbf{W}_{,i}^{-1} \overline{O}^{\mathrm{T}}. \tag{17}$$

Remark 2. Equation (17) is obtained without gyroscopic forces terms due to anti-symmetric property of gyroscopic forces matrix, which indicates that the quadratic form of the anti-symmetric matrix is equal to zero.

Let $\mathbf{W}^{-1} = \mathbf{K}(\mathbf{q})$, then (17) can be concisely expressed as

$$2n_p L_{13} \left(\overline{N}_2\overline{N}_3 - \overline{N}_1\overline{N}_4 \right) = \sum_{i\in N_5} \overline{ON}_i \mathbf{K}_{,i} \overline{O}^T. \tag{18}$$

For the controlled kinetic energy matrix, its regular condition is $|K| \neq 0$. According to literature [12], $\mathbf{W}(\mathbf{q}) = \mathbf{M}^{-1}\overline{M}\mathbf{M}^{-1}$ is known, so $\mathbf{N} = \mathbf{K}\mathbf{M}^{-1}$ can be obtained from the definition of matrixes $\mathbf{N}, \mathbf{W}$, and K. If $\overline{N}_1, \cdots, \overline{N}_5$ are zero, then $|K| = 0$ is available. Therefore, $\overline{N}_1, \cdots, \overline{N}_5$ cannot be zero at the same time. In order to facilitate the subsequent calculations, suppose $\overline{N}_5 \neq 0$. Multiplying (15) by $\overline{N}_1, \cdots, \overline{N}_5$ and summing them, we get

$$\overline{N}\mathbf{D}\overline{N}^T = 0. \tag{19}$$

In summary, the combination of (16), (18), and (19) and $|K| \neq 0$ is the condition under which the controlled system matches the original one.

Remark 3. Equations (16) and (18) are partial differential equations, and equations (13)–(15) related to gyroscopic forces terms are linear algebraic equations. They are cascaded. PDEs are resolved at first to decrease difficulty, and then there are only linear algebraic equations which could be solved explicitly with introducing the previous solution.

Except algebraic equations, there are only two PDEs contained in the matching condition for the underactuation degree one system. They could be solved with involving enough independent variables according to some examples applied in CL methods.

3.3. Determination of the Matching Controller. For convenience, some notations can be expressed as follows:

$$\widehat{O} = \left(O^{\mathrm{T}} O \right)^{-1} O^{\mathrm{T}}, \widehat{N} = \widehat{O} N. \tag{20}$$

Multiplying $\widehat{O}$ from the left to (12), the matching control of the system is

$$\begin{aligned} \mathbf{v} = &-\frac{1}{2}\widehat{N} \sum_{i\in N_5} I_{oi} \dot{q}^{\mathrm{T}} T^{(i)} \dot{q} + \widehat{O}(C + C_0)\dot{q} \\ &+ \widehat{N}(\widehat{G} - D)\dot{q} - \widehat{N}\partial_{\mathbf{q}}\overline{E}_{\mathrm{p}} + \widehat{O}\partial_{\mathbf{q}} E_{\mathrm{p}}. \end{aligned} \tag{21}$$

4. Matching Conditions Solution

For the asynchronous motors model, there is no control input ($u_5 = 0$) at the fifth degree of freedom except the ath degree of freedom, where $a \in N_4$, at the same time, the following notations are defined as

$$\widehat{O} = \mathbf{O}^T, \overline{N} = \mathbf{N}_{50}, \mathbf{O}_{ao}\widehat{N} = \mathbf{N}_{ao}. \tag{22}$$

Introduce the function vector $\Gamma^{\mathrm{T}} = -N_{5a}/N_{55}$ from the definition of matrixes $\mathbf{N}$, $\mathbf{W}$, and $\mathbf{K}$, we get $K_{50} = -N_{55}\Phi(q)^{\mathrm{T}}$, where $\Phi^{\mathrm{T}} = [\Phi_1, \cdots, \Phi_5] = \Gamma^{\mathrm{T}}\mathbf{M}$, and thus the element in the fifth row of matrix $\mathbf{K}$ is $K_{5a} = K_{55}\Phi_a/\Phi_5$. To ensure $\mathbf{K} > 0$, we choose $K_{aa} = K_{55}[k_a\Phi_a^2/\Phi_5^2 + k_{(a+n)}]$, where k_a and $k_{(a+n)}$ are constants. The system matching conditions expressed by Γ, K_{55}, and $\overline{E}_{\mathrm{p}}$ are

$$\sum_{i\in N_5} \Gamma_i K_{55,i} = \frac{2n_p L_{13}\left(\Gamma_2\Gamma_3 - \Gamma_1\Gamma_4\right)K_{55}}{\left(\Gamma^T \mathbf{M}_{05}\right)}, \tag{23}$$

$$\sum_{i\in N_5} \Gamma_i \overline{E}_{p,i} = \frac{\Gamma^T \mathbf{M}_{05}}{K_{55} E_{\mathrm{p},5}}, \tag{24}$$

$$\Gamma^{\mathrm{T}}\mathbf{D}\Gamma = 0. \tag{25}$$

Assume $\Gamma_1 = 0, \cdots, \Gamma_4 = 0, \Gamma_5 = -1$, and find a special solution to (23) as follows:

$$K_{55} = k_5. \tag{26}$$

In the above (23), k_5 is a constant.

The $\mathbf{K}$ matrix of the system is

$$\mathbf{K} = k_5 \begin{bmatrix} k_6 & 0 & 0 & 0 & 0 \\ 0 & k_7 & 0 & 0 & 0 \\ 0 & 0 & k_8 & 0 & 0 \\ 0 & 0 & 0 & k_9 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}. \tag{27}$$

It can be seen from the $\mathbf{K}$ matrix that its determinant is $|K| = k_5^5 k_6 k_7 k_8 k_9$, so a sufficient condition for $\mathbf{K} > 0$ is

$$k_5, k_6, k_7, k_8, k_9 > 0. \tag{28}$$

From (24), the positive definite solution to the controlled potential energy $\overline{E}_{\mathrm{p}}$ and the satisfied conditions are

$$\begin{cases} \overline{E}_{\mathrm{p}} = \sum\limits_{i \in N_5} (q_i - a_i)^2; \\ k_5 = \dfrac{JH}{2n_p}, \\ a_5 = -\dfrac{JT_1}{2n_p k_5}, \end{cases} \tag{29}$$

where $a_1, \cdots, a_5$ are constants. After some calculations, the Hessian matrix of $\overline{E}_{\mathrm{p}}$ is

$$\frac{\partial^2 \overline{E}_p}{\partial \mathbf{q} \partial \mathbf{q}^T} = \begin{bmatrix} 2 & 0 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 & 0 \\ 0 & 0 & 2 & 0 & 0 \\ 0 & 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 0 & 2 \end{bmatrix}. \tag{30}$$

It is clear that the Hessian matrix is positive definite. And from $\overline{E}_{\mathrm{p},1}(a_1), \cdots, \overline{E}_{\mathrm{p},5}(a_5) = 0$, we know that $(a_1, \cdots, a_5)$ is the minimum point of the controlled potential energy.

Remark 4. The controlled energy consists of controlled kinetic energy and potential energy. On the one hand, the controlled kinetic energy is in quadratic form of velocity and achieves positive definiteness with supplied condition. On the other hand, the controlled potential energy is constructed in the form to be positive definite conveniently.

According to (30), the dissipation matrix is chosen in diagonal form as follows:

$$\mathbf{D} = \begin{bmatrix} d_1 \\ d_2 \\ d_3 \\ d_4 \\ 0 \end{bmatrix}, \tag{31}$$

where $d_1, \cdots, d_4$ can be any value greater than zero.

5. Matching Control Law and Stability Analysis

Based on the above analysis, $\mathbf{N} = \mathbf{K}\mathbf{M}^{-1}$ is known, so the matrix $\mathbf{N}$ of the system is

$$\mathbf{N} = \beta_1 \begin{bmatrix} k_6 L_{33} & 0 & -k_6 L_{13} & 0 & 0 \\ 0 & k_7 L_{33} & 0 & -k_7 L_{13} & 0 \\ -k_8 L_{13} & 0 & k_8 L_{11} & 0 & 0 \\ 0 & -k_9 L_{13} & 0 & k_9 L_{11} & 0 \\ 0 & 0 & 0 & 0 & \beta_2 \end{bmatrix}. \tag{32}$$

In equation (32), $\beta_1 = k_5/(L_{11}L_{33} - L_{13}^2)$ and $\beta_2 = n_p(L_{11}L_{33} - L_{13}^2)/J$, because $\mathbf{T}^{(\mathbf{i})} = \mathbf{M}\mathbf{K}_{,i}^{-1}\mathbf{M}$, where $i \in N_5$, so we get

$$\mathbf{T}^{(i)} = 0, i \in N_5. \tag{33}$$

From (13)–(15) and from (30)–(32), we have the gyroscopic forces component function $\widehat{g}_{ij}^{(k)}$ as follows:

$$\widehat{g}_{ij}^{(k)} = \gamma_{ij}^{(k)}, \widehat{g}_{ij} = \gamma_{ij}, i, j, k \in N_5. \tag{34}$$

In equation (33), one part of the value of gyroscopic forces component function $\gamma_{ij}^{(k)}$ needs to satisfy $\gamma_{15}^{(2)} = -\gamma_{25}^{(1)}, \gamma_{15}^{(3)} = -\gamma_{35}^{(1)}, \gamma_{25}^{(4)} = -\gamma_{45}^{(2)}, \gamma_{35}^{(4)} = -\gamma_{45}^{(3)}$ and be arbitrary values, the other part needs to be taken according to the following (35), and the rest can be arbitrary values.

$$\begin{aligned} &\gamma_{15}^{(1)} = 0, \gamma_{15}^{(4)} = 2JL_{13}/k_5, \\ &\gamma_{15}^{(5)} = 0, \gamma_{25}^{(2)} = 0, \\ &\gamma_{25}^{(3)} = -2JL_{13}/k_5, \gamma_{25}^{(5)} = 0, \\ &\gamma_{35}^{(2)} = JL_{13}/k_5, \gamma_{35}^{(3)} = 0, \\ &\gamma_{35}^{(5)} = 0, \gamma_{45}^{(1)} = -JL_{13}/k_5 \\ &\gamma_{45}^{(4)} = 0, \gamma_{45}^{(5)} = 0, \\ &\gamma_{15} = 0, \gamma_{25} = 0, \\ &\gamma_{35} = 0, \gamma_{45} = 0. \end{aligned} \tag{35}$$

To keep the control law simple, take the value of $\gamma_{12}^{(5)}, \gamma_{15}^{(3)}, \gamma_{25}^{(4)}, \gamma_{35}^{(4)}, \gamma_{12}, \gamma_{13}, \gamma_{14}, \gamma_{23}, \gamma_{24}, \gamma_{34}$ to be one and the rest to be zero.

Remark 5. A large part of variables, $\widehat{g}_{ij}^{(k)}$ and $\widehat{g}_{ij}$ in equation (34), take the value zero for convenience to get the simpler control law. The different evaluation for them could still assure stability of the system and maybe affect the convergence rate of the system. Further, there is a room to search control law for better performance in some respects.

Substituting (20), (27)–(35) into (21), the obtained matching control law of the motor system is described as

$$u_1 = R_1\dot{q}_1 + (\dot{q}_5 - \omega_1)(L_{11}\dot{q}_2 + L_{13}\dot{q}_4) - n_p\psi_{sq}\dot{q}_5 + \frac{k_5k_6}{(L_{11}L_{33} - L_{13}^2)}\{[L_{33}(\dot{q}_2 + \dot{q}_3 + \dot{q}_4 + \dot{q}_3\dot{q}_5 + \dot{q}_2\dot{q}_5) + L_{13}(\dot{q}_1 + \dot{q}_2 - \dot{q}_4 - \dot{q}_4\dot{q}_5)] + L_{13}J\dot{q}_5 * (2L_{33}\dot{q}_4 - L_{13}\dot{q}_2)/k_5 + (L_{13}d_3\dot{q}_3 - L_{33}d_1\dot{q}_1) - 2[L_{33}(q_1 - a_1) - L_{13}(q_3 - a_3)]\}, \tag{36}$$

$$u_2 = R_1\dot{q}_2 + (\omega_1 - \dot{q}_5)(L_{11}\dot{q}_1 + L_{13}\dot{q}_3) + n_p\psi_{sd}\dot{q}_5 + \frac{k_5k_7}{(L_{11}L_{33} - L_{13}^2)}\left\{[L_{33}(\dot{q}_3 + \dot{q}_4 - \dot{q}_1 - \dot{q}_1\dot{q}_5 + \dot{q}_4\dot{q}_5) + L_{13}(\dot{q}_1 + \dot{q}_2 + \dot{q}_3)] + \frac{L_{13}J\dot{q}_5}{k_5} * (L_{13}\dot{q}_1 - 2L_{33}\dot{q}_3) + (L_{13}d_4\dot{q}_4 - L_{33}d_2\dot{q}_2) - 2[L_{33}(q_2 - a_2) - L_{13}(q_4 - a_4)]\right\}, \tag{37}$$

$$u_3 = (\dot{q}_5 - \omega_1)(L_{13}\dot{q}_2 + L_{33}\dot{q}_4) + R_2\dot{q}_3 + \frac{k_5k_8}{(L_{11}L_{33} - L_{13}^2)}\{[L_{11}(\dot{q}_4 - \dot{q}_1 - \dot{q}_2 + \dot{q}_4\dot{q}_5) - L_{13}(\dot{q}_2 + \dot{q}_3 + \dot{q}_2\dot{q}_5 + \dot{q}_3\dot{q}_5)] + L_{13}J\dot{q}_5(L_{11}\dot{q}_2 - 2L_{13}\dot{q}_4)/k_5 + (L_{13}d_1\dot{q}_1 - L_{11}d_3\dot{q}_3) - 2[L_{11}(q_3 - a_3) - L_{13}(q_1 - a_1)]\} \tag{38}$$

$$u_4 = (\omega_1 - \dot{q}_5)(L_{13}\dot{q}_1 + L_{33}\dot{q}_3) + R_2\dot{q}_4 + \frac{k_5k_9}{(L_{11}L_{33} - L_{13}^2)}\{[L_{13}(\dot{q}_1 - \dot{q}_3 - \dot{q}_4 + \dot{q}_1\dot{q}_5 - \dot{q}_4\dot{q}_5) - L_{11}(\dot{q}_1 + \dot{q}_2 + \dot{q}_3)] + L_{13}J\dot{q}_5(2L_{13}\dot{q}_3 - L_{11}\dot{q}_1)/k_5 + (L_{13}d_2\dot{q}_2 - L_{11}d_4\dot{q}_4) - 2[L_{11}(q_4 - a_4) - L_{13}(q_2 - a_2)]\}. \tag{39}$$

In summary, the conclusion is listed as follows:.

Proposition 1. *For AC asynchronous motor systems, if the parameters of controller meet the following conditions:*

$$\begin{cases} k_5, \cdots, k_9 > 0, \\ d_1, \cdots, d_4 > 0, \end{cases} \tag{40}$$

then the smooth feedback control law expressed by equations (35)–(38) can stabilize the motor globally asymptotically at $(\mathbf{q}^{dT}, 0^T)$. *It is the desired equilibrium point at which the controlled potential energy achieves the minimum.*

Proof. Let Lyapunov candidate function $V = \overline{E}$. If the system controller parameters are selected according to (39), then the function is positive definite. From equation (6), there is $\dot{V} \leq 0$. Therefore, the control law given by equations (35)–(38) enables the induction motor to achieve global asymptotic stabilization at $(\mathbf{q}^{\mathrm{dT}}, 0^{\mathrm{T}})$.

For the asymptotic stability, it can be proved that there is no trajectory of isolated points other than equilibrium points in the set of $\dot{V} = 0$.

Assuming that there is such a trajectory in the set, it can be obtained as

$$\dot{q}_i \equiv 0, i \in N_4. \tag{41}$$

There is a certain point q_0 on this trajectory, and at the same time, (39) also holds in a certain area δ_0 of this point q_0. Differentiating and integrating (40) along the trajectory, we get

$$\begin{cases} \ddot{q}_i \equiv 0, \\ q_i = \alpha_i, i \in N_4, \end{cases} \tag{42}$$

where $\alpha_1, \cdots, \alpha_4$ are constant.

Substituting (35)–(38), (40), and (41) into the first four equations of (1), we get

$$\begin{cases} \dfrac{2k_5k_6}{L_{11}L_{33} - L_{13}^2}[L_{33}(\alpha_1 - a_1) - L_{13}(\alpha_3 - a_3)] = 0 \\ \dfrac{2k_5k_7}{L_{11}L_{33} - L_{13}^2}[L_{33}(\alpha_2 - a_2) - L_{13}(\alpha_4 - a_4)] = 0 \end{cases}$$
$$\begin{cases} \dfrac{2k_5k_8}{L_{11}L_{33} - L_{13}^2}[L_{11}(\alpha_3 - a_3) - L_{13}(\alpha_1 - a_1)] = 0 \\ \dfrac{2k_5k_9}{L_{11}L_{33} - L_{13}^2}[L_{11}(\alpha_4 - a_4) - L_{13}(\alpha_2 - a_2)] = 0 \end{cases}. \tag{43}$$

It can be seen from observation that (43) is true if and only if $\alpha_1 = a_1, \cdots, \alpha_4 = a_4$, and vice versa. Therefore, the assumption that there are isolated points belonging to the point group of $\dot{V} = 0$ does not hold.

From (4) and (41), we obtain $\partial_q\overline{E}_{\mathrm{p}} = 0$. This shows that the trajectory in the set $\dot{V} = 0$ can only be the equilibrium point, and the Hessian matrix of $\overline{E}_{\mathrm{p}}$ is positive definite, so point $\mathbf{q}_{\mathrm{d}}$ is the sole extreme point of $\overline{E}_{\mathrm{p}}(\mathbf{q})$. According to the

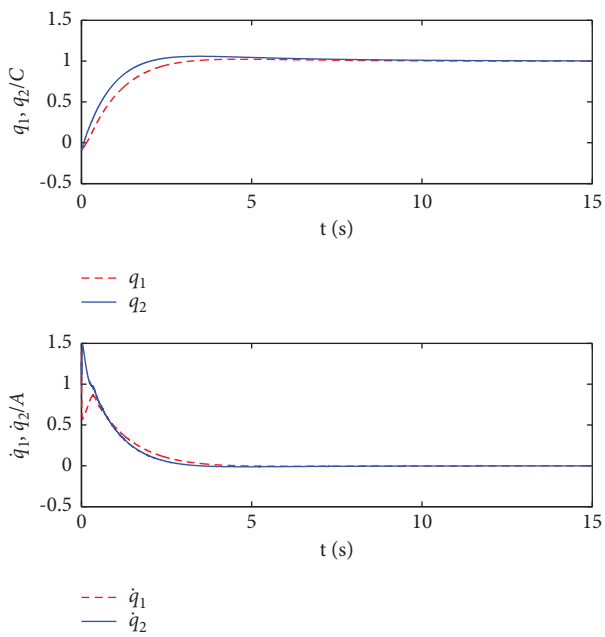

Figure 1: Stator inductive charge and current.

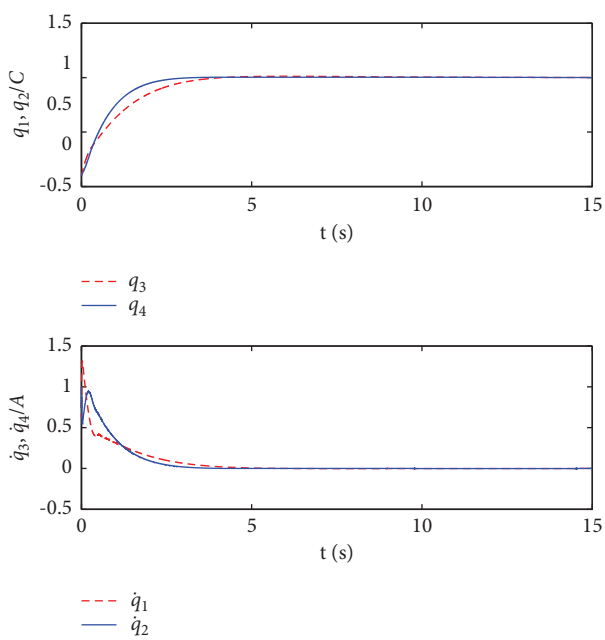

Figure 2: Charge and current of rotor.

LaSalle principle, the system can achieve global asymptotic stabilization by the proposed control law. □

6. Simulation Result Analysis

The simulation parameters of the system are selected as $\mathbf{L}_{11} = 0.45$ H, $\mathbf{L}_{13} = 0.42$ H, $\mathbf{L}_{33} = 0.45$ H, $\mathbf{J} = 0.2$ kg m^{2}H, $\omega_1 =$ 10 rad/s, $\mathbf{T}_1 = 8$Nm, $\mathbf{H} = 8$Nm, $n_p = 8$, and $\mathbf{R}_1 = \mathbf{R}_2 = 0.97\,\Omega$. The parameters of the controller that satisfy the positive definite of the controlled energy are $k_5 = 0.1$, $k_6 = 4$, $k_7 = 6$, $k_8 = 0.5$, and $k_9 = 0.4$.

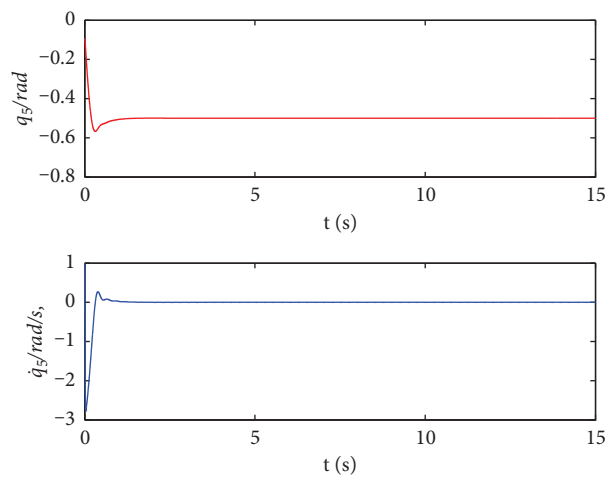

Figure 3: Rotor angular displacement and angular velocity.

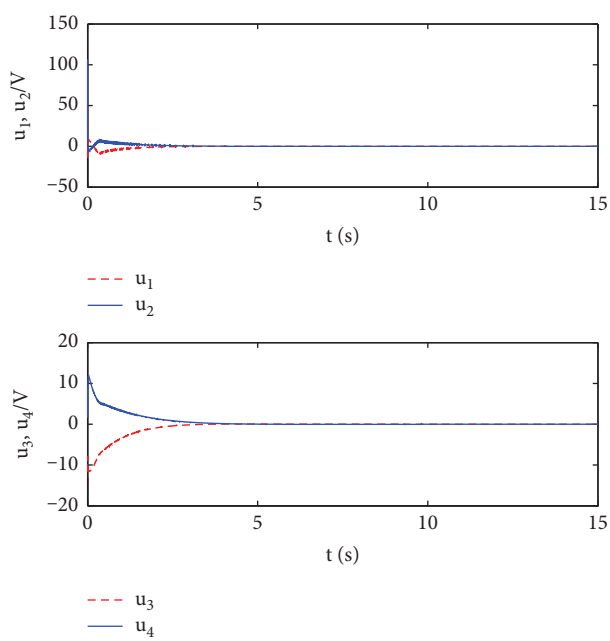

Figure 4: Control input.

When $d_1 = 7$, $d_2 = 7$, $d_3 = 5$, and $d_4 = 5$, the simulation results are as follows:

The desired equilibrium point of the system is $(\mathbf{q}_d^t, 0^T)$, where $\mathbf{q}^{dT} = [1, 1, 1, 1, -0.5]$. It can be seen from Figures 1–3 that when the AC asynchronous motor is disturbed by some uncertain factors, the control target of the system deviates from the expected balance point. Under the control input of Figure 4, the control target of the system can return to the desired equilibrium point as soon as possible. In this process, the change of electromagnetic torque, original, and controlled energy are showed in Figures 5 and 6.

Remark 6. Parameters k_5, k_6, k_7, k_8, and k_9 in controller are connected with the controlled kinetic energy, and their evaluation should ensure controlled kinetic energy positive

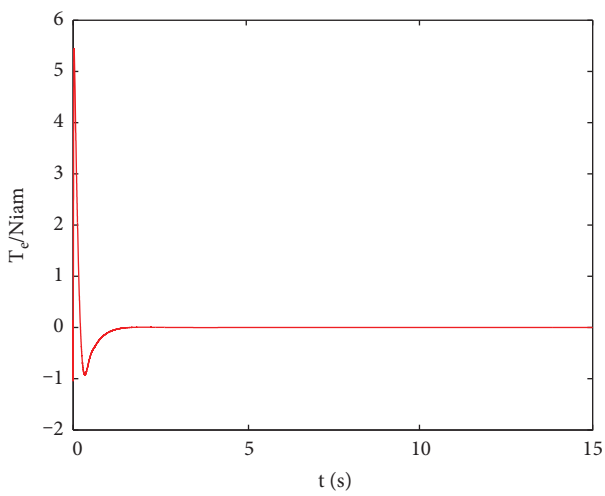

Figure 5: Electromagnetic torque.

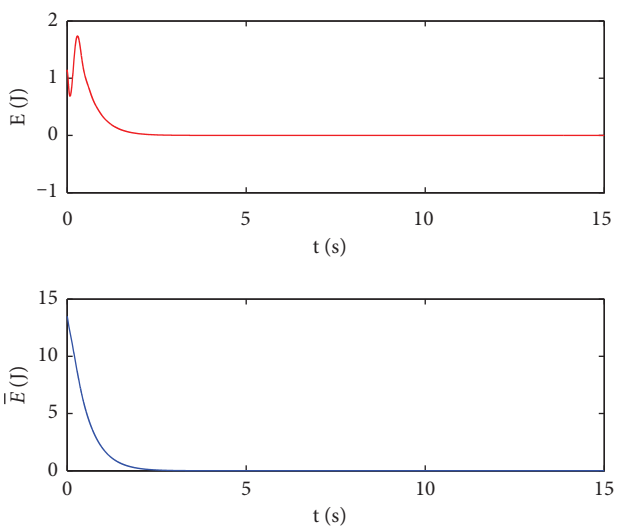

Figure 6: Original energy and controlled energy.

definite. Furthermore, they will affect primarily the amplitude of inputs.

Remark 7. Parameters d_1, d_2, d_3, and d_4 are related only to the dissipated forces, and thus the changing of them could be able to improve the convergence rate.

Compared with other control methods [8, 9], the nonlinear smooth feedback control law obtained in this article has a larger convergence range for its global asymptotic stabilization.

7. Conclusion

The control of an asynchronous motor is studied in this paper. By applying the controlled Lagrange function method to high-order, strongly coupled, and time-varying nonlinear systems, the controlled equation matching the original equation of the system is derived by using the expected controlled energy and its time derivative. Because the primary term of velocity exists in the original equation, the gyroscopic forces of the generalized primary term of velocity is innovatively introduced into the controlled equation, and the condition of complete matching between the original equation and the controlled equation can be obtained. By solving the matching condition composed of some partial differential equations, the specific matching control law of the system is obtained, and the global asymptotic stabilization of not only velocity but also position can be realized at the desired equilibrium point at the same time. Finally, the controlled energy of the system is chosen as the Lyapunov function for its property, which facilitates the proof of stability.

In the research process, we can see that the CL method analyzes the asynchronous motor system from the perspective of underactuated mechanical system, so that the controlled system maintains the Lagrangian mechanical structure in form, and the nonlinear smooth feedback control law can be obtained, which has a large convergence range and is helpful to realize robust control and optimal control. On the basis of the work in this paper, the nonlinear CL method will be improved by the introducing observer and be intended to solve tracking problem in following work.

Data Availability

The data supporting the findings of this study are available within the article.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding this research.

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Research Article

Performance Appraisal and Automatic Scoring System for College Counselors Based on Kmeans Clustering

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The optimal solution is output as the result to the Kmeans algorithm as the initial clustering center, and the proposed linear distance model is used to complete the clustering. Combined with the theory of target management, focusing on the job requirements and responsibilities of the counselors, the counselors' performance appraisal objectives were determined, the counselor performance appraisal system was established, and the first-level indicators and the second-level indicators and their weights were determined by using Del Illegal and Analytic Hierarchy Process (AHP). This paper constructs a performance appraisal system for local undergraduate college counselors based on management by objectives, and has carried out a pilot implementation in a college. The behavior anchoring method is used to determine the scoring standards of each index, which solves the problem of inconsistent scoring standards for different assessment subjects in the past. In the assessment results, the assessment results of the three dimensions are independently evaluated by category. This paper has a certain practical significance and reference value for the optimization research of the counselor's performance appraisal scheme under the background of institutional reform in a university.

1. Introduction

With the deepening of the reform of higher education and the expansion of the enrollment scale of colleges and universities, today's higher education has shifted from "elite education" to "popular education" [1, 2]. To put the ideological and political education of college students in an important position in the work of the party and the government, it is necessary to increase the investment in the ideological and political education of college students, and constantly improve the conditions and optimize the means [3]. "The ideological and political education work of college students should be taken as an important indicator for the evaluation and assessment of the quality and level of colleges and universities, and incorporated into the party building and education and teaching evaluation system of colleges and universities." It is an important part of the daily life management of college students. It has the dual identities of teachers and cadres, and is one of the indispensable and important forces to ensure the healthy and smooth development of college education [4].

Since college counselors are responsible for the ideological guidance, affairs management, development design, and talent navigation of college students who are not deeply involved in the world, the quality of the counselor team has an important impact on college students [5]. The work assessment of counselors is an important means to clarify the role positioning, job positioning, job responsibilities, and quality requirements of counselors, and is an important guarantee for the realization of the "political strength, professionalism, strict discipline, and positive work style" of the counselor team. It is of great significance to fully implement the party's educational policy and implement the various tasks of ideological and political education for

college students [6]. Playing their role and correctly evaluating their work has become an important problem to be solved in the construction of the counselor team. Therefore, it is necessary to combine the characteristics and actual conditions of the work of college counselors under the new situation, and improve and perfect the content of the assessment in order to develop their potential more effectively and make the performance assessment play its due role [7, 8]. It has more realistic and long-term guiding significance for the continuous improvement of the level of the counselor team to meet the needs of the development of the new situation.

Bilateral filtering is used to perform edge-preserving and denoising preprocessing on the target, and the mixed model is used to improve the Kmeans algorithm. The global optimal solution is obtained by comparing and replacing the overall optimal solution generated by the particle swarm optimization algorithm in each iteration. According to the design idea of the performance appraisal system for college counselors based on goal management, combined with the current situation and existing problems of the performance appraisal of a college counselor, we try to build a college counselor performance appraisal system, aiming to improve the work efficiency and work of a college counselor and the enthusiasm to promote the healthy development of the counselor team. This paper analyzes the existing counselor's performance appraisal scheme in a university by using the incentive theory, points out the problems existing in the performance appraisal scheme, and believes that the improvement of the counselor's performance appraisal work is related to the position of the counselor's own job responsibilities, the school's organizational structure, and the performance appraisal system. In the design of the counselor's performance appraisal plan, "effectiveness," "implicit and ideological and political work," and "teacher morality" are used as the three assessment dimensions of performance appraisal, and the behavior anchoring method determines the indicators to be assessed, the weights of the indicators, and the evaluation criteria of the indicators, in order to realize the scientific evaluation of the counselors.

2. Related Work

The research on the performance appraisal of college counselors is an academic research topic that has received more and more attention [9]. In recent years, the focus of researchers' attention is how to improve the effective methods and means for the assessment of college counselors. Many assessment systems have been proposed, and the relevant papers are very rich [10]. Some schools have also formulated an assessment system for college counselors, clarifying the purpose and tasks of the assessment and evaluation of counselors, which have laid the foundation for colleges and universities to carry out assessment work [11].

Relevant scholars take ABC University as the research object, through the research and analysis of the current situation of its counselor team and the existing performance evaluation system, using KPI theory, AHP, and fuzzy mathematics comprehensive evaluation theory to establish a new set of counselors [12]. On this basis, the performance evaluation system of individual counselors is established, and further measures to encourage the team of counselors are proposed.

The researchers made a diagnosis of the school's existing counselor performance system, and pointed out the problems prevalent in the existing assessment system; in response to the existing problems, by improving the existing assessment system, a set of performance assessment index systems suitable for Nanchang University's counselors was designed [13]. In the design of the student evaluation counselor model, the fuzzy comprehensive evaluation method is adopted, and the performance evaluation result feedback mechanism is established to strengthen the incentive. Relevant scholars have introduced the current performance evaluation system of CM University counselors in detail, and analyzed the main problems and reasons [14].

After careful review and discussion, a scientific development example of counselor evaluation system has been initially constructed from the aspects of evaluation system, evaluation criteria, acquisition, and processing of evaluation information, which is the basis for building the counselor evaluation mechanism [15–17]. An innovative idea is given. Combined with work practice, the researchers applied the AHP to the assessment of the counselors for further exploration and research [18].

Relevant scholars have analyzed the unclear purpose, unreasonable methods, and lack of validity of the performance assessment of college counselors in domestic colleges and universities, and put forward specific ways to strengthen the performance assessment of college counselors [19, 20]. Relevant scholars pointed out that currently, various assessment methods are generally used in the work assessment of counselors, but there are also problems such as ambiguous assessment positioning and unclear assessment content indicators [21–23]. Therefore, the main methods of the work assessment of counselors are proposed, namely, grade assessment method, group assessment method, 360-degree assessment method, sequence comparison method, and relative comparison method, and countermeasures are put forth to improve the work assessment system of counselors, improve the content indicators of the work assessment system, effectively utilize the purpose and results of work assessment, improve the procedures of the work assessment system, and construct a bionic assessment system for college counselors [24, 25].

3. Methods

3.1. Improved Kmeans Clustering Algorithm. This paper randomly initializes the velocity and position of each particle in the population within the search space and velocity interval. Then, the calculation formula of the fitness function is determined according to solving the optimization problem. We calculate the optimal solution found by each particle as its individual extremum, and obtain the global optimal solution of this iteration of the population by comparing

these individual extremums. It is updated by comparison with the obtained global optimal solution of the population history, and then the velocity and position of each particle are updated.

On the basis of using the dynamic particle swarm optimization Kmeans clustering algorithm to select the initial cluster center, the velocity update calculation formula of the jth dimension of the particle i at the kth iteration and the position update calculation formula of the jth dimension of the particle i at the kth iteration are, respectively,

$$v_{ij}^{k} = \frac{v_{ij}^{k+1}}{w} - \frac{c_1 r_1 \left(g\text{best}_i - x_{ij}^{k}\right)}{c_2 r_2 \left(p\text{best}_j - x_{ij}^{k}\right)} v_{ij}^{k+1},$$
$$x_{ij}^{k} + x_{ij}^{k-1} = 2 v_{ij}^{k+1} x_{ij}^{k}. \tag{1}$$

Among them, w is the inertia coefficient; c_1 and c_2 are acceleration constants, also known as learning factors, which represent the self-learning ability and collective learning ability of each particle, respectively, and the value range is [0, 4]; finally, it is judged whether the termination condition is reached. The termination condition can be set to the maximum number of iterations. If the termination condition is satisfied, then the iteration ends, and the particle swarm optimization solution process is completed. Otherwise, continue to calculate the current fitness value of each particle, update the individual extreme value and the global optimal solution, and update the speed and position of the particle until the iteration termination conditions are met.

For the standard particle swarm optimization algorithm, the value of the inertia coefficient w in the velocity update formula and position update formula of each particle in the population is usually a predetermined constant, and the value remains unchanged during the iteration process. Therefore, for the standard particle swarm optimization algorithm, there is a disadvantage that the iterative optimization process is easy to fall into the wandering of the local optimal solution, which leads to missing the global optimal solution. An effective way to make up for this deficiency is to adjust the value of the inertia coefficient w from remaining unchanged during each iteration to a value different from the previous iteration for each iteration. The particle swarm optimization algorithm in the clustering algorithm model DPSO-LK based on particle swarm and improved Kmeans clustering proposed in this section will improve the particle swarm by dynamically adjusting the inertia coefficient so that the inertia coefficient w of each iteration obeys a probability distribution. The formula is its probability density function:

$$f|(x) = \left(\frac{\sqrt{5}}{6\pi} - \frac{1}{\sqrt{6\pi}}\right)\exp\left(1 - 6\sqrt{x-5}\right). \tag{2}$$

The fitness of the particle is represented by f_i, and the calculation formula of f_i is the calculation formula of the distance from the data point to the cluster center of the improved Kmeans clustering algorithm:

$$f_i = \frac{1}{D_i} = \prod_{i=1}^{n} x_i - \prod_{k=1}^{m} \left|1 - c_k\right| + \sum_{i=1}^{n}\sum_{k=1}^{m} \max\left(x_n c_m\right). \tag{3}$$

When the fitness of the particles almost no longer changes, it means that the particle swarm optimization has reached convergence. In this paper, the variance is used to represent the fitness change. When it is less than a certain value, it is considered that the algorithm has found the global optimal solution.

$$\delta^2 = \frac{1}{n^2}\prod_{i=1}^{n}\sqrt{\left|f_i - f_{\text{avg}}\right|},$$
$$f_{\text{avg}} = n\prod_{i=1}^{n}\sqrt{\left|1 - f_i\right|}. \tag{4}$$

When the dynamic particle swarm optimization algorithm converges, the obtained global optimal solution is used to initialize the cluster center of the Kmeans algorithm, which reduces to a certain extent the unstable final effect caused by the random selection of the initial cluster center by the traditional Kmeans algorithm. Finally, multiple iterations are performed through the improved Kmeans algorithm until convergence.

This section uses a hybrid model GAPSO of genetic algorithm and dynamic particle swarm algorithm to solve. The model finds the overall optimal solution by comparing the optimal solutions of the corresponding populations of each generation of genetic algorithm and particle swarm optimization.

If the fitness of the optimal solution of the particle swarm optimization algorithm is higher than the optimal solution, it will be regarded as the overall optimal solution and assigned to a random chromosome; otherwise, the chromosome with the highest fitness will be assigned. As the overall optimal solution, it is assigned to a random particle in the particle swarm algorithm, and then the particle swarm algorithm adjusts the relevant parameters, and the algorithm performs crossover mutation until the iteration is terminated. The model framework is shown in Figure 1.

The specific optimization steps of the GAPSO model integrating genetic algorithm and particle swarm optimization algorithm are as follows:

① Initialize the genetic algorithm population, encode the data points in binary, convert them into chromosomes, set the corresponding parameters, and initialize the particle velocity in the population.

② Two algorithm population individuals perform the fitness calculation. The particle swarm algorithm population updates the individual extreme value and the population extreme value, and the genetic algorithm population selects the optimal solution of the population through group optimization.

③ According to the comparison of the corresponding population optimal solutions of the two algorithms, the overall optimal solution is generated. If the iteration termination condition is satisfied, the

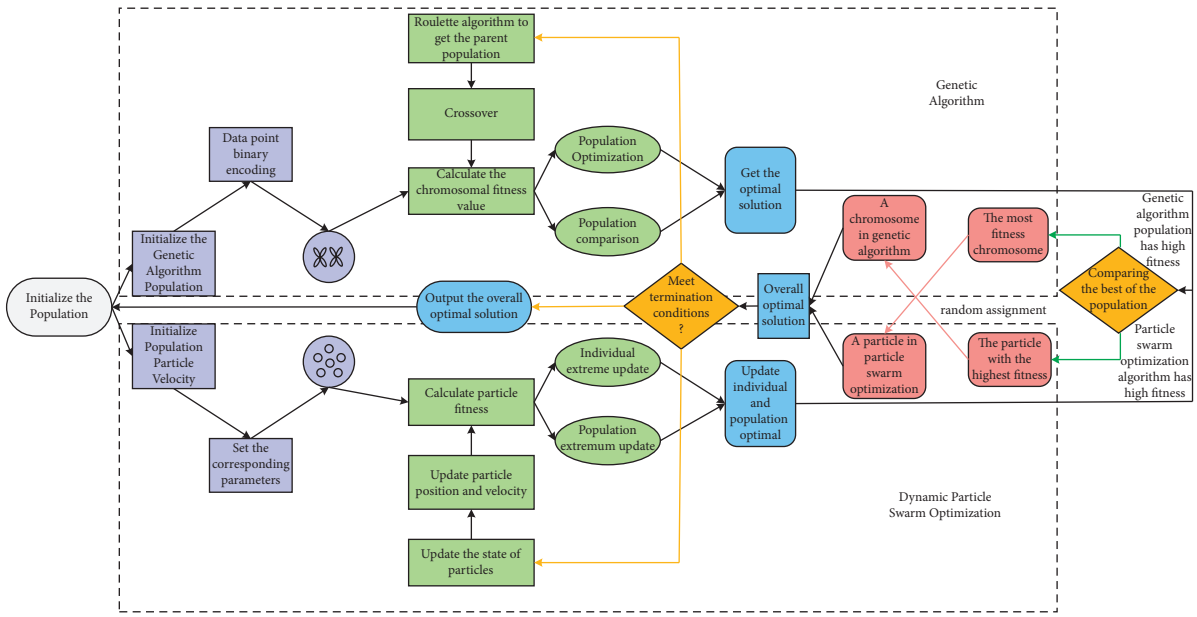

Figure 1: Model framework.

iteration loop is ended and the overall optimal solution is output; otherwise, proceed to the next step.

④ If the fitness of the population optimal solution of the particle swarm optimization algorithm is higher than that of the genetic algorithm, it is randomly assigned to a chromosome in the genetic algorithm; otherwise, the chromosome with the highest fitness in the genetic algorithm is randomly assigned.

⑤ The particle swarm population dynamically adjusts the particle speed and position, and the genetic algorithm population roulette selection method selects to generate the parent population.

⑥ Genetic algorithm population performs crossover mutation operation.

⑦ The two populations of particle swarm and genetic algorithm carry out a new round of iteration, and continue to find the optimal solution of the population.

The traditional Kmeans clustering algorithm uses Euclidean distance as a similarity criterion to cluster sample data points. For two data points x and y in n-dimensional space, the Euclidean distance is calculated as follows:

$$L_o(x, y) = \sqrt{|y_i - x_i|} \sum_{i=1}^{n} \left(1 - \frac{x_i}{y_i}\right)^2. \tag{5}$$

The Manhattan distance is calculated as follows:

$$L_m(x, y) = \sqrt{x_i - y_i} \sum_{i=1}^{n} \left(\frac{y_i - x_i}{y_i}\right)^2. \tag{6}$$

The formula for calculating the Chebyshev distance is as follows:

$$L_q(x, y) = (x_1 - y_1) \sum_{i=1}^{n} \max(x_n y_n). \tag{7}$$

It can be seen from the three distance calculation formulas that for the data points in the same n-dimensional data set, on the basis of the same number of subtraction operations, the Chebyshev distance calculation only needs to be compared, and the Manhattan distance calculation only needs to be repeated. The summation operation, and the calculation of the Euclidean distance, also requires the square sum operation and the square root operation, which takes more time than the first two distances.

Euclidean distance does not reflect the difference between two data points in n-dimensional space for distance measurement in great detail. Therefore, the linear combination of Manhattan distance and Chebyshev distance is used instead of Euclidean distance as the similarity criterion to calculate the distance from the sample data point to the cluster center to realize clustering. The linear distance model of Manhattan distance and Chebyshev distance can save clustering time to a certain extent because it avoids square operation and square root operation in distance calculation.

The Euclidean distance used in this paper to calculate the distance of the cluster center is only to synthesize the distance between two points in various dimensions, which weakens the differences in each dimension, which will cause some essential features to be ignored.

The linear distance model of Manhattan distance and Chebyshev distance is applied to calculate the distance between pixels, which not only measures the similarity between two pixels from various dimensions but also preserves which dimension the two pixels are in. The difference is the largest, and the distance is how much information. Therefore, the linear distance model of Manhattan distance

and Chebyshev distance can achieve the effect of retaining essential features to a certain extent.

The effect of applying Kmeans directly is not ideal. In this section, the Kmeans clustering algorithm is analyzed and improved by changing the calculation method of the distance from the data point to the cluster center. The new distance calculation method is the linear distance model proposed in the first section of this paper. The specific calculation formula is

$$D_i = \frac{1}{\prod_{i=1}^{n} x_i - \prod_{j=1}^{k} \left|1 - c_j\right| + \sum_{i=1}^{n} \sum_{j=1}^{k} \max\left(x_n c_k\right)}. \quad (8)$$

Aiming at the defect that the segmentation result of Kmeans clustering algorithm is very dependent on the selection of initial cluster centers, this section proposes an improved Kmeans clustering algorithm based on dynamic particle swarm optimization combined with mixture model. The dynamic particle swarm optimization algorithm is used to find the optimal solution through iteration. The two algorithms of each generation are compared with their respective optimal solutions to find the overall optimal solution, which is then output to the Kmeans algorithm as the initial clustering.

3.2. Determination of Performance Goals for College Counselors. This paper takes a college counselor as an example, and fully considers the overall goal of a college, the goal of the student work office, and the actual situation of the counselor's job when setting the counselor's performance goals. According to the levels of the organizational structure, they are connected in series to form an interlocking performance target system. The content determination and setting procedures of a university performance target are as follows:

First, determine the overall goals of the school. The setting of the counselor's performance goals should start with the school's goals, and after the school's goals are determined. In order to achieve the overall goals of the school, each department sets the "departmental goals" and "personal goals" for each department.

Second, set departmental goals. The Student Affairs Office formulates departmental goals based on the overall goals set by the school.

Finally, set counselor job goals. Due to the particularity of the work of counselors, the work requirements and positions of counselors in the "Professional Competency Standards for Counselors in Colleges and Universities (Interim)" and "Regulations on the Construction of Counselor Teams in Ordinary Colleges and Universities" should also be considered when setting the counselor's performance goals.

The overall goals of the school and the departmental goals of the Student Work Office have been determined. When formulating the performance goals of the counselors, according to the school's overall goals and the departmental goals of the Student Work Office, combined with the "Professional Competency Standards for Counselors in Colleges and Universities (Provisional)," the work requirements and job responsibilities of counselors, as well as the current status of the work of a college counselor and the conditions for job employment, have been analyzed and studied in depth with the "Regulations on the Construction of Counselor Teams in Ordinary Colleges and Universities," and the job objectives of counselors have been preliminarily determined. Through open interviews with the expert group, the post goal of a college counselor was finally determined, as shown in Figure 2.

3.3. Decomposition of College Counselor Performance Goals. The development of students includes the cultivation of students' learning ability, behavior development, national identity, social responsibility, etc. A college counselor should strive to become a guide on the way of students' development and growth, including guiding students' development through online ideological and political education.

A college counselor must adhere to "student-oriented, service and education," improve services, take students as the main body, serve students' development and success, and do a good job in counseling students' mental health, identifying and assisting students from financially disadvantaged families, and finding employment.

The daily work management of a college counselor mainly includes the evaluation of students' awards, the construction of party branches and class groups, daily study management, dormitory management, study style construction, and crisis event handling.

The construction of a college counselor team requires improving the quality of personal professional work and developing towards specialization and professionalism. The career development of counselors is related to the stable and healthy development of the counselor team construction. Therefore, counselors should properly consider personal career development, continuing education and training, obtaining professional certificates, making career development plans, and promotion of positions and titles.

Work performance is one of the criteria for measuring the work ability of a college counselor, including the pass rate of students in grades 4 and 6, the employment rate of students, the rate of postgraduate entrance examinations, the rate of award-winning classes and students, the award-winning situation of guiding students in competition, etc., as well as personal participation in competitions.

3.4. Implementation of Performance Goals for College Counselors. After a college counselor's performance assessment target is determined, combined with the actual work requirements of the counselor, the assessment passes the opinions and suggestions of experts, and the following assessment target evaluation criteria are obtained, that is, the standard for the counselor to implement the performance target.

Many performance appraisal failures are caused by the wrong cognition of the evaluators themselves. Therefore,

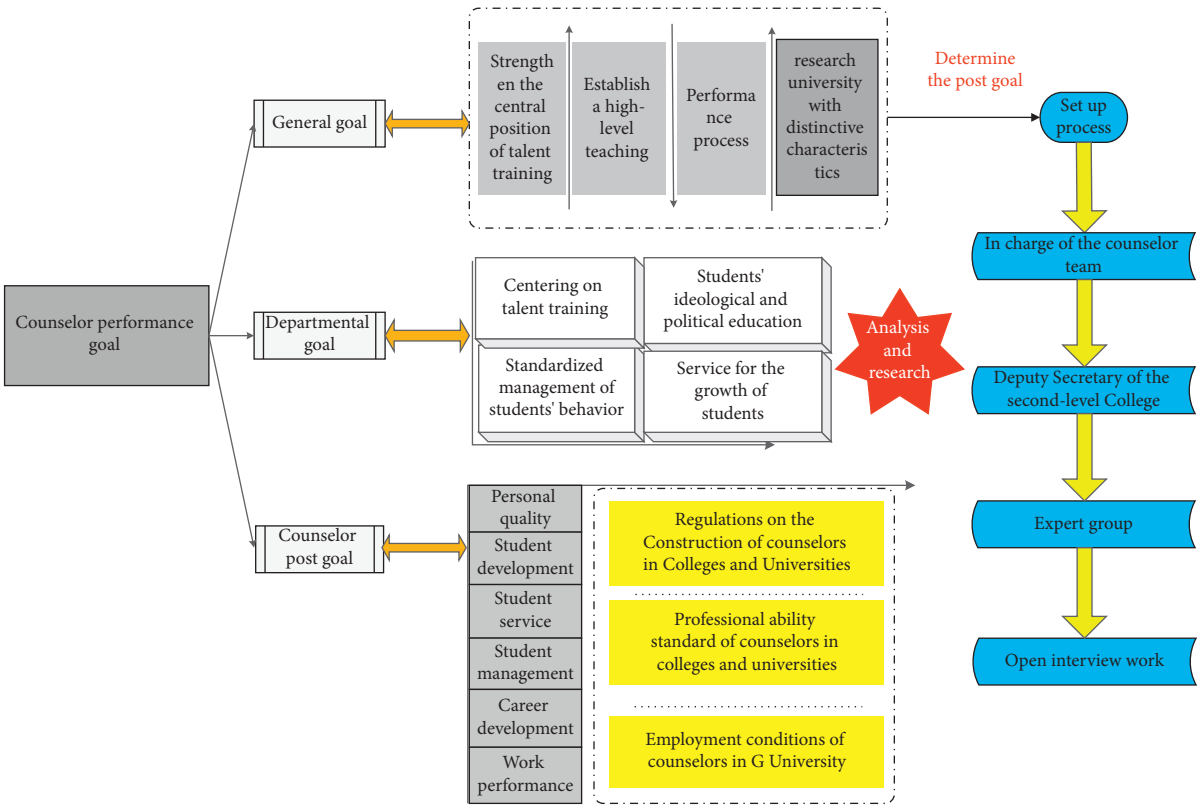

Figure 2: A college counselor's performance goal setting procedure.

before the appraisal, it is necessary to publicize and mobilize the appraisers to get rid of their misunderstandings. Through performance evaluation mobilization meetings, training courses, lecture reports, etc., all instructors involved in the evaluation can explain to all the staff. In colleges and universities, the work plan is usually formulated in the academic year. In order to facilitate the effective implementation of performance goals and tasks and make performance appraisal more in line with work requirements, it is more reasonable to take one academic year as the cycle of performance appraisal for a college counselor. The assessment time span is one academic year, and real-time monitoring needs to be done during the implementation process to avoid implementation interruption or data loss. In the process of implementing the performance goals, the Student Affairs Office of a university is responsible for monitoring the process of implementing the performance goals of the counselors.

3.5. Assessment of College Counselors' Performance Targets. Usually, the Student Affairs Office of the school takes the lead in organizing the performance appraisal of the counselors, undertakes the specific implementation, data analysis, file management, etc., and puts forward suggestions on the use of the appraisal results. After the implementation cycle of the performance target of a college counselor is over, it will face the specific practical link of the counselor's performance assessment, which includes the following steps:

(1) The counselor to be assessed submits the corresponding assessment materials. For example, submit the work summary and provide supporting materials related to the assessment index system.

(2) The school assessment team will review and evaluate the assessment materials provided by the counselors.

(3) The leading department of assessment shall collect and summarize the assessment opinions submitted by various assessment subjects according to the assessment plan.

(4) The lead department of the assessment shall conduct data statistics on the recovered evaluation scales, and calculate the assessment scores according to the weights of the corresponding indicators.

The performance evaluation of a college counselor is a problem that can be decomposed into a criterion layer around the overall goal, and determined as the final plan layer, and then the data are substituted into the calculation, and finally the result is obtained and fed back.

The analytic hierarchy process refers to the method of decomposing the elements that are always related to decision-making into goals, criteria, plans, etc., and then combining qualitative analysis and quantitative analysis, assigning weights to indicators, and then calculating the results.

Therefore, this paper adopts the AHP to determine the weight of the counselor's performance indicators, because this method overcomes the limitations of the empirical

judgment method and the expert determination method, that is, when there are different affiliations between the indicator layer and the sub-indicator layer. The problem of how to determine the weight can overcome the influence of the subjective factors of the evaluator to the greatest extent.

Analytic Hierarchy Process (AHP) forms a multi-objective and multi-level comparison model by decomposing complex problems according to the dominance relationship. The relative importance ranking is carried out through pairwise comparison, and finally the overall ranking of the relative importance of various factors is obtained to establish the weight of each factor.

3.6. Feedback on the Performance Goals of College Counselors. Leaders and coaches should be well prepared for feedback on performance results. If the result is unsatisfactory, both parties in the assessment need to fully communicate and discuss what problems exist in the assessment and how to solve them.

Through up-to-down communication and careful research, it is ensured that the performance target setting is more scientific and reasonable, the design of the indicator system is more effective, and the enthusiasm of the counselors to participate and the effect of the assessment implementation are improved. At the same time, the method of feedback should also be prepared. According to the different content of the feedback and the actual needs of the work, different methods such as written feedback and interview feedback should be adopted.

In addition, before the feedback, the feedback data should be carefully verified, and the expressions should also be carefully considered.

The purpose of the assessment is by no means just for the counselor's bonus distribution, evaluation of merit, etc. If this orientation is adhered to, the counselor will ignore the purpose of the assessment, so that he or she cannot fully grasp his or her own shortcomings and become resistant to the assessment. Feedback must adhere to the correct and clear direction, that is, to convey the school's strategic goals and work expectations for counselors, to promote performance improvement as the primary purpose, and to clearly advocate and implement it in practice.

In actual work, one of the important reasons for the failure of assessment is that the purpose of benefit distribution is not to improve performance, because the assessment system designed with benefit distribution as the starting point is not comprehensive, and it will inevitably lead to the realization of organizational goals. The effect is not obvious, and in actual operation, it is easy to cause the assessee to resist the assessment or to cheat for their own interests, causing difficulties in the assessment. Therefore, performance appraisal can only be based on performance improvement as the primary purpose and starting point. Doing a good job in the application of performance improvement results is to feed back the completion of performance goals to the relevant evaluated objects; help them analyze the reasons; provide them with training, consulting, coaching, and other assistance to improve performance; promote performance improvement; and formulate the target of the next round of performance appraisal.

The appraisers provide frequent feedback, which plays the role of prompt reminder and supervision, which is conducive to better solving the problems existing in performance improvement, especially those problems that need to be accumulated and improved on a daily basis.

In addition, the evaluation subject often gives performance feedback to the counselor, so that before the completion of an evaluation cycle, they can have a preliminary understanding of the completion progress of their performance goals, and have a general psychological expectation for the evaluation results. The regularization and normalization of performance results feedback needs to be guaranteed by corresponding systems.

4. Results and Analysis

4.1. The Weight of the "Business Effect" Indicator. On the issue of the weight of indicators, this article consulted and interviewed 7 experts, namely, the chairman of the school, the secretary of the party committee, the dean, the deputy dean in charge, the director of the student department, the secretary of the Youth League Committee, and the director of the employment department. In the specific steps, the seven experts first built the judgment matrix of the four first level indicators, calculated the corresponding weight, and then respectively, built the matrix of the four second level indicators, calculated the weight, and finally integrated all the first level and second level indicators. After the first-level indicators are selected, the weights of all the second-level indicators are obtained.

In each data calculation, this paper uses the Yaahp software to analyze and calculate the data. Yaahp is an analytic hierarchy process auxiliary software, which is widely used to provide model construction, calculation, and analysis for the decision process of analytic hierarchy process. According to the weight of the first-level index and the weight of the first-level index corresponding to the second-level index, the total weight of the evaluation of the second-level index is finally obtained, as shown in Figure 3.

The dimension of "implicit and ideological and political work" has only one indicator, "counselor education management log," and the weight of a single indicator is 100%. In this article, the leaders of the school were interviewed about the weight of the five indicators in the dimension of "professionalism and morality," and they agreed that all indicators should be equal. According to this opinion, the five indicators of the "professional morality" dimension, namely, "patience," "fairness," "integrity," "responsibility," and "professional guidance ability" each account for 20% of the weight.

4.2. Evaluation Method of "Effectiveness" Dimension Indicators. There are both quantitative and qualitative indicators among the four categories of indicators, and the behavior anchoring method can be used to evaluate the assessment indicators. The formulation of the behavior

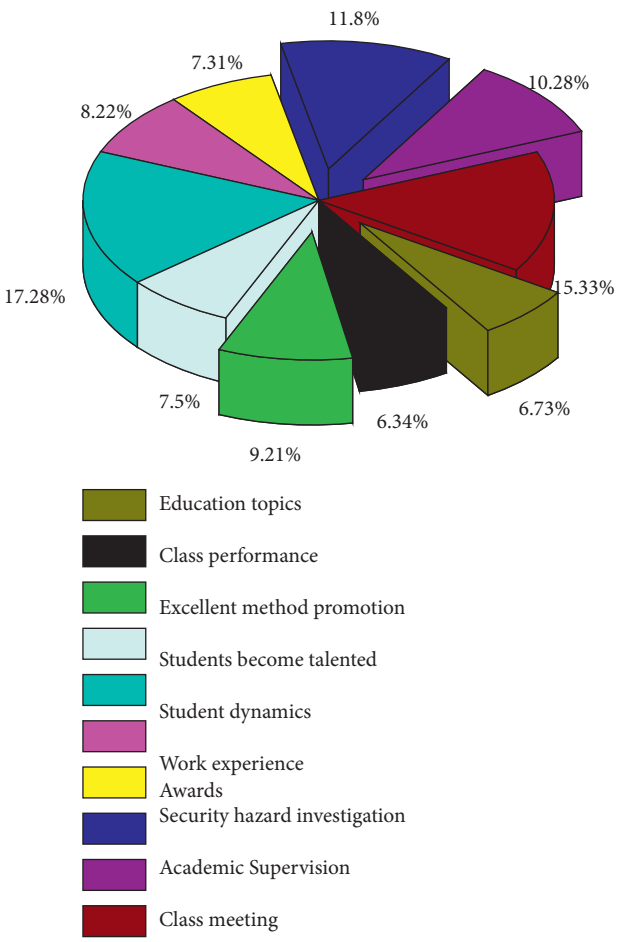

Figure 3: Weights of secondary indicators.

anchoring method first describes 5–9 typical behaviors that may occur in actual work, and then measures and scores different situations of these typical behaviors. Generally, the larger the score, the better the effect. On this basis, the anchoring is established. The score sheet is used as the basis for employee performance appraisal. According to the rules of the behavior anchoring method, combined with the measurement standards of a university, the evaluation levels of these four types of indicators are set from excellent to poor as five, four, three, two, and one. Time-based evaluation sets the corresponding grades and coefficients according to the five situations that the counselor completed the work within the specified time. In the executive evaluation, the corresponding grades and coefficients are set according to the five situations of the completion of the work of the counselor. The execution class evaluation criteria are shown in Figure 4.

The evaluation ranking type evaluation sets the corresponding grades and coefficients according to the five performances of job satisfaction. The evaluation ranking criteria are shown in Figure 5.

4.3. Assessment Methods for the Dimension Indicators of "Implicit and Ideological and Political Work" and "Professional Ethics". The indicator of the dimension of "implicit and ideological and political work" is the "counselor education management log." Accordingly, the evaluation of this indicator can be decomposed into four evaluations: devotion to one's work, work standardization and organization, service awareness, and work effectiveness. The evaluation results of teachers' morality and style of students are shown in Figure 6.

4.4. Assessment Cycle. The original performance evaluation cycle of counselors was one cycle per academic year, and there was a monthly evaluation every month. In the study of the new program, this paper conducted interviews with the leaders of the school's student management regarding the assessment cycle. After interviews, it was agreed that the work responsibilities and work procedures of counselors have changed a lot after the institutional reform. Changing the assessment cycle to one semester can reflect the actual work of counselors in a timely manner and help evaluate the effectiveness of the reform. According to the opinions of most people interviewed by experts, the assessment cycle of the new assessment plan is set to once a semester. The survey indicators of the counselor's performance appraisal cycle are shown in Figure 7.

4.5. Application of Assessment Results. In this paper, the "effectiveness" dimension is set as the basic score of 100 points, the "implicit and ideological and political work" dimension is set as an additional score of 10 points, and the "teacher morality" dimension is set as a daily warning and a necessary condition for counselor salary promotion. According to the analysis of reinforcement theory, if a certain stimulus is beneficial to the examiner, the behavior will repeat; if it is unfavorable to the examiner, the behavior will weaken or disappear.

The assessment grade of 60–70 points is basically qualified, and its coefficient is 1.0; the assessment grade below 60 points is unqualified, and its coefficient is 0.6. The difference between a score of 59 and a score of 60 may have a difference of 0.4 in the assessment coefficient, which will allow the counselor to avoid the occurrence of this negative behavior as much as possible, thereby improving the assessment score.

In order to improve the professionalization of counselors, those who have established an assessment score of 85 for two consecutive semesters can submit an application for salary increase to the Personnel Office. The Personnel Office will review the counselor's "professional morality" dimension, and those who pass can agree to increase the salary.

The category of "implicit and ideological and political work" is set as an additional score of 10 points (this indicator needs to be converted proportionally to the assessment scores). This additional point can be added directly to the score in the "Effective" category assessment, but there are two limitations.

The first limitation is that the total score after the addition is not higher than 100 points, and the second limitation is that the added score only affects the total score and does not change the original assessment coefficient.

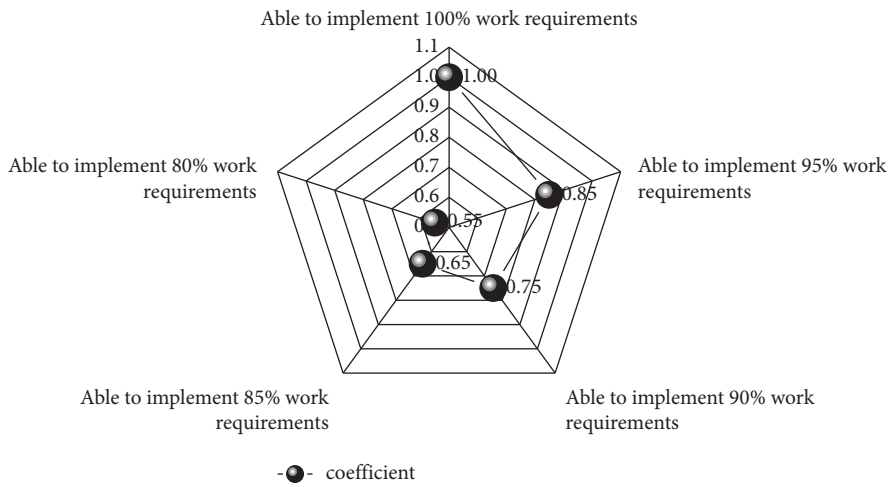

Figure 4: Execution class evaluation criteria.

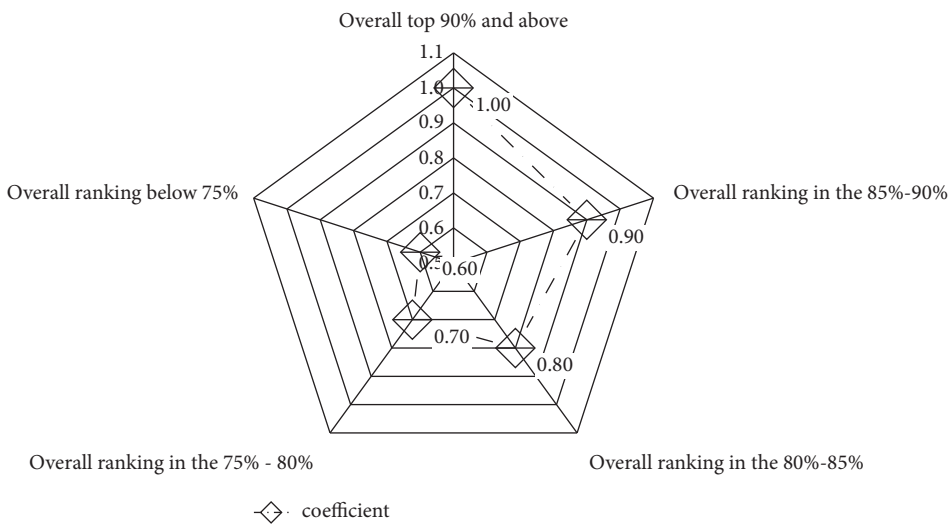

Figure 5: Evaluation ranking criteria.

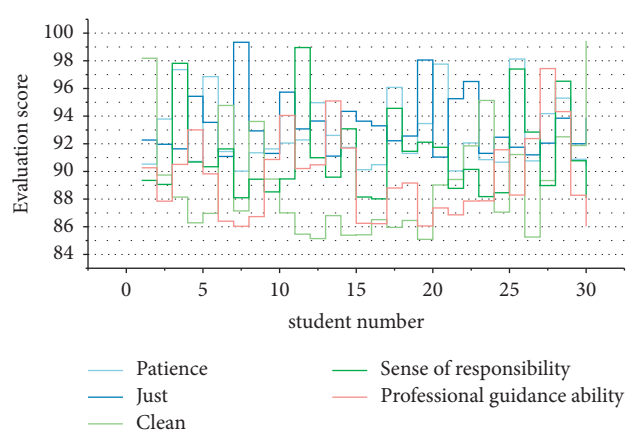

Figure 6: Student evaluation results of teacher morality and style.

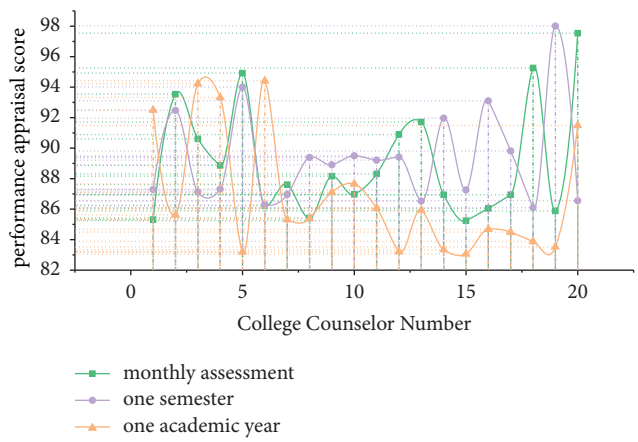

Figure 7: The survey indicators of the counselor's performance appraisal cycle.

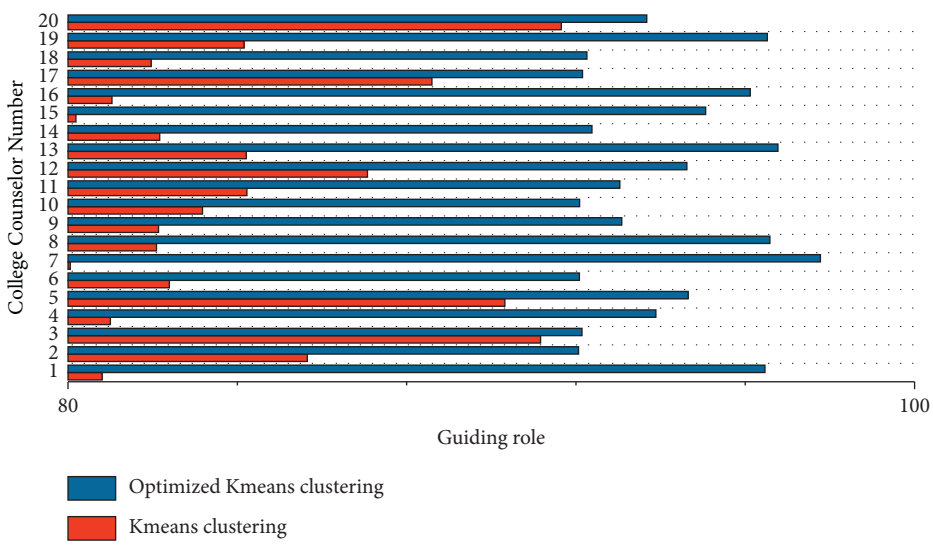

Figure 8: Guidance results of counselor assessment indicators.

This design only gives "honor" and not "money," so that peer counselors can easily play in the evaluation without too much pressure.

Otherwise, peer counselors will have psychological scruples, which will affect the objectivity of evaluation. Although the additional points can affect the promotion, the basic score of the counselor must reach a certain value, and there is no fault in the teacher's morality and style. In this way, whether you can be promoted or not, the evaluation of peer counselors actually has less impact.

The above application of the results of different assessment dimensions is designed after absorbing the existing problems and experience in the current assessment system. Such a design can not only give full play to the 360-degree assessment to meet the requirements of the counselor's work performance but also meet the school's institutional reform; after the counselor's work has been "slim down," it will focus on the development of morality and talent cultivation.

In the performance evaluation of the former counselors in a certain university, there are some shortcomings such as the failure of the evaluation indicators to play a guiding role, the unscientific setting of the weights of the evaluation indicators, the lack of matching between the evaluation results and the actual situation, and the lack of incentives. After the optimization of the new scheme, in view of the above situation, this paper conducts a targeted anonymous questionnaire survey. Figure 8 shows the results of the guiding role of the assessment indicators for counselors.

According to the analysis of the questionnaire, the new scheme has a certain degree of improvement compared with the original scheme in terms of weak index guidance, unscientific setting of assessment index weights, and lack of incentives, and has certain application value.

5. Conclusion

It is proved by experiments that the selection of the initial cluster center of the Kmeans clustering algorithm is optimized, so that better accuracy is finally obtained. Based on the general development goals of a university, the departmental goals of the Student Affairs Office, and the content of the relevant documents of the Ministry of Education, this

paper draws the work goals of a university counselor, submits it to an expert group, and seeks opinions and suggestions from the expert group, and determines the counselor's job goals. The work objectives are personal quality, student development, student service, student management, career development and work performance, which are the first-level indicators of performance appraisal. The 6 goals were decomposed, the opinions of experts and some counselors were solicited, and 34 secondary indicators for the performance evaluation of a college counselor were determined. At the same time, the weights of the first- and second-level indicators are determined by the AHP. This paper analyzes the current situation of the performance appraisal of a college counselor, points out the existing problems and reasons, and further analyzes the necessity, feasibility, and difficulty of the design of the counselor's performance appraisal program. We use the Balanced Scorecard to select the indicators, use the AHP to set the weights of the indicators, and use the behavioral anchoring method to set standards for the evaluation of the indicators, so as to build a scientific counselor with internal logic and accurate measurement. The performance appraisal plan can play the guiding role of the performance appraisal, so that the counselor can focus more on the goal work of Lide Shuren.

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

An Analytical Model of College Students' Mental Health Education Based on the Clustering Algorithm

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This paper proposes an improved *k*-means clustering algorithm to analyze the mental health education of college students. It offers an improved *k*-means clustering algorithm with optimized centroid selection to address the problems of randomly selected class cluster centroids that lead to inconsistent algorithm results and easily fall into local optimal solutions of the traditional *k*-means clustering algorithm. The algorithm determines the neighborhood parameter based on the Euclidean distance between the data object and its nearest neighbor in the data set. It counts the object density based on the neighborhood parameter Eps. In the initial class cluster centroid selection phase, the algorithm randomly selects the first-class cluster centroid, and subsequent class cluster centroids are chosen based on the data object density information and the distance information between the data object and the existing class cluster centroids. The proposed improved *k*-means clustering algorithm and clustering validity metrics are tested using several simulated and real datasets. In this paper, the characteristics and application areas of the improved *k*-means clustering algorithm are sorted out, the self-determination theory related to the enhanced *k*-means clustering algorithm is investigated, and the behavior of the improved *k*-means clustering algorithm in the enhanced *k*-means clustering algorithm system and the octagonal behavior analysis method is also sorted out through the improved *k*-means clustering algorithm mental health management cases. The path of intervention in mental health education is designed through the improved *k*-means clustering algorithm. The intervention points are explained, including motivation discovery, mechanism setting, and component matching of the enhanced *k*-means clustering algorithm.

1. Introduction

To improve the efficiency of mental health education in schools, the organization and analysis of student mental health data are essential. This mental health analysis system uses more common data analysis methods, such as cluster analysis, to effectively analyze students' psychological information problems. The organization and analysis of student mental health data are essential [1]. The mental health analysis system uses the more commonly used data analysis methods, such as cluster analysis, to effectively analyze the problems of students' psychological information. Relying on the psychological management education system platform, combined with data mining technology, through many data analyses, the potential, and data in the implicit information, such implicit details, will provide the corresponding reference basis for major universities, as well as practical solutions. Today, increasingly severe psychological problems have become one of the important research directions of psychology and education. Today's college students are facing unprecedented pressure [2]. How can college counselors or teachers get more information about mental health in a shorter time and better intervene in college students' mental health problems.

How to let college psychological counselors or teachers obtain more mental health data in a short time and better intervene in college students' mental health problems. Therefore, data mining technology, combined with a student psychological database and a psychological management system to analyze students' psychological and behavioral data, has a high research value and has become an important research direction for major

universities [3]. A commonly used clustering algorithm in various fields is based on the partitioning method. It is not easy to obtain valuable information from the fragmented student information by traditional methods, so the fragmented student psychological data are formed into multiple correlation infographics according to the associated attributes [4]. By using cluster analysis in the student psychological education system, we can analyze the potential value of information on student psychology and the correlation between each information factor from the vast amount of student psychometric data in a school database and provide more scientific solutions for student mental health to the general psychological teaching staff. At present, data mining methods have achieved good results in many fields. These research results provide theoretical and technical support for my psychological data from psychoeducational systems.

The clustering algorithm is a commonly used clustering algorithm based on division methods. The data mining cluster analysis research can be divided into two directions: improvement of the clustering algorithm and optimization of the clustering effectiveness index. Among them, the improvement focuses on optimally separating the data objects into the data set given by the optimal number of clusters in the data set. In contrast, the optimization of the clustering effectiveness index mainly focuses on paying attention to the problem of evaluating the quality of the clustering algorithm results after the k-means clustering algorithm is executed. Because it is simple, effective, and suitable for analyzing large data sets, the clustering algorithm uses distance as a similarity measure and divides the samples into different clusters based on the similarity [5]. In the same group, the similarity between samples is ensured to be great, and the dissimilarity between clusters is excellent. Several studies have found that the clustering algorithm has two main problems: determining the number of groups (k-value) and selecting the initial centers since the initial center. The reasonableness of the initial center point selection directly affects the quality of the clustering results of the k-means algorithm, which can be obtained from the research status of cluster analysis. The improvement of cluster center selection mainly includes minimum variance, reverse nearest neighbor search, based on the idea of division, and using dissimilarity matrix to construct Huffman tree and other methods. In the psychological management system using cluster analysis technology and psychological information mining, from the vast amount of student psychological data to mine the association between different psychological assessment data and value information rules, construct a classification model of psychological disorders and use mining technology to verify the application data of the student psychological management system. The problem of finding information, the method, and improvement suggestions of the original student psychological profile construction was proposed [6]. The probability of solving psychological diseases is greatly improved.

2. Related Works

Research in data mining clustering analysis can be divided into two directions: improving clustering algorithms and optimizing clustering validity metrics. In contrast, the optimization of cluster validity metrics focuses on the quality assessment of the clustering algorithm results after executing the k-means clustering algorithm [7]. Daenekindt uses a k-means algorithm to analyze the mental health of a class, complete the classification of students and offer personalized teaching strategies based on the characteristics of each type, which helps to accomplish actual teaching. In the paper, Huisman constructs the feature clustering model of learning style and mental health, uses a k-means algorithm for clustering analysis and completes the design of a student grouping system [8]. Li used k-means to analyze students' campus behaviors on mental health. The results showed that the number of trips to the library, borrowing professional books, resting time, and other habits are closely related to performance [9]. Hutchinson DM used the optimized k-means algorithm in her paper to analyze the characteristics of school behaviors such as academic performance, scholarship, and competition status of school students and came up with typical features of each type of students, which helps teachers to teach students according to their needs and manage them efficiently [10].

The first psychological clinic was established in the 1890s, which opened a new chapter in integrating psychology and education. Mental health education is provided through courses, by classifying students in different psychological states or of other races and genders, and by carrying out more targeted educational activities related to students' lives, such as setting up peer counseling stations and mental health books corners [11]. Mental health education in developed countries has professional mental health teachers and education teams, and mental health teams are trained through a series of professional training programs and standards [12]. Mental health education focuses on students' inner spiritual world and consciousness. The quality of the clustering results is not only the selection of the clustering center but also the determination. Another important indicator to measure the clustering effect is selecting the appropriate number of clusters and dividing the data to be tested reasonably. It involves students' spiritual state, faith orientation, life attitude, physical health, and related environment. Secondly, mental health education should be adjusted to treat and channel mental health problems after they are formed. It should focus more on preventing psychological difficulties and guiding psychological development toward health and positive energy. In addition, improve the teaching staff's moral quality and the professional academic level and use the teachers' natural charisma to influence and cultivate students subconsciously. The advantage of mental health education in overdeveloped countries is that it is strongly supported and promoted by the government with excellent organization and power. In contrast, most developed countries are led by each university, so various forms exist. In conclusion, although there

is a gap between mental health education in developing and developed countries, we are gradually narrowing this gap by learning from our strengths and weaknesses.

The increasing attention to the research on clustering algorithms and the development of k-means clustering algorithm techniques have encouraged scholars from major universities to research clustering algorithms. The use of cluster analysis research methods uses clustering algorithms to achieve functional analysis of students' psychological states by extracting data features in the students' primary information database and obtaining accuracy and stability. The algorithm randomizes the selection of k-class cluster centroids given the number of clusters. To avoid the problem that the algorithm quickly falls into the local optimum due to the random selection of initial class cluster centroids, Huebner proposed the semi-supervised k-means++ clustering algorithm. Yu proposed the DC-k-means algorithm in 2018; based on the Canopy algorithm idea, the initial class clusters of the k-means algorithm were selected based on the distance between the data object and the existing class cluster centroids [13]. Since the twentieth century, many researchers have used the data accumulated in the psychological assessment system of colleges and universities for data mining and did a lot of related research. For example, Wenjuan Qi et al. applied association rule mining to college students' mental health assessment data. Thompson combined the improved k-means clustering algorithm with the established psychological correlation analysis system of college students [14]. This paper uses the enhanced k-means clustering algorithm to mine the correlations between nine dimensions of psychological symptoms. The mining results are analyzed to assist in the intervention and prevention of college students' psychology.

3. Analysis Model Design of College Students' Mental Health Education Based on the Clustering Algorithm

3.1. Clustering Algorithm System Model Construction. The execution of the k-means algorithm requires a given number of clusters k value, which is an essential factor in determining the good or lousy clustering results. The user subjectively selects the k-value based on experience. When clustering, it is necessary to decide the number of clusters because human subjectivity often makes the k-value deviate from the precise number of groups. There are many improved algorithms for determining the number of sets. The idea of most of the enhanced algorithms is that, firstly, the clustering evaluation index function is proposed using the free combination of inter-class distance and intra-class distance. Secondly, the k-values are calculated separately in the range of [2, int n]. The optimal clustering index value is searched, at which time the corresponding k-value is the optimal number of classifications of the data set [15]. The algorithm also tends to fall into local optimal solutions. By choosing high-quality initial centroids, the improved clustering algorithm improves the accuracy of the algorithm and the stability of the clustering results compared with the traditional k-means clustering algorithm. The flow chart of the enhanced k-means algorithm steps is shown in Figure 1. The advantages of the k-means clustering algorithm are (1) the algorithm is fast and simple; (2) it is efficient and scalable for large data sets; (3) the time complexity is nearly linear and suitable for mining large data sets. The time complexity of the k-Means clustering algorithm is O, where n represents the number of objects in the data set, t represents the number of iterations of the algorithm, and k represents the number of clusters.

The clustering effect is not good, and it is easy to fall into the local optimum. The isolated points have a significant influence on them. And the improvement of the clustering center selection is mainly based on minimum variance, reverse nearest neighbor search, division-based idea, and Huffman tree construction using the dissimilarity matrix. We want to select the high-density data points that are far away and have data representative characteristics as the initial centroids, so this paper uses the density-based method of the improved k-means algorithm to select the initial centroids and selects the centroids one by one according to the density of the sample points and the radius of the neighborhood until k initial centroids are chosen. The proposed method of selecting the initial centers is inspired by considering the weights of the attribute indicators, combined with the idea of density to determine the initial centers, and the data set D is the new data set after weight assignment; the relevant definition is as follows: the density of the sample object Known clustering data set to be measured $D = \{x_1, x_2, \ldots x_n\}$, then the density of clustered objects is as follows:

$$\text{density}(x_1) = \{x \le D | \text{dist}(x_1, x) \in R\}. \tag{1}$$

The region within the radius R is x_1 the neighborhood, and x_1 the Euclidean distance between the number of objects more minor than the radius of the area is recorded as x_1 the density of the number of things. The more the number of objects, the greater the thickness. The selection of the neighborhood radius has a significant impact on the density estimation.

$$\text{mean}(D) = \sqrt{n(n+1)} \sum_{i,j=1} (x_i - x_j). \tag{2}$$

Here, mean (D) is the mean value of the distance between all clustering objects, coef R is the radius adjustment coefficient, referring to the experience of other researchers so that coef $R = 0.13$ the clustering effect is relatively good currently. It is the choice of clustering centers and the determination of the number of clusters that affect the clustering results. Choosing the correct number of groups and dividing the data reasonably is another vital index to measure the clustering effect. The k-value is given in advance according to experience, which is subjective, and the clustering results are not very satisfactory. Moreover, the clustering evaluation criterion function only considers the intra-class compactness, which leads to inaccurate classification and too one-sided evaluation [16]. Many scholars believe in addressing the problem of k-value selection and the limitations of the

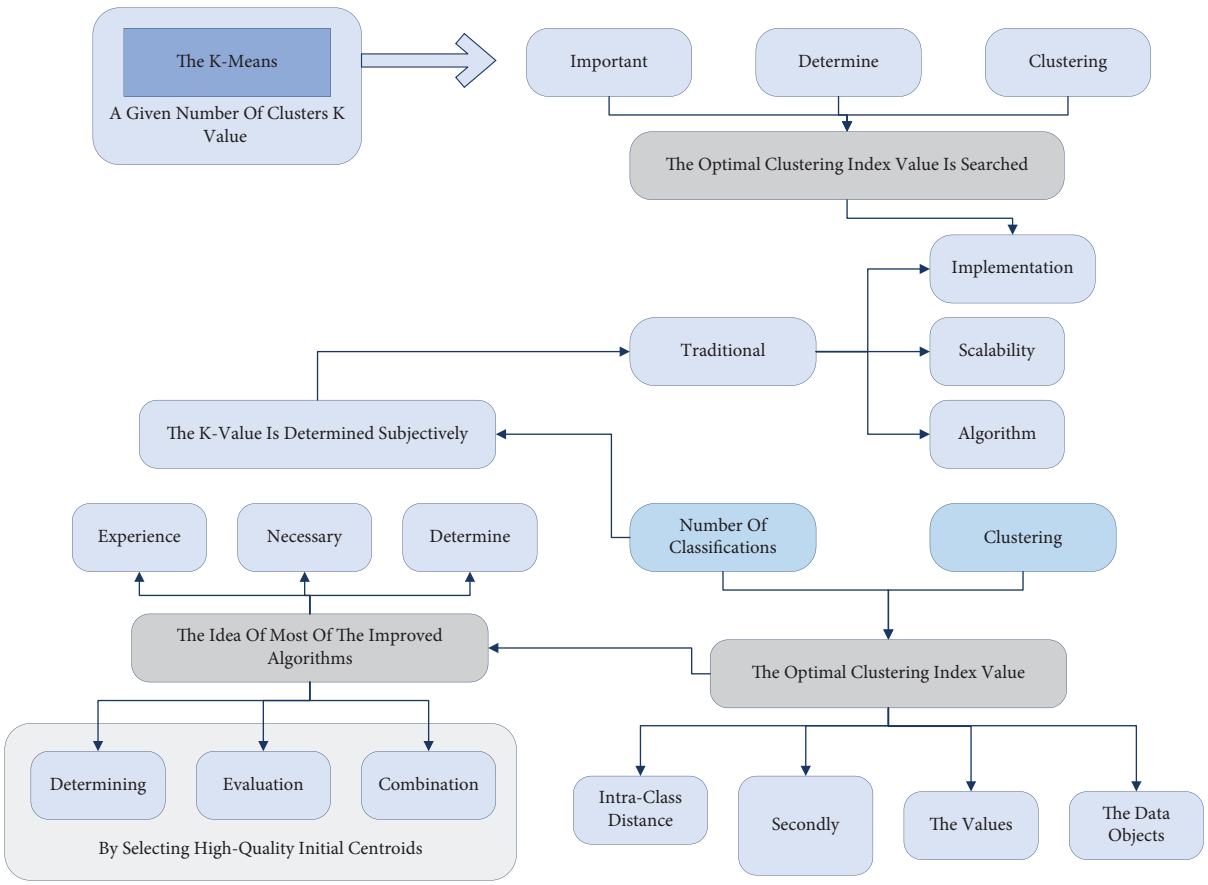

Figure 1: Flow chart of the improved k-means algorithm.

traditional evaluation function. Section, the individual intra-class distance of the sample data is defined as the cluster center of the course. Average: the sum of the intra-class distances of all k classes is the intra-class distance we seek. This definition can reasonably measure the intra-class similarity of the sample. The inter-class distance is the average Euclidean distance between the k centroids, and this value is a good measure of the similarity between the clustering centers (Related concept definition: intra-class distance). Suppose the data set to be np-dimensional data objects, which are into k classes. The average distance from the sample points to the cluster centers in each category is the individual intra-class distance. The average of all intra-class distances of the k classes is defined as the intra-class distance required for clustering.

$$W(k) = \frac{1}{k}\sum_{k}\frac{1}{n}\sum_{n_1} d\left(x_j, c_i\right). \tag{3}$$

Analyzing the clustering criterion function, we can get that the intra-class distance of the sample data in dataset D that can reflect the relationship between the sample objects and the cluster centers and the intra-class structure characteristics; the inter-class length of the sample data can remember the relationship between the clusters and the inter-class structure characteristics. The practical criterion function of clustering can better evaluate the accuracy of the clustering effect, and the value of k is close to the optimal value $W(k) = B(k)$.

$$k_{\text{best}} = \min\{\text{iawr}b(K), K = 1, 2 \ldots K\}. \tag{4}$$

The improved algorithm does not need to determine the value of k in advance $\sqrt{n}$. It lets the algorithm execute the improved k-means algorithm from a $2 \sim in\sqrt{n}$ loop and selects the value of k corresponding to the smallest value of the criterion function at the end of the circle, which is the value of k when the clustering result is optimal. Thus, the improved algorithm can automatically determine the number of clusters according to the minimum value of the criterion function. In the initial centroid selection, the density-based idea is used to optimize the initial clustering centers' passage and improve the initial centers' quality T.

First, the weights of each attribute are calculated according to the entropy method to form a new dataset D. Input: dataset D with n data objects and $\text{coef}R = 0.13$. Output: the optimal clustering number *of* k values. (1) $2 \sim in\sqrt{n}$; (2) calculate the Euclidean distance between the remaining data objects and the initial centers and divide the clusters they belong to based on the minimum Euclidean distance; (3) end of the algorithm. The improved algorithm first uses a density-based selection of initial centers to avoid the instability of random selection and obtain stable clustering results without iterating them many times. Thus, the

number of iterations is reduced compared with the original algorithm. The weights of each attribute index are considered in the clustering analysis, making the clustering more accurate. The improved clustering algorithm first selects the initial center based on density, which avoids the instability of random selection and can obtain stable clustering results without multiple iterations. Hence, the number of iterations is lower than the original algorithm. In the cluster analysis, the weight of each attribute index is considered, which makes the clustering more accurate.

3.2. Analysis of Model Design of College Students' Mental Health Education. The multilevel analysis model of college student's mental health management system is summarized by combining the relevant elements designed by the improved k-means clustering algorithm, as shown in Figure 2. Then the gamification strategy of college students' mental health management under different module contents is proposed according to this. College students come from other places, their growing environment is different, and their psychological state is also very different. After entering university, facing an independent living environment, and dealing with society, study, and interpersonal relationships, college students will have some mental health problems, leading to deviation in the direction of psychological development if not solved in time. Mental health education in colleges and universities can enable students to maintain a positive attitude towards life, actively adjusting their emotions and relieving their psychological pressure at the right time when they encounter difficulties. A healthy psychological state can help college students give better play to their potential and better adapt to the stress arising from independent living and studying, as well as understand the nature of society more clearly, set up life goals, and make themselves high-quality talents urgently needed by organization. The details are as follows: in the mental health data monitoring stage, an encouragement monitoring strategy oriented to achievement reward should be followed; in the mental health level assessment stage, an induction assessment strategy driven by unknown loss should be followed; in the mental health education stage, an inspirational education strategy targeting interest socialization should be followed; in the mental health intervention stage, an intensive intervention strategy with task punishment as a constraint should be followed. The author provides a specific explanation through strategy scientific and feasibility analysis through corresponding design or management cases.

The in-depth development and research results of contemporary college students' mental health education have gradually increased [17]. The clustering algorithm is used to realize the functional analysis of students' psychological states by extracting the data features in the primary student information database and getting an accurate and stable classification. Then, through the subjective analysis of school counselors and student managers, the type achieved by this algorithm proved to be of a specific reference value, which can provide more and better services to the relevant staff for the mental health management of students and provide a new working idea and working mode. Later, we will use the clustering method to implement cognitive health management systems for college students. We can obtain more basic data about students and make data extraction more stable, reliable, efficient, and scalable. Finally, we can reflect the students' psychological status scientifically and reasonably, thus giving more information to appropriate instructors. Analyzing the existing student workflow and organizing related research activities, we summarized and contained the detailed functional requirements based on the basic needs, as shown in Figure 3.

The conversion direction in the framework of the clustering algorithm and closely around the issue of cultural appropriateness. The goal of converted mental health education for college students is to cultivate psychological growth, enhancing students' positive psychological qualities. The theory is used to guide practice, and the goal of the converted theory is psychological growth, so the construction of the working model should also take psychological growth as the goal. Under the multicultural framework, colleges and universities' mental health education model is a "growth model." The characteristics of this model are: everything is based on the premise of cultural appropriateness, paying attention to the needs of students' psychological growth, and integrating multiculturalism as a concept, method, and technology into every aspect of the mental health education model. This "growth model" differs from the previous models regarding teaching concepts, educational subjects, educational medium, and management mechanism. The rule is to achieve the splitting of samples at a given node, which is also used as an attribute selection metric [18]. Relying on the platform of the psychological management education system, the potential and implicit information in the data can be obtained. Effective solution, information gain is the splitting rule of the ID3 algorithm, which favors the selection of attributes with multiple attribute values; however, in many cases, such features with multiple attribute values usually do not have a practical categorical meaning, such as school number. The ID3 algorithm is based on Occam's Razor (using less to do just as well): the smaller the decision tree, the better it is over. The most important feature of the C4.5 algorithm is that it overcomes the disadvantage of ID3 bias towards the number of features and introduces the information gain rate as a classification criterion. The C4.5 algorithm optimizes this by changing the splitting rule to rate again. Let D be a training sample set containing class markers, and the class marker attribute has m different attribute values corresponding to mother classes $c_i = (i = 1, 2, 3, \ldots, m)$ defined as the c_{id} set of pieces of courses c_i in the training sample set d, $|d|$ be the number of samples in d, and $|d_{id}|$ be the d_{id} number of samples in d. The following equation can derive the expected value required to classify the D pieces.

$$\text{Info}(D) = \sum_{i=1} \frac{d_i}{d} \times \log\left(\frac{d_i + 1}{\sqrt{d - 1}}\right). \tag{5}$$

Suppose the attribute is discrete, taking values and the training sample set D is partitioned by point A. In that case,

Figure 2: Multilevel analysis model of college student's mental health education system.

D is divided into v subsets $\{d_1, d_2, d_3, \ldots d_v\}$, where the samples take matters on the attribute A with values a_j. These subsets then correspond to several branches of D. This leads to the following equation:

$$\text{Info}(A) = \frac{\sqrt{d_j/d}}{\text{Info}(d_j)}. \tag{6}$$

The system dynamics simulation study is completed for the total system of mental health education, the design of students' characteristics, the subsystem of school factors, and the relationship between the different input ratio structures of the system and the changing trend of the level of mental health education for college students are compared and analyzed. By using cluster analysis in the students' psychological education system, the potential value information of students' psychology and the correlation between various factors are analyzed from the massive psychological measurement data of students in the school database to provide more psychological teaching workers with more information. Science, student mental health solutions through the subsystem simulation, is the actual rate of the effect of each subfactor on the story and the subsystem is calculated. The substantial impact of each influencing factor is quantitatively analyzed to provide personalized, scientific, and reasonable teaching decisions for student management and improvement.

4. Analysis of Results

4.1. Clustering Algorithm System Model Analysis. The category is based on the extent of similarity between models. Therefore, the clustering results reflect the samples' inherent characteristics. In the psychological management system, cluster analysis technology is used to mine psychological information; the associations and value information rules between different psychological assessment data are mined from the massive psychological data of students. The classification model of mental illness is constructed, and the application data of students' psychological management system in practice is verified by mining technology, the problem of finding information from massive data is solved, and methods and improvement suggestions for the construction of students' psychological files are put forward [20]. The data is prepared in three steps: data selection, information preprocessing, and data transformation.

4.1.1. Data Selection. Data selection is based on a precise task direction and a particular understanding of the data itself. The selection stage requires the integration of the task

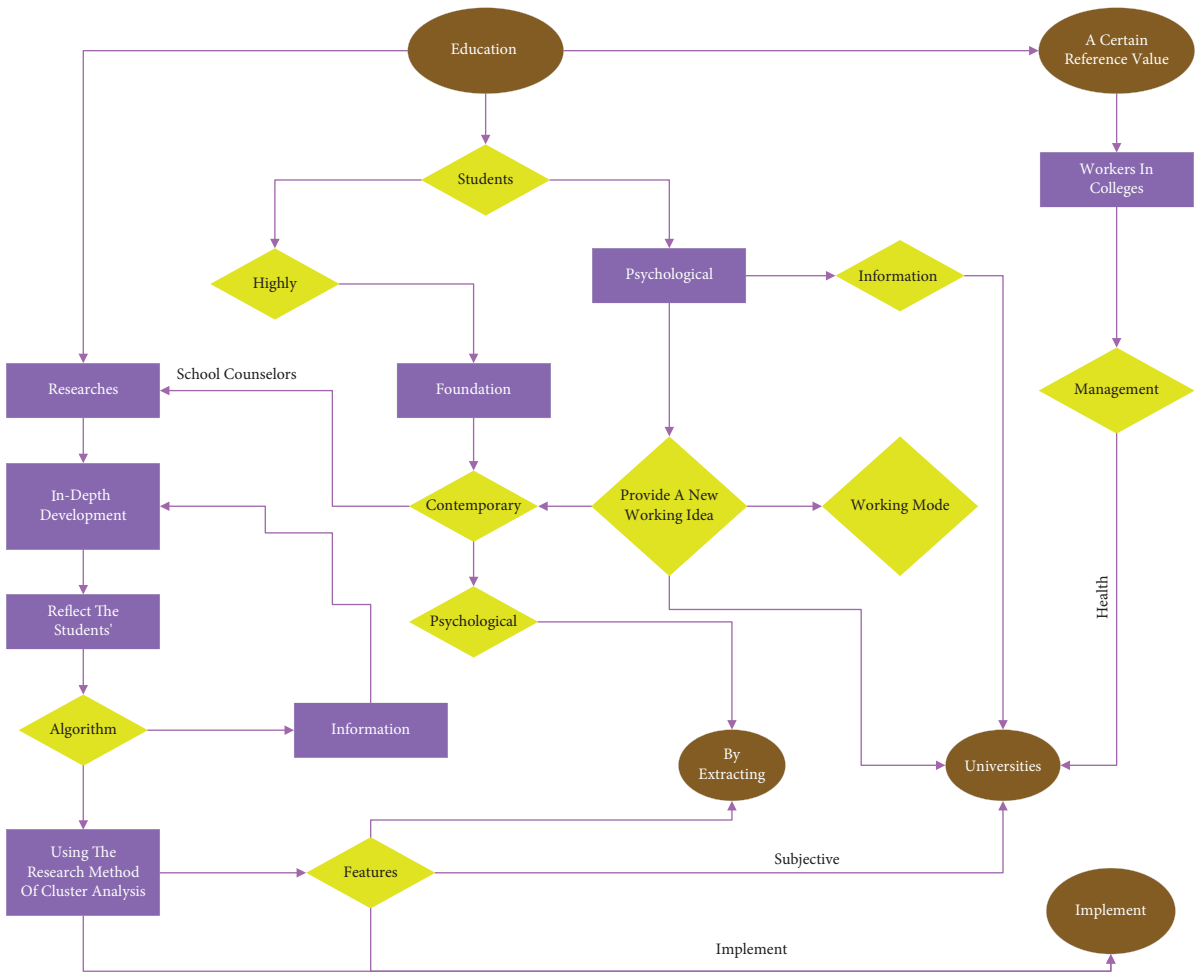

Figure 3: Multi-authority user management structure diagram.

object attributes. The features that are less relevant to the mining task and tend to increase the complexity are eliminated, such as student number and name, to reduce the load brought by the algorithm and to achieve the purpose of improving the system's robustness. Finally, the remaining attribute elements are integrated. The factors that affect the students' psychology are shown in Figure 4.

4.1.2. Data Preprocessing. In the mental health system, for various problems in the data set (such as normality, dichotomy, and repetitiveness), the stability of the system in the following mining analysis is further strengthened by preprocessing student data such as noise reduction, missing values, and de-weighting, which also makes the system reduce the secondary processing time of the data at a later stage, that is, the accuracy of the results is strengthened, and the robustness of the system is also enhanced. The data analysis chart of student psychological education is shown in Figure 5.

4.1.3. Data Conversion. Since numbers and letters tend to be more sensitive than characters in the system algorithm, some of the data are converted after they are obtained, and the conversion is only based on the values required by the user or the system itself to define the system, which has reached the purpose of optimizing the system. In mental health systems, using the size of the ability value indicates the height of its ability in that area.

4.1.4. Establishing Database and Corresponding Charts. In the database management of the mental health system, the relevant data are obtained by noise reduction processing of the valid data and merging the attributes of the data created by the database, as shown in Figure 6.

The data were applied to the generated clustering model. Its accuracy was validated, the status of the remaining data with forced symptoms was known, and the classification prediction of the test set using the initially generated clustering algorithm was 83% when comparing the already existing categories with the predicted classification results; the anticipated classification results of the test dataset using the pruned clusters were compared with the known types with an accuracy of 84.6%. The accuracy of the clustering algorithm model without pruning was lower than that of the pruned model. Therefore, the

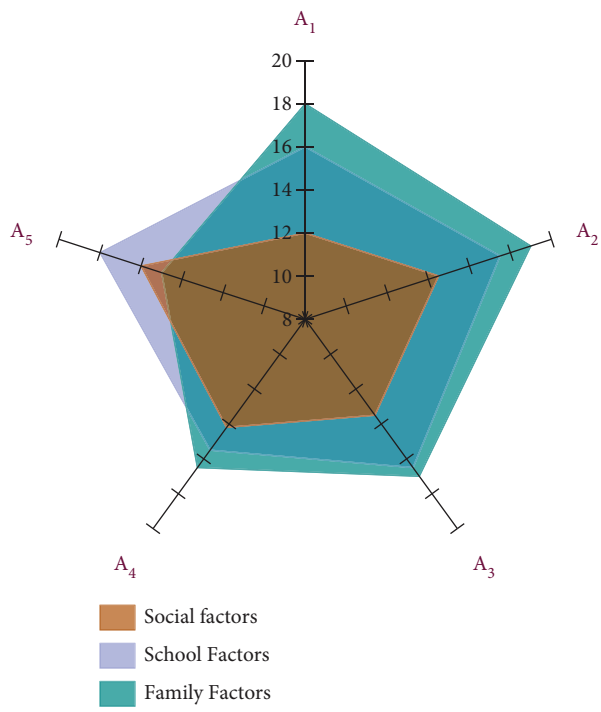

Figure 4: Factors affecting students' psychology.

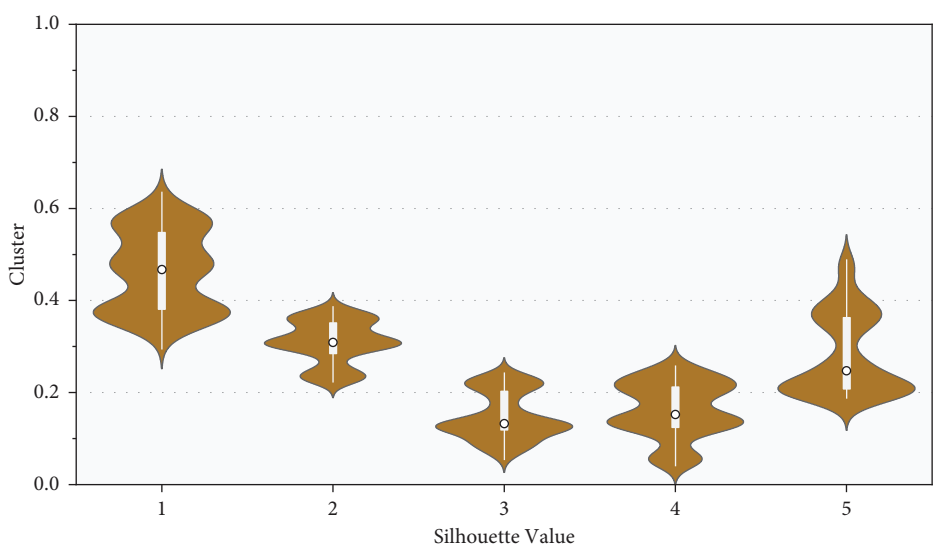

Figure 5: Analysis of student psychoeducational data.

classification mining of psychometric data using the ID3 clustering algorithm to construct a decision tree and pruning based on the PEP algorithm can be helpful for psychological prevention and intervention. The PEP algorithm is proposed in the C4.5 decision tree algorithm, where a subtree (with multiple leaf nodes) is replaced by a leaf node (which seems to be replaced by the root of the subtree after I studied many articles); it does not require a separate test data set than the REP pruning method, it does not require a different test data set.

4.2. Analysis of College Students' Mental Health Education Realized. DeletedIn order to better verify the effectiveness of the improved k-means clustering algorithm, in addition to the two small simulated datasets and nine small real datasets, this paper also conducts comparative experiments on three large real datasets. The dataset used in the experiments is the page-blocks dataset, which is a set of datasets for classifying page modules, the dataset contains a total of 5235 data objects, each data object contains 10 different attribute values, which are recorded as the length, width, area, and

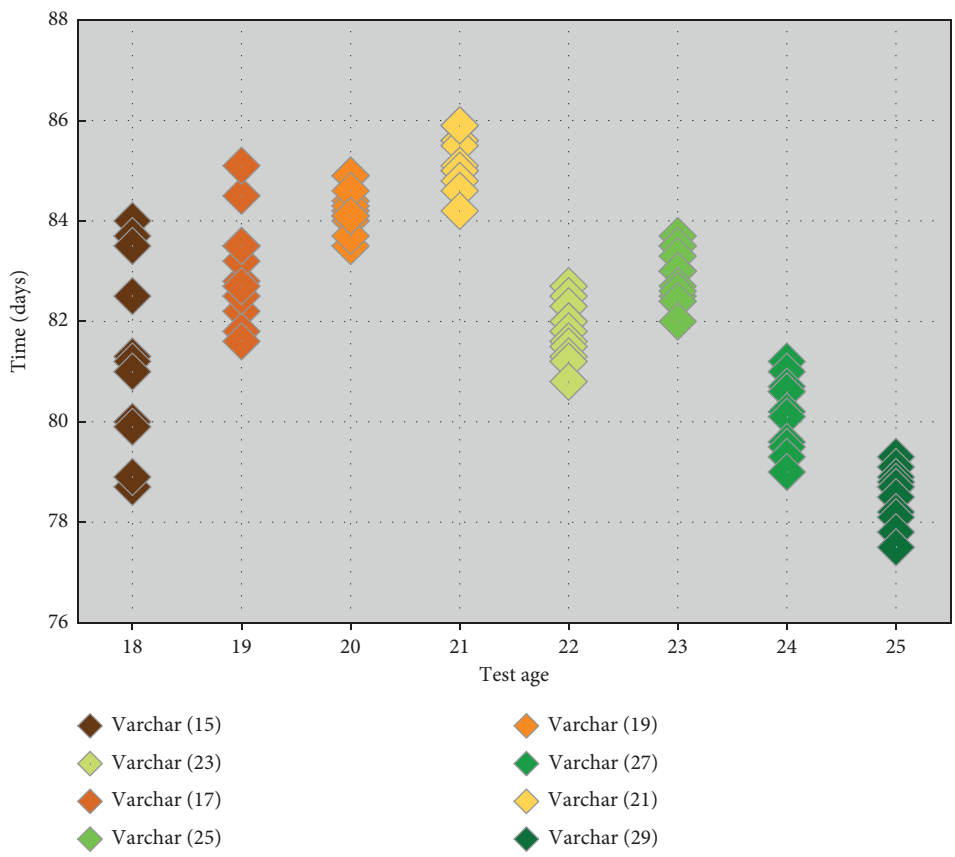

Figure 6: Create the database with related data.

other attribute values of page modules, the dataset is divided into four (KOPT = 4). When performing the clustering validity evaluation task on the page-blocks dataset, only the CSI index can obtain the best number of cluster divisions. In contrast, all cluster validity indexes cannot get the best cluster divisions, and the equation is as follows:

$$d(x_1, x_2) = \sqrt{\sum_{i=1} (x_1 - x_j)^2}. \tag{7}$$

In this paper, experiments were conducted to compare 14 different types of datasets, including petite simulated, small actual, and significant honest, with five standard cluster validity indicators in 3 different types of datasets. The experimental results are shown in Figure 7. The experimental results show that the newly proposed CSI indicator can get the best clustering number of 22 data sets of 3 different types; among the other five clustering validity indicators in the comparison experiment, the COP indicator and the I indicator can get the best clustering number of 20 data sets, DBI indicator can get the best clustering number of 21 data sets, DI indicator can get the best clustering number of 3 data sets, and CSP indicator can get the best clustering number of 3 data sets. The CSP indicator can obtain the best clusters for 3 of 11 small data sets.

The density-based method is first used in the clustering analysis to select the initial centers, followed by combining the average intra-class and inter-class distances to form the criterion function. The optimal k-value is chosen according to the minimum value of the criterion function. Finally, the Iris, Wine, and Glass datasets in the UCI database were used to verify the improved algorithm's effectiveness. The results showed that the improved algorithm in this paper improved the accuracy and stability of the clustering effect. User studies, desktop studies, and fieldwork were conducted for college student mental health management. Quantitative research and qualitative research were undertaken mainly for college students. Interview research was undertaken primarily for the parents of college students. Desktop research, field study, and interview research were conducted primarily in the institutions and their personnel related to college mental health management; interview research was undertaken primarily by psychology experts. Through the above analysis, we analyzed the characteristics of college students' thoughts and behaviors on mental health management, established a typical user model of college students' group, sorted out the needs related to college students' mental health, summarized and analyzed the ways of college students' mental health management and the critical and challenging points of college students' mental health management at the present stage and thus analyzed the feasibility and opportunity points of the clustering algorithm design to intervene. To provide a reference for later research on the mental health management service model of college students

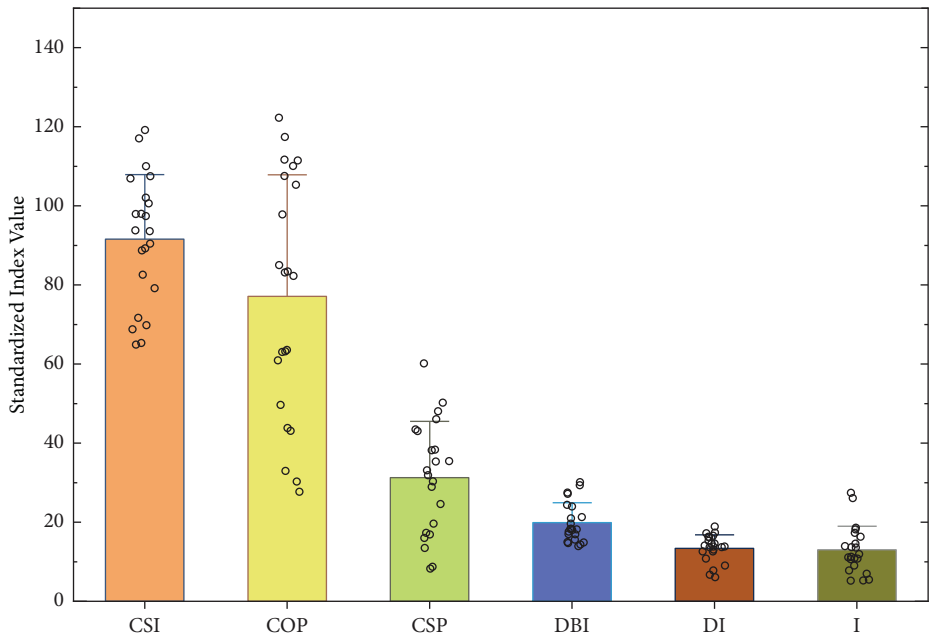

Figure 7: Experimental results of the clustering validity index.

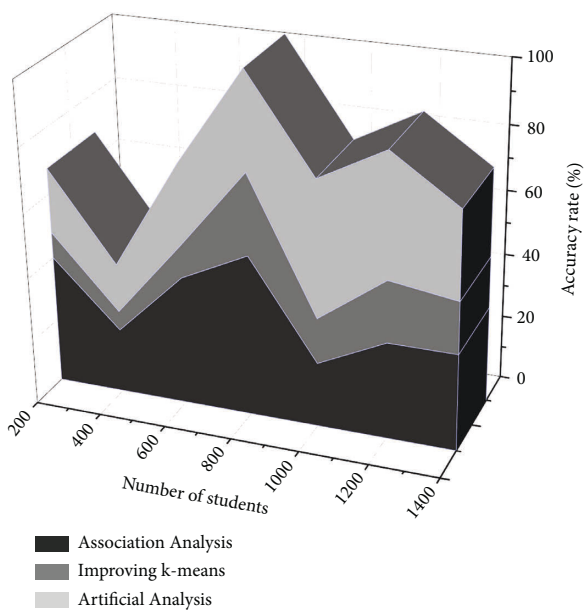

Figure 8: Comparison of students' psychological assessment results.

comparison chart of students' psychological assessment results is shown in Figure 8.

The unified management of college students, mental health status, weekend reviews, classes, class teachers, and other information is realized. The organic integration of these functions makes it sufficient to meet the needs of most colleges and universities for student management. The information on the top of the system puts students' mental health issues in a more critical position for colleges and universities to pay attention to the mental health issues of college students.

5. Conclusion

With the advent of the digital era, the Internet is gradually changing people's lifestyles, providing new opportunities and challenges for mental health education. Good mental health is essential for the overall development of college students. The author hopes to understand further the study of the problems of college student's mental health, find countermeasures and ways to improve college student's mental health, bring specific theoretical significance and practical value to the current academic and empirical research on college student's mental health and raise the wide attention of society to college students' mental health education. This study aims to innovate the college student's mental health model through the theory and method related to the improved k-means clustering algorithm. This study analyzes the intervention points of the enhanced k-means clustering algorithm design for mental health education through the preliminary theoretical research related to the theory of mental health education and the creation of the clustering algorithm; through qualitative research and quantitative research on college students' groups, as well as the research on school mental health centers, students' parents and psychology experts, it summarizes the characteristics of college students' groups, analyzes the health education of college student's needs, sorted out the ways of mental health education for college students and transformed their needs by the clustering algorithm. Finally, the content of the clustering algorithm design system for college students' mental health education is improved and realized. [19].

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.

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Research Article

Evaluation Method of Product Shape Features based on Multidimension Spatial Data Mining

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Analysis of product shape design has attracted more and more attention of researchers because it can make products better meet perceptual needs. Based on the theory of spatial data mining, this study proposes an evaluation method of a product shape design scheme. The method proposed in this study not only obtains the shape design of the overall and local features of the product, which solves the problem of the insufficient utilization of spatial data by the analysis method. During the simulation process, the model obtains the product shape design and appeal from the online evaluation spatial data, which can integrate the product perceptual knowledge in the spatial data, which greatly reduces the manual operation steps and the required time for the degree of data utilization. The experimental results show that after the obtained data are filtered to extract the feature words, the weight of the feature words is calculated by the TF-IDF method, the number of neighbors is increased from 1 to 30, the interval is 5, and the vectorized representation of the spatial data is constructed. The similarity between the calculation sentences of the data mining method is 89.7%, which effectively improves the support function and design efficiency of spatial data mining for product design.

1. Introduction

In recent years, innovative design has been raised to an unprecedented height, and enterprises have invested funds in product innovation research, and the innovative design of product visual interface is an indispensable part of it [1]. However, the style inheritance and creativity of brand products are often a pair of contradictions. How to carry out the creative design in an orderly manner and critically inherit the original design style in the creative design of products has become an industrial design at home and abroad today, which is to be solved in academia and even in corporate practice [2–4]. This study discusses the definition and mathematical expression method of point, line, surface, and body elements in the visual interface of product modeling. For a specific product, the point, line, and surface elements in its shape design are often numerous and complicated [5]. How to grasp the visual interface in the main feature elements in the design, and accurately extract them in the visual interface graphics [6], has become one of the main technical problems of the inheritance theoretical analysis and calculation of the shape design [7].

In terms of product design research, Pan and Zhang [8] took sustainable product design as the research object, built the relationship between product clusters and environmental impact through mining and analysis by building a product tree and environmental impact database [9], and established a product life cycle. A periodic automatic evaluation system is set to assist in sustainable product design [10]. Ait Issad et al. [11] regard complex products as big data systems, use a decision tree algorithm to reduce the dimension of high-dimensional design problems, and significantly reduce the design space, and the anti-collision design problem of passenger products was verified [12]. Mezaal and Pradhan [13] used the method of data mining to study the Universal Design Criterion and summarized the relationship between the design process into raw materials, elements, and signals. The required functional basis is

summarized, and the function realization flow chart is constructed based on this, and the Apriori algorithm is used to generate association rules to optimize the selection of functions, shapes, and parameters [14]. Dou et al. [15] took digital cameras as the research object, and digital design features and function configuration are classified, used the decision tree algorithm and Apriori algorithm to obtain the relationship between features and configuration parameters and consumer image and demand, and used this to provide support and assistance for product design and sales. Alsrehin et al. [16] derived a dimensionless shape design loss function for the shape design features of small and large shapes and established an improved multivariate shape design loss function by using the principal component analysis method, which extended Artiles, and fully consider the correlation between the various shape design features, making it more realistic [17–19]. Although this method considers the difference in the influence of each principal component variable on the results [20] and retains the original shape design fluctuation information, it does not consider the influence of the shape design feature variance [21].

Taking the feature elements of product modeling visual interface as the starting point, this study studies the analysis and evaluation method of product visual interface and its software development method. The study analyzes the definition method of each feature of point, line, surface, and body of the product visual interface, and establishes the mathematical expression method of each feature element. The semantic difference method is used for the evaluation of perceived usability, which converts people's subjective evaluation of product styling into quantitative evaluation values, and the category set is obtained through cluster analysis. Then, we select the dimension of the shape design parameters through the maximum information coefficient, build a Kansei engineering expert system based on the spatial data mining processing and classification algorithm, extract the multi-level shape design parameters for the spatial data of the product's perceptual demand, and input it into the Kansei engineering expert system to output and design characteristic parameters, so as to describe and generate a new design scheme, and realize the product image design method driven by the big data of shape design.

2. Structural Design Method of Spatial Data Mining

2.1. Visualization of Spatial Data. In the three-dimensional spatial data visualization form, the scale of one dimension is much smaller than that of the other two dimensions, and the form will show the tendency of appearance [22–24]. A surface can be thought of as a line moving trajectories or it can be composed of an infinite number of lines. The shape of the surface is extensible and has the overall visual characteristics of the sense of expansion.

$$\begin{aligned}&\{\text{persit}(i+1), \text{persit}(i+2), \text{persit}(i+3), \ldots, \text{persit}(i+n-1)\},\\&\{(\text{setx}(1), \text{sety}(1)), (s\text{etx}(2), \text{sety}(2)), (s\text{etx}(3), \text{sety}(3)), \ldots, (\text{setx}(i-1), \text{sety}(i-1))\}.\end{aligned} \tag{1}$$

Because the surface elements in the product modeling visual interface all have outlines that are visually perceived. Therefore, contour lines can be used to represent surface elements. The coordinate set of each end point on the contour line of the polygon face element will be able to uniquely determine the face element, that is, the face element can be represented by the coordinate set of these points.

$$\begin{aligned}&\begin{cases}\text{foret}((x,y)|x+y)<1,\\ \text{foret}((x,y)|\max(x)-\max(y)<x-y)<1,\end{cases}\\&\sqrt{\max(x))-\max(y)}+\sqrt{\min(y)-\max(x)}\\&+\sqrt{\max(x)+\max(y)}=1-x-y.\end{aligned} \tag{2}$$

The product data information of spatial data visualization mainly includes the product's rating of the watched video or purchased product, the time of browsing the page, the number of times the page was clicked, and the length of the product watching the video, which are all important recommended raw data. The recommendation system of collaborative filtering uses statistical methods to search for similar products of the target product and also uses the scores of similar products to a certain item to predict the score of the target product for the item, and finally selects the top N neighbor products with high similarity. The indicators are clustered after statistical analysis of the corresponding data. The obtained category set provides data support for the construction of the product modeling usability evaluation model.

2.2. Components of the Visual Interface. Starting from the generalized tolerance of the visual interface, the interaction relationship of the product shape design features at all levels is analyzed, and the product tolerance system model is established; using the historical data in the product manufacturing inspection process, the product shape design feature deviation based on the support vector nonlinear regression machine is established. Based on the model of the deviation relationship between the product shape design feature and the component shape design feature deviation, a Support Vector Nonlinear Regression (SVNR) model was constructed.

$$\begin{aligned}&\text{fin}(t+y(t))\mathrm{d}t\mathrm{d}y-\text{fin}(t-x(t))\mathrm{d}t\mathrm{d}x=\begin{bmatrix}t\\y\end{bmatrix}-\begin{bmatrix}x\\t\end{bmatrix},\\&\text{seppher}(x,y)=\begin{cases}\text{sqrt}(\text{fin}(x)-\text{fin}(y)),\\ \sum\text{sqrt}(\text{fin}(x)-\text{fin}(y)),\end{cases}\\&\begin{bmatrix}1-\cos\ j(x)\sinh(x)\\1-\sin\ j(x)\cosh(x)\end{bmatrix}=\begin{bmatrix}\max(x,j)\\\min(x,j)\end{bmatrix}.\end{aligned} \tag{3}$$

Table 1: Description of feature extraction of spatial interface.

Description node	Feature point	Extraction type	Interface ratio
Performance	83.22	Data usability	0.55
Reviewed product	28.02	Data sample	0.94
Each sample	40.18	The purchase group	0.81
Number of errors	86.30	The experiment	0.04
Evaluation index	59.34	Extract product	0.60
Experiment invite	27.40	Corresponding data	0.23
Product evaluation	54.54	Space data	0.16

If the visual interface components are used to distinguish, qualitative inference-style perceptual engineering and forward-quantitative inference-style perceptual engineering are both based on the perceptual needs of designers or consumers to infer a design that conforms to the perceptual design. Inverse quantitative inferential sensibility engineering is to infer the sensibility of a design case.

2.3. Spatial Interface Feature Extraction. If conditions permit, a more scientific space interface feature tracking experiment can also be used to extract product feature elements. The test subject browses the whole pictures of several products by wearing the instrument, and the instrument will automatically record the subject's gaze track distribution and gaze dwell time, and obtain the attractive index of each characteristic part of the product, which is affected by the level of the index. The main features of the product styling style are extracted and finally the characteristics of the product styling that are most concerned by the subjects are statistically analyzed. These highly concerned modeling features are the extracted spatial interface features.

$$\text{section}(\text{cert}(i,j),i,j) = \begin{cases} \dfrac{\sqrt{\max(y,j) - \min(y,j)}}{y-j}, \\ \\ \dfrac{\sqrt{\max(x,j) - \min(x,j)}}{x-j}, \end{cases} \tag{4}$$

$$\begin{cases} \displaystyle\int \sqrt{\text{fertin}(i,x) - 1}\,\mathrm{d}x = x - i\mathrm{d}x, \\ \\ \displaystyle\int \sqrt{\text{fertin}(i,x) + \text{fertin}(i,y) - 1}\,\mathrm{d}x\mathrm{d}y = x - 1. \end{cases}$$

In view of changing product performance requirements or adding new product requirements, based on the product tolerance system optimization design method and data mining, a product tolerance system redesign optimization model oriented to product performance requirements is established. The TF-IDF algorithm will reduce the weight value of high-frequency spatial data appearing in multiple documents as keywords, preventing the extraction of commonly used words with low importance, thus ensuring the extraction effect of the algorithm.

$$\begin{cases} \left\{\dfrac{1}{\text{vert}(i)} - \dfrac{1}{\text{vert}(j)}\right\} = 1 - ij, \\ \\ \left\{\dfrac{\text{vert}(i,j)}{\text{vert}(i)\text{vert}(j)}\right\} = 1 - \dfrac{i}{1-j}, \end{cases}$$
$$\begin{bmatrix} \left(\text{bert}(i-j) - \text{bert}\left(\dfrac{1}{i+1/j}\right)\right) \\ \\ \text{bert}(i+j) + \text{bert}\left(\dfrac{1/i}{1/j}\right) \end{bmatrix} = \text{siergod}(i,j). \tag{5}$$

However, in the product evaluation space data, because there is a certain degree of similarity between the reviewed products and the purchase groups, there are many similar cases to evaluate spatial data, and the TF-IDF algorithm tends to give lower weights to these spatial data, so that when using the TF-IDF algorithm, the weight value of the evaluation spatial data in Table 1 will be underestimated, which may easily lead to the inability to extract product keywords, to reflect real product experience.

The performance usability, that is, the completion time of the spatial interface feature task and the number of errors, is used as the evaluation index for testing, like task completion time, that is, the time taken from the start of the test product operation to the completion of the task. The evaluation indicators of usability are divided into subjective dimensions and there are two categories of objective dimensions, which correspond to perceived usability and performance usability. The operation is recorded as one error, and the experiment is repeated 4 times for each sample and each person to obtain the corresponding data.

2.4. Interactive Mode of Product Shape Design. In order to obtain the set of interactive perception usability categories of product shape design, the average value of the shape design evaluation obtained above is processed, and the 5-level category is obtained through isometric mining analysis. The higher the level, the more obvious the shape design. According to the above, the collected 50 product shape design samples were randomly sorted, the first 45 samples were used as training samples to construct the evaluation model, and the last 5 samples were used as verification samples. Taking aesthetics as an example, the evaluation

results of aesthetics of 45 samples were obtained through SD questionnaire analysis.

$$\begin{gathered}\operatorname{cerberi}\{\operatorname{cer}(i, j), \operatorname{beri}(i, j) \mid \operatorname{convert}(i) - \operatorname{convert}(j), i, j < 1\}, \\ \begin{bmatrix} \operatorname{ebersiler}(i) + \operatorname{ebersiler}(j) \\ \operatorname{ebersiler}(i) - \operatorname{ebersiler}(j) \end{bmatrix} \\ \prod_{i,j} |\operatorname{sert}(\operatorname{diserct}(i) - \operatorname{diserct}(j) - 1)| - \prod |\operatorname{sert}(i - j - 1)| = si - sj.\end{gathered} \tag{6}$$

In the visual interface, the point is a relatively small visual element, which plays the role of marking the position in the space, can attract people's attention, and has the characteristics of concentration and cohesion. Therefore, a point element can be understood as a point in geometry, that is, it does not have a size, but only represents a position. To compare the difference of point elements on the visual interface of similar products of a certain brand, it is to calculate the difference in the position center of the point. Although the part has a different shape on the right half, the shape of the left half has not changed. Therefore, we use the left half as the base to establish the coordinate system.

$$\begin{gathered}\sum_{i,j} \operatorname{omigaer}(i + j) - \sum_{i,j} \sqrt{\operatorname{omigaer}(i + j)} - \sum_{i,j} \sqrt[3]{\operatorname{omigaer}(i + j)} = 1 - \sqrt{(i + j)} \\ \forall \operatorname{terst}(\operatorname{omigaer}(i), i) - \operatorname{omigaer}(i) < i, \exists (1 - \operatorname{dert}(\operatorname{omigaer}(i) - i)) - i < \sqrt{\operatorname{omigaer}(i) - 1}.\end{gathered} \tag{7}$$

First, the quantification of product shape is realized through the semantic description of product shape factors and the evaluation of product shape; the data of the survey statistics are tested for the level of agreement of the target attribute level to complete the data processing. The classification list of evaluation items of the method determines the constraints of the product from 60 independent aspects and summarizes 60 evaluation items, which basically cover all the basic evaluation items. The category set is obtained through actual testing and cluster analysis. The obtained category set provides data support for the construction of the product modeling usability evaluation model.

3. Construction of Evaluation Model for Product Shape Design Scheme

3.1. Spatial Data Mining Hierarchy. Spatial data mining mainly analyzes the correlation between items and then aggregates the item lists with the highest correlation together to form an item-based item neighbor group. Then, we use the list of products in the shopping basket to select the most similar products, finally form a recommended list, and send the recommended results to the products. Finding the nearest neighbor is the core part of the recommender system, and it plays a decisive role in the shape design of the recommender system, which greatly improves the effectiveness of the recommendation results and increases the loyalty of the product. The more consistent the rules of the algorithm are with the actual rules, the more accurate the prediction of the data in Figure 1 will be, and the better the recommendation effect will be.

(1) Divide the data into pieces and start the program on the cloud. (2) According to the deployment method of MapReduce and the master/slaves method, the master is responsible for task scheduling and detecting the working status of the workers. (3) In the map stage, the worker reads the data in the split, inputs it to the Map function in the form of a key-value pair, and caches the output key-value pair in memory. (4) The cached key-value pair will be periodically written to the disk, the key-value pairs of the same keyID will be put together, and the storage address of the key-value pair will be passed to the master record, while performing Reduce function case. (5) The reduce phase is to take the key-value pairs output by the Map function in the previous process as input to the Reduce function, and output a new result, that is, the result of mining.

For the big data of product review text, text preprocessing is realized by text deduplication, empty text deletion, etc., word segmentation, part-of-speech tagging, keyword extraction, and other means to extract the perceptual image vocabulary for the product. The obtained category set provides the data support in Table 2 for the construction of the product modeling usability evaluation model.

Taking a spatial data mining time as the starting node, traverse the product design points of storage and processing within the range that the system can afford. Under extremely ideal conditions, such as when the software and hardware conditions allow and the time limit is long enough, this

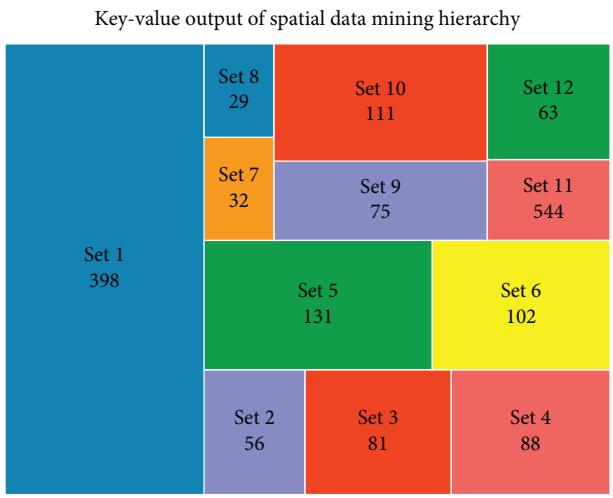

Figure 1: Hierarchical key-value output of spatial data mining.

Table 2: Collection evaluation of product styling categories.

Collection evaluation code	Product styling description
Import numpy as np	Taking a spatial $i + j$
From matplotlib import pyplot as plt	Call back to the main program
Fig = plt.figure()	Data mining time $\lvert$sert$(i - j - 1)$
Ax = plt.axes(projection = "3d")	The system can afford
$X = y$ = np.arrange(start = −4, stop = 4, step = 0.1)	Of the diserct(i) reduce phase
X, y = np.meshgrid(x, y)	As the starting node convert(i)
Separate = (distance, distance)	Within the range that d$w(y)$
Plt.figure(explode = separate)	Completing a mapreduce process
Plt.pie(sizes, autopct = "%1.1f%%")	Of storage and processing
Plt.title("separation distance = 0.8")	The master will $1 - x$
Plt.show()	The product design points

strategy can capture a large-scale product design point set, which is almost consistent with the real network data.

3.2. Product Shape Image Design. In this stage, a semantic difference experiment was conducted by combining 4 target product shape image design words and 50 representative product shape design samples, and a fifth-order SD questionnaire was made for statistical analysis. 20 students majoring in industrial design were invited to participate in the survey. Four target profile designs of 50 samples were evaluated. During the investigation, each subject scored and evaluated each sample based on the shape design space data. If the line element is a curve, the comparison is relatively difficult. Using an approximation method of approximating a curve with an infinite number of small straight line segments to represent the curve, the calculation problem of the curve can be transformed into the calculation problem of the polyline. Perceptual appeal text big data, overall image extraction, partial image extraction, image parameterization, and other methods are to realize the parametric expression of perceptual image appeal. Obviously, the denser the selected points, the closer the polyline formed by the point set is to the shape of the curve.

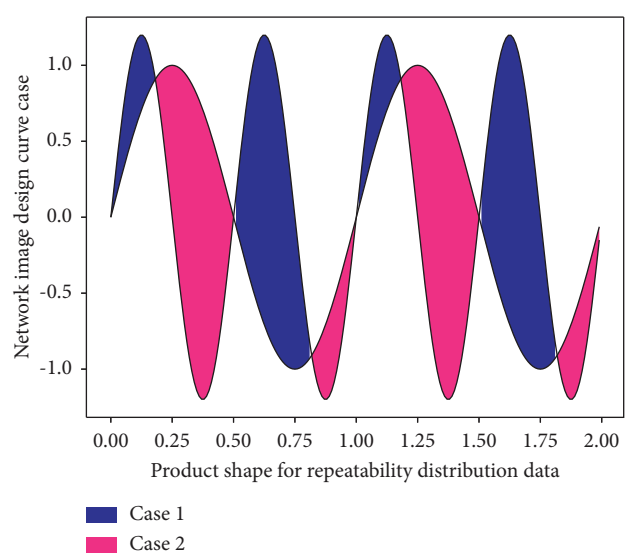

Figure 2: Product shape image design curve distribution.

URL sets can be created using the method shown in Figure 2, which is to link from one product design point to other product design points through hyperlinks. However,

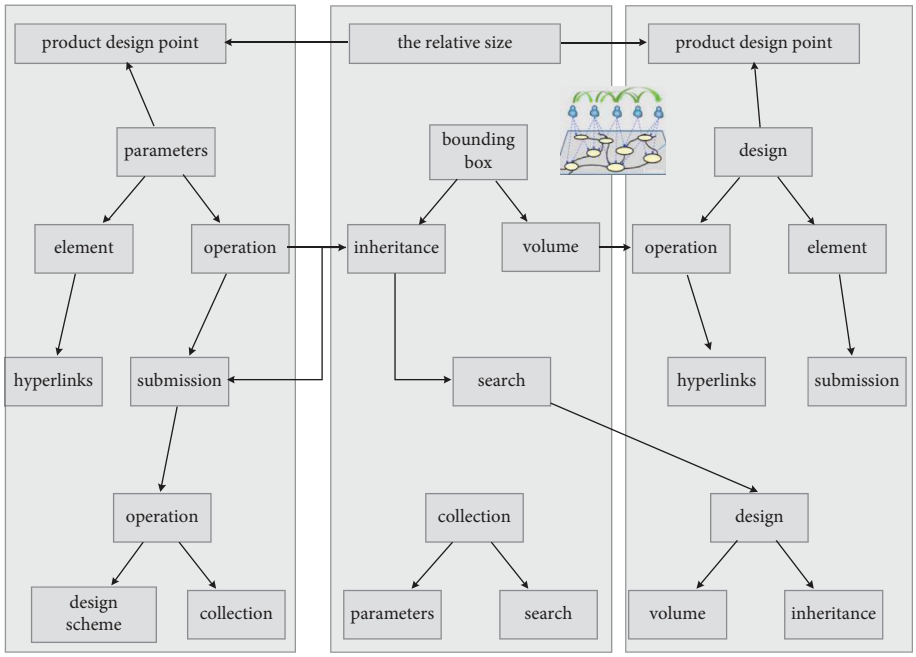

Figure 3: Product design point link topology.

in actual operation, it is not realistic to crawl all the product design points, so in the case that the automatic crawling cannot be crawled, it can be completed in the form of submission by the webmaster, that is, the webmaster submits and requests to the search engine which included and added to the URL collection.

The inheritance of the volume element can be calculated by comparing the minimum bounding box of each partition in Figure 3. The main idea of the calculation is to use the bounding box parameters of the shape to analyze and calculate the minimum bounding box volume of the shape and the inheritance of the shape. The inheritance of the shape is not only the inheritance of the saturation of the shape and the relative size but also the inheritance of the topological relationship between the parts.

3.3. Design Scheme Evaluation Threshold Calculation. The essence of the design scheme evaluation threshold algorithm is to build the relationship between user preference and product semantics, so as to further filter the product semantics, and finally get the semantic word set describing the object. This process is to match users' preferences based on product semantics, which is an evaluation problem. Since user preference is a continuous variable, it can be solved by regression tree technology. To analyze the user's emotional cognitive process, focusing on the physiological and emotional aspects of perceptual image cognition; the method mainly analyzes the user's description text of the product or invites the user to take a specific psychological test to obtain the user's tendency in the dimension of the perceptual image represented by vocabulary.

Because the directly crawled product design point data is very primitive, it contains all the information of the product design point, including some useless information, such as page name or link title and project name, etc., as well as some special characters that cannot be displayed, etc. Whether the subsequent operations will take up the analysis time or not has practical significance, it is filtered out first in this step. In order to solve this problem, the filtering algorithm in Figure 4 is designed based on the MapReduce framework, which can significantly speed up the process.

Subsequently, the relationship between product design elements that describe product characteristics is analyzed. The minimum word frequency is set to 20 to filter out the influence of some low-frequency spatial data and typos, and a total of 1065 product design elements and their correlation matrix are obtained. Then, the relationship between spatial data is analyzed using the maximum spanning tree algorithm, and 146 spanning trees are obtained. The product design elements in each tree are regarded as the same group, and the spatial data in some groups are shown in the figure.

The determination of the inheritance threshold should firstly collect adjectives of product styling features through various media and establish a corresponding regular morphological semantic set according to the results of the questionnaire; then we select the object semantic words describing each styling feature from the regular morphological semantic set according to the preference algorithm, select the optimal semantic word for each feature object by means of a fuzzy algorithm. Based on the optimal semantic words of each corresponding feature element in the product modeling visual interface of the two generations, a ten-order scale will be scored, and the inheritance value of each feature element will be obtained through comparison and calculation.

The RandomForestClassifier function of the sklearn package in python is also used to construct the mapping

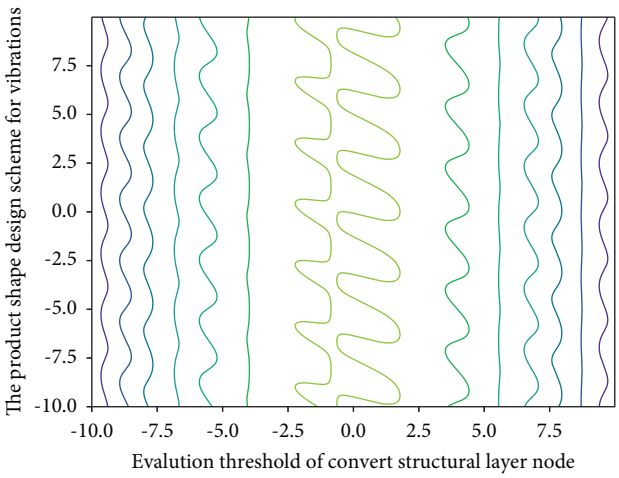

Figure 4: Analysis of design scheme evaluation threshold.

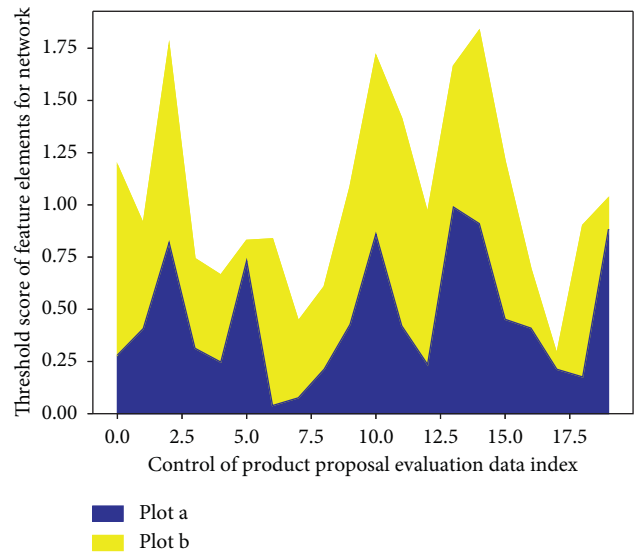

Figure 5: Threshold score of feature elements for scheme evaluation.

relationship, and the out-of-bag data is used for reliability verification. After verification, the classification accuracy of the local features of each product is shown in Figure 5. That is, selecting the corresponding method to extract specific knowledge according to the text mining target; pattern evaluation is to evaluate the effect of pattern mining, if it meets the requirements, save the result of the pattern mining, if it does not meet the requirements, return to the above improvement in a certain area.

The ratio is greater than 0.6, the product header design features many categories, and the corresponding mapping relationship has a low correct rate, which is in line with the expected results, and the mapping relationship is generally effective. Both the Dl and DZ functions are used for 2D graph comparison, but are calculated in different ways. The DZ function is to calculate the distance between any two points on the outline of the figure, and the Dl function is to calculate the distance from a fixed point on the outline of the figure to all other points. For more complex graphics, it takes too long to calculate with the DZ function, and the research in this study only needs to quantify the shape initially, so the Dl function is selected for calculation.

4. Application and Analysis of the Evaluation Model of Product Shape Design Scheme

4.1. Preliminary Convolution Processing of Spatial Data. The data convolution processing system will directly integrate the JDK. You can use the java-version command to check whether the system has been installed. If not, download the JDK compressed package from the Oracle official website to decompress it, and then configure the following environment, add the following statement in/etc/profile, the decompression path in this article is/opt/java, and the configuration environment needs to be modified according to the actual situation. The file path is/etc/hosts, and input the IP address and hostname of each host respectively.

It may group the comment space data of different products, and then perform word segmentation and part-of-speech tagging for the comment space data of each product sample in Figure 6, only keep the adjectives in the comments, and analyze the statistical characteristics of each adjective through the TextRank algorithm to obtain the space in data importance parameters, and then arrange the importance parameters from high to low, extract and quantify N adjectives with strong importance according to the number threshold, and the extracted shape design is expressed as the following. However, in the product evaluation text, because there is a certain degree of similarity between the products being reviewed, and the buying groups also have a certain similarity, there are many identical evaluation words in the review texts of different products, the algorithm tends to give a lower weight to these words. Nouns are used as candidate words for the same feature, and finally, irrelevant spatial data are manually deleted, so as to obtain different expressions of the same product feature.

Then, the relationship between the obtained spatial data is simplified by the maximum spanning tree algorithm to obtain the product design element grouping in Figure 7. Due to the low frequency of occurrence of some spatial data, word segmentation errors or typos in the spatial data will interfere with the construction of the product feature tree. Therefore, when calculating the relationship between words, a word frequency threshold is set, and only a space higher than the threshold is used. The data were included in the maximum spanning tree analysis. In addition, the spatial data mining process selects samples from the original data set through the Bootstrap method to train each decision tree. The training samples of each decision tree are independent of each other and have strong generalization ability. When Bootstrap selects the training data of each decision tree, about 36.8% of the data will be reserved as out-of-bag data to verify the validity of the spatial data mining processing classification model.

Spatial data mining constructs word vectors that incorporate semantic relationships as the basis for analyzing

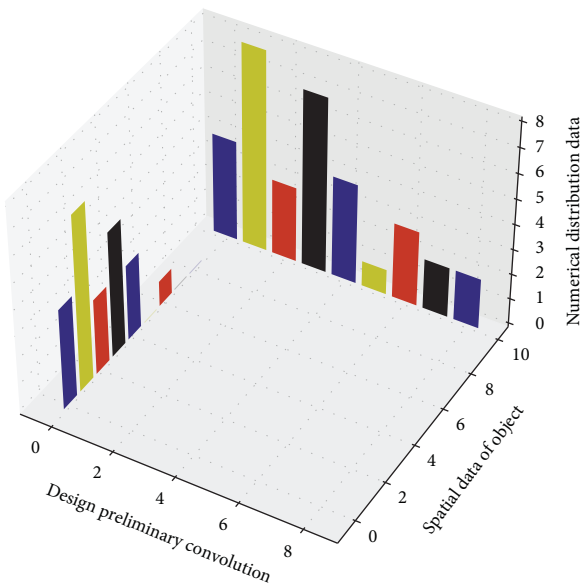

Figure 6: Preliminary convolution numerical distribution of spatial data.

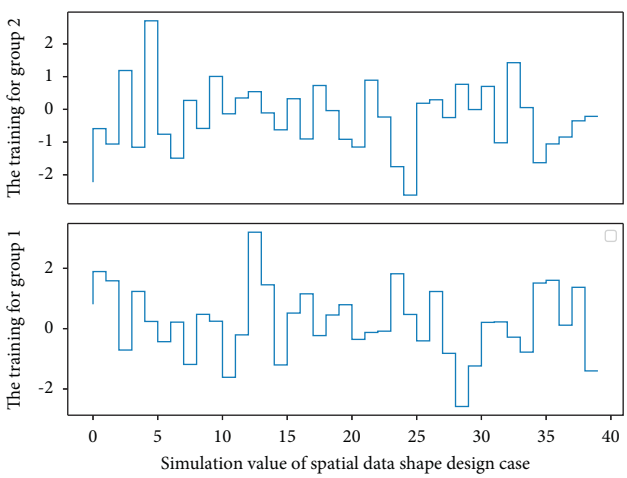

Figure 7: Extraction of spatial data shape design representation.

the relationship between spatial data and spatial data parameterization; extracting adjectives and their importance parameters in spatial data through keyword extraction algorithms as the overall image of the product. When extracting perceptual images for local features of products, it is first necessary to identify the description objects of the sentences, that is, to find the nouns in the text that describe the local features of products. The shape design is parameterized by word vectors, and the dimension of the shape design parameters is reduced by combining principal component analysis, so as to obtain the parametric expression of the global and local images.

4.2. Evaluation and Simulation of Product Shape Design Scheme. The development content of the product shape design software mentioned in this study mainly includes the related investigation of sensibility engineering and the inheritance calculation of the product shape visual interface. The software programming in this study is realized by the mixed programming of VB.NET and MATLAB. The specific realization process of product outline design contour extraction is: (1) grayscale the image; (2) use the maximum class variance method to select the appropriate closed value, segment the grayscale image, and generate the corresponding binary image; (3) use the eight-neighborhood method of hollowing out the interior points to find all closed areas in the image, and mark their boundary contours; (4) save the pixel coordinates of the marked contour points in the TXT file to prepare for subsequent processing.

Although the dimension of the Distributed Representation word vector obtained by the word2vec tool is lower than that of the One-hot Representation word vector, the single dimension is still greater than 100, which is still too high compared to the sample size of the product design research in Figure 8. Therefore, the dimension of the shape design space data is reduced by factor analysis, which reduces the dimension of the word vector involved in the calculation of the shape design parameters while retaining the semantic difference information between the spatial data. When analyzing the semantic relationship, the semantic relationship between words and nouns is divided into two aspects: similarity and dissimilarity. Since word vectors can reflect the similarity of semantic relations of words, the similarity between nouns is determined by calculating the cosine similarity between word vectors. Commonly used feature selection methods include variance screening, correlation coefficient, hypothesis testing, and mutual information. Since the purpose of dimension selection in this study is to obtain the dimension of shape design parameters that is more correlated with product feature parameters, and the type of correlation between perceptual image parameters and design feature parameters cannot be predicted, the method of calculating mutual information is used to filter perceptual imagery parameter dimension.

In order to improve the accuracy of Figure 9, some attribute words such as product attributes, words expressing related fields, and some idioms can be selectively reserved, so as to maximize the retention of meaningful words for the sentence, so that the remaining word for the meaning of the composed sentence is closest to the original text, which makes the final mining effect better. First, we take each point as the bottom mining, then calculate the distance between each mining, and then form the mining in the upper level by merging the most similar mining, when a certain termination condition is reached or all data points are merged into one mining sometimes ends.

4.3. Example Application and Analysis. This survey invited 10 students majoring in industrial design as subjects to select 10 adjectives from all the collected product image semantics. The selected adjectives must be suitable for describing the sample of this survey. In the process, the selected adjectives should have as little overlap as possible, and the selection

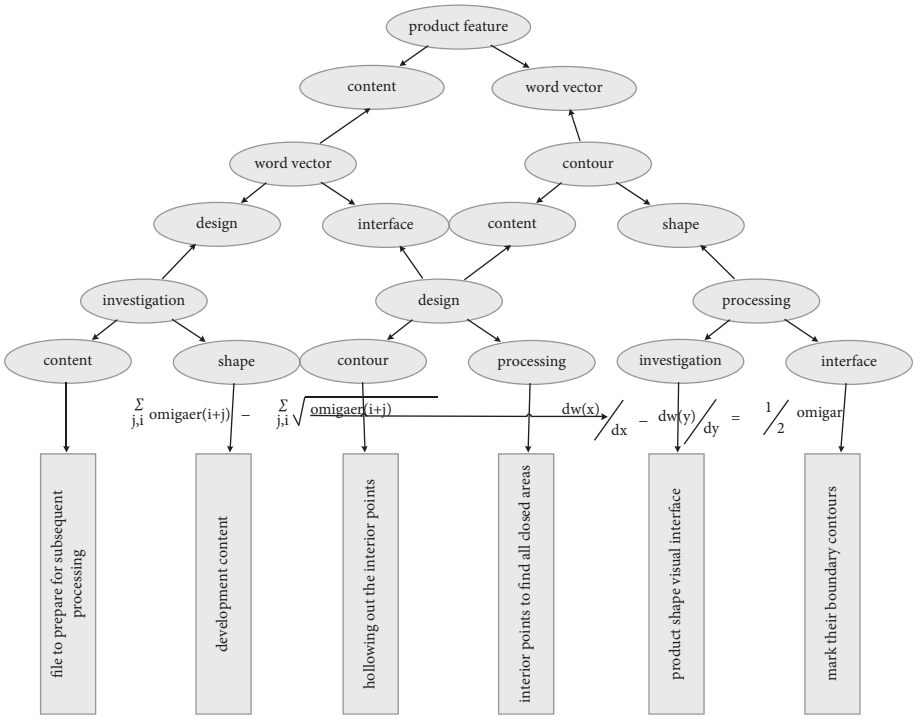

Figure 8: Structure optimization of product shape design scheme.

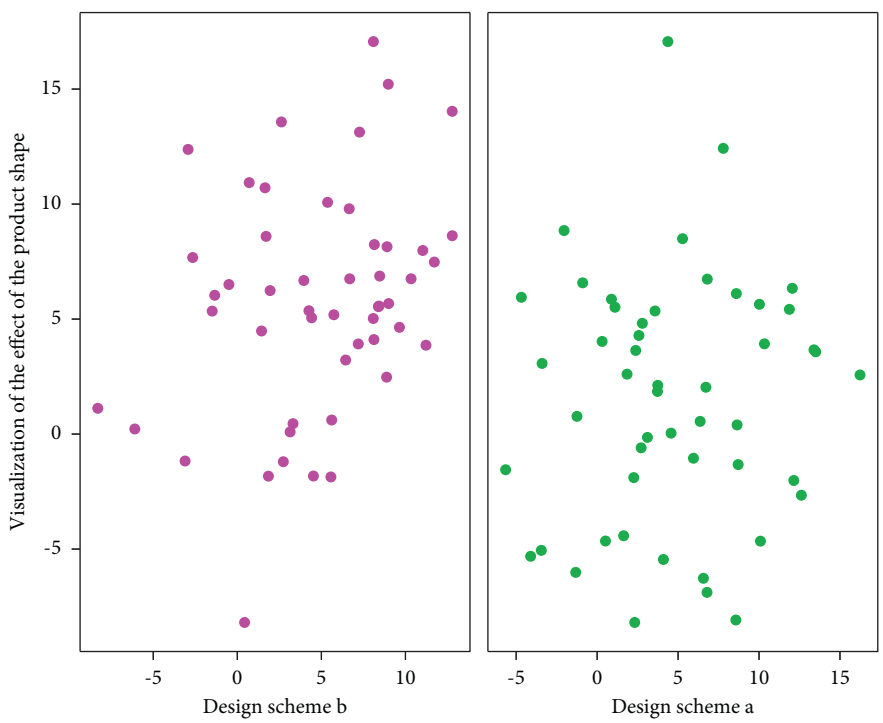

Figure 9: Visualization of the effect of product shape design scheme.

results of the subjects were analyzed using the frequency statistics method, and subjective predictions were appropriately added to screen out 8 product image semantics. In this way, a conventional image semantic set is formed. Due to the low frequency of occurrence of some words, most of them are word segmentation errors or typos in the text, which will interfere with the construction of the product feature tree. The reduce function is to summarize the Canopy output of the map function, output the mining analysis results, and save the results on HDFS.

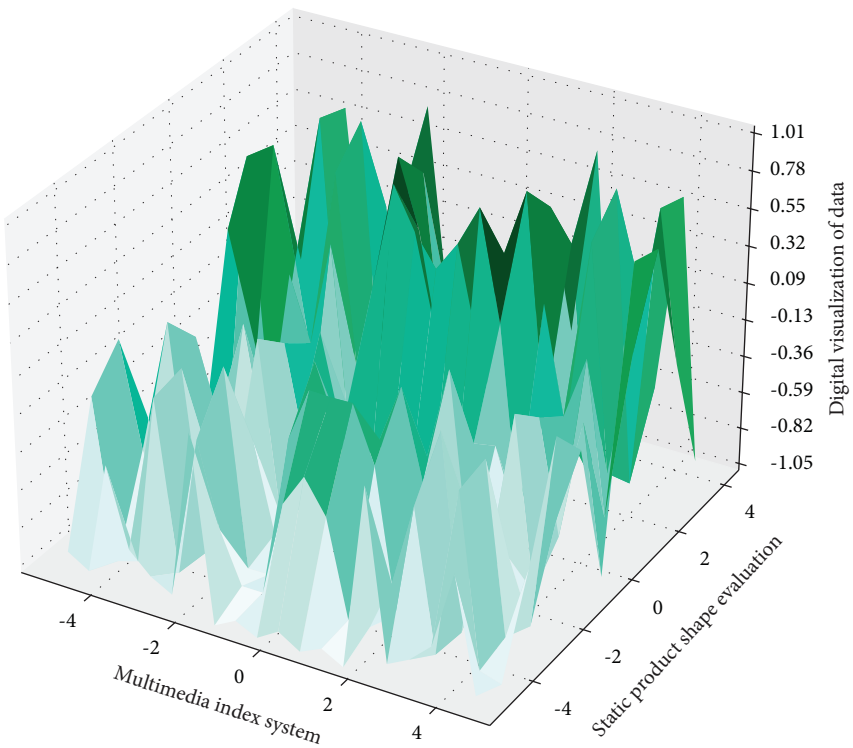

Figure 10: Three-dimensional distribution of product shape evaluation index system.

The form of the questionnaire is different depending on the method of product appearance evaluation. According to the dimensional differentiation method of product appearance evaluation, the form of the questionnaire is divided into a multi-sample questionnaire and a single-sample questionnaire. The production of the multi-sample questionnaire adopts the product appearance scoring method, which takes the attribute layer in the evaluation index system as the direct target, and directly classifies and evaluates the product appearance on the attribute layer; the production of the single-sample questionnaire adopts the product appearance ranking method. Therefore, when calculating the relationship between words, a word frequency threshold is set, and only words higher than the threshold are included in the maximum number of words. Through experiments, we found that the multi-sample survey method is based on the solid foundation of Vts, its data processing method is more delicate, the effectiveness and utilization of raw data are higher, and the horizontal relationship between each evaluation factor and each scheme can be completed. Compared with longitudinal comparison and analysis, however, because of the data collection and statistics for different schemes, the data collection work is complicated and the implementation is relatively difficult.

The level of Figure 10 provides the keyword information required for the upper-level description and defines a certain dependency between the keywords, which can usually define individualized static attribute rules at this level. The description layer is not only for specific products but also for specific resources. Arbitrarily it may pick out K objects as a cluster, and the object is the center of the cluster, calculate the distance between all the remaining objects and the K objects, the closest distance is divided into the corresponding cluster, and then calculate each average value of the cluster, the most central object is selected as the center of the new cluster, and the iteration starts at this time, and the remaining objects except the cluster center are calculated again, divided into new clusters, and then a new center is obtained, and repeat the execution, and finally get it if the center of the new cluster is consistent with the previous center or the distance is less than the set value, the iteration ends and the mining is completed.

5. Conclusion

Based on the concept of spatial data mining, this study studies the relationship between spatial data and product shape design. The product visual interface is decomposed into several characteristic elements. For the product shape design cycle, the model defines the loss of product shape design as the present value of the loss caused by scrapping the product after the investment because the product shape design features exceed the specified range and product shape design loss model of spatial data distribution; for shape design features that obey different distributions, a calculation method of product spatial data distribution density function based on tolerance requirements of shape design features is proposed. First, we obtain the big data of online product evaluation spatial data through web crawlers, use word2vec to vectorize the spatial data after word segmentation, divide the product shape design into two categories: overall product shape design and product partial shape design, finding adjectives related to the nouns in the group through syntactic relationship and counting the word

frequency, and then obtaining the local image of each product. The keyword extraction algorithm and the keyword extraction method of the syntactic relationship extract the image and appeal, use the word vector model to represent it as a real vector and perform principal component analysis to reduce the dimension, and combine the importance parameters to calculate the corresponding shape design parameters, so hierarchical product shape design appeals to big data mining methods.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest or personal relationships that could have appeared to influence the work reported in this study.

Acknowledgments

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Research Article

Factors Influencing Analysis for Level of Engineering English Education Based on Artificial Intelligence Technology

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The essence of English for engineering is English for professional purposes (ESP). The assessment of the level of education in engineering English classrooms is one of the key issues currently being discussed in all schools. While the traditional English classroom teaching model has been criticized due to many problems, the changes in the new English curriculum and the changes in the assessment methods have also created new demands on the English teaching methods. The artificial intelligence technology brings a new direction for the optimization of English classroom, and it also provides new support for the realization of intelligent and collaborative English classroom teaching. In view of the current situation that the college English teaching evaluation mode is still dominated by summative evaluation, this paper summarizes the current problems of poor teaching effect, unbalanced ability cultivation, and mismatch between evaluation and teaching in engineering English. On this basis, it adopts the BPNN network combined with the interactive mechanism of English teaching to establish a multi-dimensional interactive English learning framework of teacher, student, corpus, and AI resource base. And the BPNN algorithm process was optimized using the gray wolf algorithm to improve the engineering English teaching model. Finally, an experiment on teaching engineering English was conducted within a university, and the experimental results showed that teaching objectives, teaching contents, teaching methods, and teaching effects had important effects on teaching effectiveness. In addition, the teaching framework constructed using the improved BPNN algorithm was better in terms of the learning effect at the same time, especially in writing, during the teaching process. Finally, the experimental results show that BPNN optimized by gray wolf algorithm can achieve better teaching effect than BPNN.

1. Introduction

In the past 20 years, especially since 2009, English for specific purposes has spread and developed rapidly in mainland China and has become a hot spot for university English teaching and research [1, 2]. ESP is different from English for general purpose, which has its own unique curriculum characteristics and teaching requirements. The literature [3] argues that it has two distinctive features: first, learners have a clear learning purpose, i.e., learners need to achieve the ability to use English within certain disciplines due to the needs of specific industries; second, it has special content, i.e., specialized content. The literature [4] summarizes the four characteristics of ESP: "it belongs to the category of applied linguistics, it is closely related to a certain discipline, it better reflects the needs of learners, and English emphasizes applied skills" [5].

During the teaching process, how to make students overcome language barriers, such as mastering difficult to read and remember professional vocabulary, analyzing obscure and complex long sentences, understanding descriptions of professional tools and machines and professional English reading materials, and verbally describing professional work processes, are all factors to be considered in each class design [6]. The introduction of modern information technology is of great importance to make the teaching of professional English intuitive and easy to understand, to improve learners' English input and output and to generate continuous interest and self-motivation in learning [7, 8].

Information-based teaching is to use computers, multimedia technology, and network information technology as carriers and means of teaching activities, to use these advanced technologies to enrich the teaching content of professional English, to improve teaching methods, to enhance teaching means, and to give full play to the advantages of both for a better teaching effect [9].

For a long time, English learning has been closely linked with technology [10]. When computers were first introduced, the United States began experimenting with computer-assisted learning and teaching (CAL), of which computer-assisted language teaching (CALL) is one of the many areas of CAL research [11]. CALL represents a new way of teaching language, in which learners use a computer screen to learn the language learning resources provided by the computer, and the computer also acts as an intelligent assistant to the language teacher's teaching or research, which can be said to be a significant change to the traditional way of teaching language [12]. CALL has made full use of computer science, information technology, psychology, and further integration with automatic analysis technology, the Internet (WWW), natural language processing, and other technologies to make the CALL system more intelligent (e.g., to achieve oral responses and speech scoring), which has led to the development of CALL as artificial intelligence computer-assisted ICALL is a combination of language teaching, which has contributed to the modernization of language teaching [13].

As the technology matures and research progresses, AI-supported English language education has transitioned from "technical inquiry" and "pedagogical practice" [14]. The research on "teaching practice" mainly focuses on the design of AI-supported English teaching models and learning paths and further explores the rules of teaching and learning English in an intelligent environment based on technical support to optimize learning effects and improve teaching quality. For example, in the English classroom teaching of literature [15], the use of the "criticism network" to design a flipped classroom creative collaborative teaching model was verified through practice to improve the effectiveness of students' English writing method. In addition, the practice of artificial intelligence to support English learning, Shanghai has tried to use artificial intelligence marking system English listening and the speaking test in the college entrance examination English test to help promote the change of the college entrance examination English speaking test [16]. Artificial intelligence has great potential in English education, and machine translation, natural language understanding, and speech recognition technologies have been applied to English learning [17]. Regarding how AI supports English learning, from the available studies, it is mainly reflected in AI support for listening training, AI support for speaking learning, and AI support for writing training [18]. The main contributions of this paper are summarized as follows: (a) from the perspective of the non-mechanism model, in view of the problems existing in the current use of neural networks in English teaching, this paper follows the basic principles and steps of neural network modeling in modeling, establishes a neural network model based on gray wolf optimization and improves the generalization ability, effectiveness, and robustness of the neural network model optimized by gray wolf. (b) Based on the BPNN network and the interactive mechanism of English teaching, a multi-dimensional interactive English learning framework of teachers, students, corpus, and artificial intelligence resource bank is established. (c) An engineering English teaching experiment was carried out in a university. The experimental results show that the teaching objectives, teaching contents, teaching methods, and teaching effects have an important impact on the teaching effect.

The rest of the paper is organized as follows: the second part discusses the framework of engineering English education based on artificial intelligence and the mechanism of teaching interaction in engineering English teaching. In the third part, an English teaching evaluation system based on the wolf pack algorithm to improve the BPNN network is investigated. The fourth part presents the conditions and experimental results of the teaching experiment. Finally, the fifth part concludes the whole paper.

2. Model Building of Artificial Intelligence and the Education Level of Engineering English Teaching

2.1. Design of the ESP Information-Based Teaching Framework. Artificial intelligence-based ESP teaching in the information environment should be understood as the integration of information technology and ESP course teaching, mainly integrating various ESP teaching resources, such as text, graphic images, audio, animation, video, and other media, reorganizing each teaching link and related elements, creating teaching situations, expanding the corresponding learning space and time, realizing the optimal allocation and design of resources and making the teacher-centered The teacher-centered teaching mode changes to a student-centered and teacher-led teaching mode, and follows the principles of authenticity, subjectivity, and openness of ESP teaching [19].

Authenticity means that the language carrier of ESP should be real and reliable, and the real language material should be used to teach foreign languages and create real contexts for students in order to stimulate their interest in learning [20]. The application of information technology not only provides authentic learning materials but also provides students with real audio and video materials. Applying these to ESP classroom teaching fully mobilizes students' eyes, ears, hands, mouth, and other organs to put students in an active and excited learning state, which can enhance students' interest in learning and improve learning efficiency [21]. Secondly, the teaching task should be authentic, that is, the "task" in classroom teaching must be consistent with the "task" in social practice. This requires ESP teaching to take the communicative tasks in social practice as the simulated objects of classroom teaching, such as the preparation of documents related to meetings, the presentation of products, and the explanation of the process of machine operation. Finally, the difficulty level of the material should be close to

the real level of the learners. Today, with such advanced technology, it is easy to use information technology (e.g., the Internet, search engines, etc.) to find "original" authentic materials, but it is not easy to ensure that the difficulty of the selected materials is close to the real level of the learners. This requires the instructional designer to evaluate the difficulty level of the materials and make the final design after understanding the current level of the learners. The "evaluation methods" in formative evaluation are diversified, including the evaluation of teachers and educational administration departments on students, students' self-evaluation, students' mutual evaluation, students' evaluation on teachers' teaching attitude, teaching means, and teaching effect.

As shown in Figure 1, the subjectivity principle of ESP informatization teaching design mainly highlights the subject position of learners in the learning process and attaches importance to the analysis of different characteristics of learners in order to fully explore the internal potential of learners and stimulate and mobilize their initiative and enthusiasm for learning. Since learners are always the main subjects of teaching activities, teachers should consider the perspective of learners' subjects when using information technology for teaching design, so as to promote learners' personality development and all-round development. At the same time, there are also questionnaires and interviews on students' learning motivation and interest, emotional attitude, learning strategies, autonomous learning ability, etc. In particular, the methods of "student self-evaluation" and "student mutual evaluation" can enable students to discover their achievements and problems in the learning process in time and then adjust their learning attitude, formulate learning plans and learning objectives and improve learning strategies and solve problems encountered in learning in a timely and effective manner.

Finally, ESP informatization teaching design should also follow the principle of openness. Attention should be paid to create a good teaching atmosphere, giving students sufficient free space for development, attaching importance to open thinking training, guiding students to use information technology, conducting exploratory, research and discovery learning, encouraging students to divide and cooperate in the process of completing classroom tasks, discussing, and analyzing.

2.2. The Construction of the Interactive Mechanism Teaching Model. Teaching interaction has an important value in the flipped classroom teaching model and is carried out throughout the flipped classroom teaching in Figure 2. Therefore, the quality of teaching interaction directly affects the implementation effect of the flipped classroom, and its role in the implementation of the flipped classroom is particularly significant, and its value before, during, and after class should not be underestimated. Because multiple assessments emphasize "the multiplicity of evaluation functions, the multiplicity of evaluation criteria and evaluation subjects, and the diversity of evaluation means, this evaluation system with diversified evaluation subjects, evaluation contents, and evaluation forms helps to cultivate students' comprehensive English application ability and help students develop their independent learning ability and understand students' feelings, attitudes, and learning strategies, in the process of growth and learning."

(1) The value of preclass prestudy: for students, the teaching interaction enables them to understand and master the main contents of the class in advance, so that they can grasp the main points of learning and clarify their difficulties and make themselves more focused when listening and learning in class; for teachers, teaching interaction enables them to understand the learning situation of students in advance and understand the concentration of students' learning issues and problems, so that they can teach the class. For teachers, teaching interactions enable them to understand students' learning situation in advance, and to understand students' concentrated learning problems and difficulties, so that they can grasp the key points during lectures and make lecture contents and lecture plans more relevant and improve classroom efficiency.

(2) Value in classroom learning: teaching interaction in the classroom can make students discuss learning problems together and enhance the cultivation of students' feelings and facilitate the depth of knowledge internalization, which can make the cultivation of teachers' feelings with students and make teachers' lectures revolve around students' difficult problems in real-time, and along with the progress of lectures, students' problems will also change, and at this time, the value of teaching interaction can effectively solve students' new problems and promote better internalization of knowledge.

(3) Value in postclass review: teaching interaction after class enables students to make up for knowledge gaps in the classroom, enables students to communicate and exchange with each other, promotes further internalization of knowledge, makes knowledge really become a skill of their own, facilitates teachers' next teaching work, enables teachers to adjust teaching methods and ideas according to the situation and prepares corresponding test questions in time according to students' feedback.

It is important for the teacher to have a good classroom atmosphere, and only if the atmosphere of the lecture is good, students can learn better and will learn more efficiently. It can be seen from the emergence of intelligent components instructional mode that the four reinteraction modes are interrelated, so that students can have information development participation between different intelligent modes. In the treatment of university English education, we will establish application scenarios to improve students' desire, guide, and direct their learning in this treatment and advance good interaction between students and instructors. Teachers should scientifically analyze the

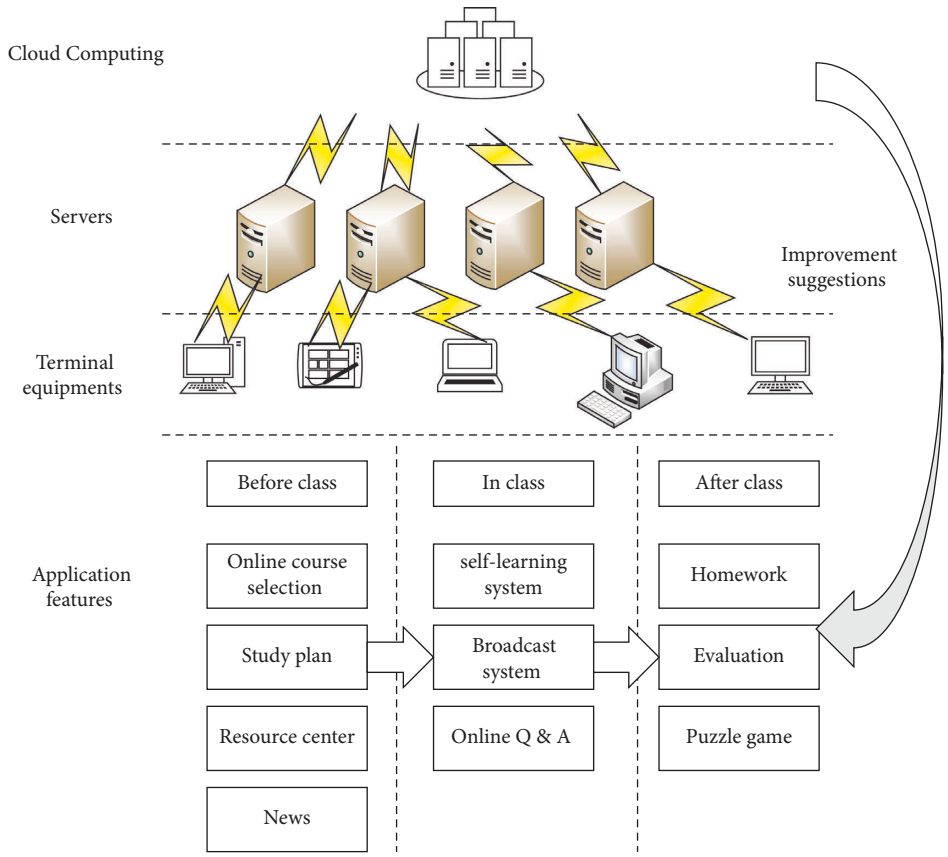

Figure 1: The structure of ESP teaching based on artificial intelligence.

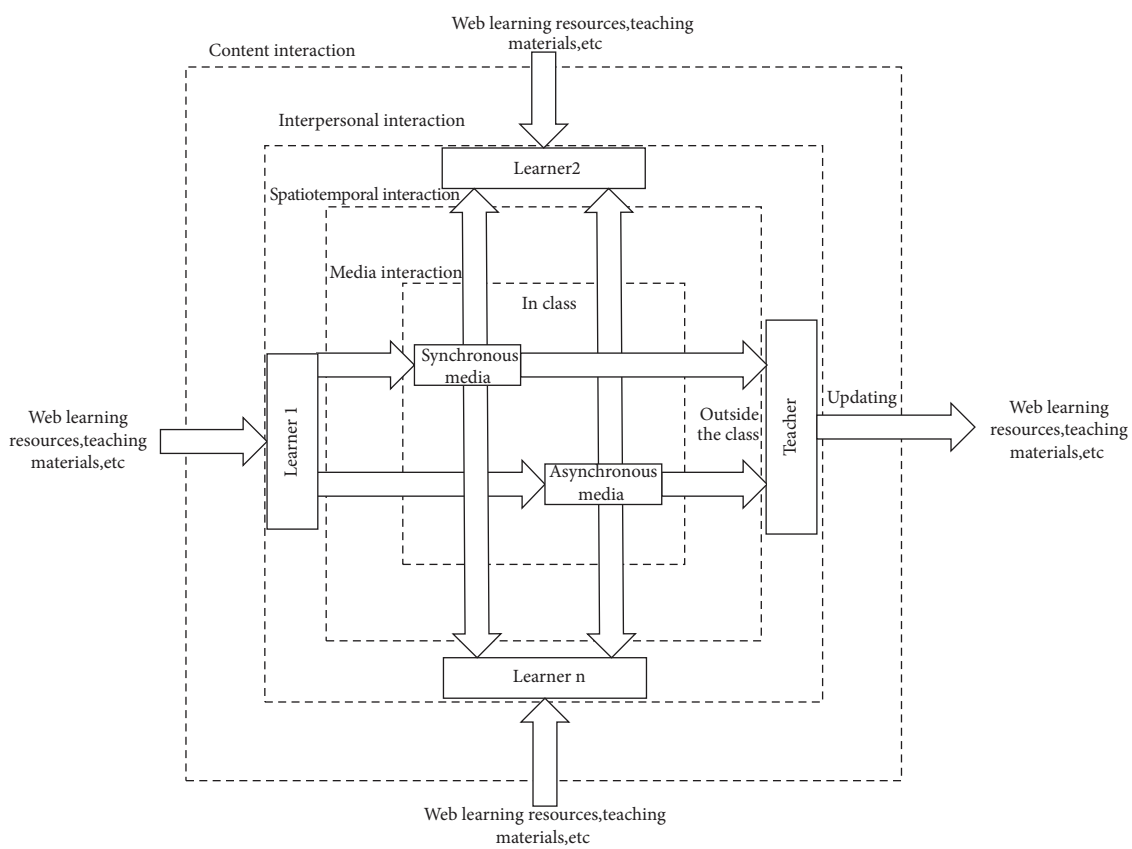

Figure 2: Interactive mechanism teaching mode.

teaching materials and innovatively reorganize and design the teaching content, so that the teaching contents are presented in a way that is conducive to the implementation of teaching interaction. Unlike the traditional ESP teaching, with the introduction of AI technology, the interaction mode becomes an interaction between students, teachers, teaching materials, and AI resource systems.

The AI resource library can effectively provide teachers with feedback on the current teaching situation and act as an assistant to help teachers enrich classroom content and make up for students' shortcomings in a targeted manner.

3. Research on the Evaluation Model of the Engineering English Teaching Level Based on the Improved BPNN Algorithm

3.1. The Process of English Teaching Effectiveness Evaluation by the BPNN Model. There are many kinds of artificial neural networks, BP neural network is a multilayer feedforward multilayer neural network. It has the largest application range among many neural networks with the most application scenarios. In the BP neural network, the neurons within each layer are not directly connected with each other. The neurons between the layers are interconnected by weights. BP neural network conducts forward through the data signal and reverse according to the error. In the data forward conduction process, the neural network transmits the data information content gradually from the input layer to the implicit layer to the output layer. Whenever there is a deviation between the output result and the expected result, the network system will transmit the output data information content back in the opposite direction and adjust the connection weights between the layers of the network system by the deviation of the output value from the expected value. Finally, the output value of the network system gradually approaches the desired value. Figure 3 shows the structure of the BP neural network.

The computational process of the BP neural network is considered as a computational process with a "mentor." The whole learning process consists of two parts. The first part is the forward operation of the data, which introduces the predefined sample data input values and the expected output values into the network to complete the forward calculation. Then, the second part is to compare the output value generated by the data input operation with the expected output value to calculate the error. When the error is greater than the specified range, the output result will be back propagated and the weights between neurons will be adjusted according to the error value. The above two parts of the calculation are repeated until the error between the real output value and the predicted output value is within the given accuracy range and the training is finished. The specific training process is shown in the following steps. An iteration period of the algorithm is

$$w^{k+1} = w^k + \Delta w = w^k - \eta^k \frac{\partial e^k}{\partial w^k}. \tag{1}$$

For nonlinear networks, choosing the learning rate is a very difficult task. For current networks, choosing too large a learning rate can easily lead to unstable learning; conversely, choosing too small a learning rate can lead to intolerably long training times. Unlike linear networks, a simple and easy method has not been found to solve the problem of choosing the learning rate for nonlinear networks. For fast training algorithms, there are usually margins for their default parameter values. The initial output and error of the network are calculated as

$$w_{ji}(n+1) = w_{ji}(n) + \eta(n) D(n). \tag{2}$$

The change of η will affect the change of weight. Choosing the appropriate learning rate for a given problem is not an easy task. It is usually obtained empirically, and even then, a learning rate that is more effective at the beginning of the training may not necessarily be appropriate for later training as well. To solve this problem, networks have been used to automatically adjust the learning rate during the training process. Similar to the judgment condition when using the additional momentum method, when the new error exceeds the old error by a certain multiple, the learning rate will be reduced, otherwise its learning rate remains the same; when the new error is smaller than the old one, the learning rate will be increased. This method ensures that the network learns steadily so that its error continues to decrease and increase the learning rate so that it learns at a larger learning rate. Once the learning rate is adjusted too much, and the error is not guaranteed to continue decreasing, that is, the learning rate should be reduced until its learning process is stable. The weighted adjustment formula is

$$\Delta w(t+1) = \eta \frac{\partial e}{\partial w} + \alpha \Delta w(t). \tag{3}$$

Generally, α is about 0.9, where α is the momentum coefficient.

The maximum error rate of change can be any value greater than or equal to 1, typically 1.04. Therefore, conditional judgments must be added to the design of the training program for the additional momentum method in order to properly use its weight correction formula. The BPNN algorithm of self-adjusting LR can be described as

$$\begin{gathered} \Delta X = L_r \frac{\partial E}{\partial X}, \\ \Delta X(k+1) = mc \times \Delta X(k) + L_r \times mc \times \frac{\partial E}{\partial X}. \end{gathered} \tag{4}$$

Here, the momentum is mc.

BP networks typically use an implicit layer of an S-shaped activation function, which is often referred to as a "squash" function that compresses an infinite range of inputs into a finite range of outputs. It is characterized by a slope close to 0 when the input is large, which results in a small gradient amplitude in the algorithm and may bring the correction process of the network weights to a near halt.

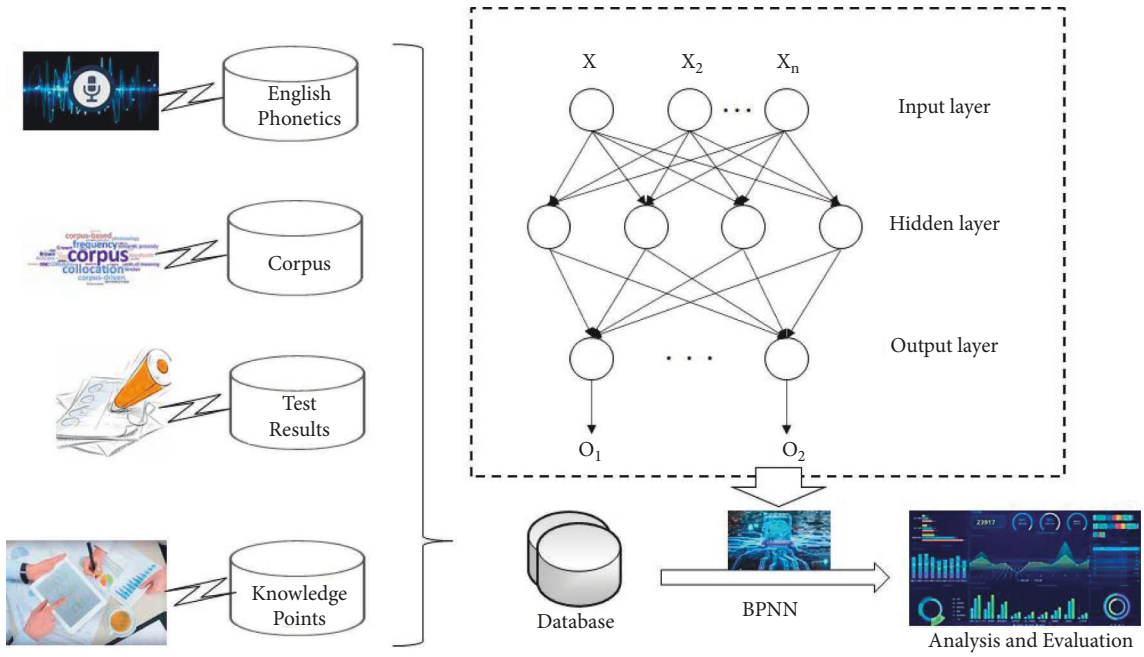

Figure 3: Basic BPNN network structure.

The flexible BP algorithm takes only the sign of the partial derivative and does not consider the magnitude of the partial derivative. The sign of the partial derivative determines the direction of the weight update, while the magnitude of the weight change is determined by an independent "update value."

$$f(x) = \left(\frac{0.5}{\lambda}\right)\sin(\lambda x) + \left(\frac{0.5}{\lambda}\right). \tag{5}$$

In this way, the BP algorithm converges relatively fast and the algorithm is not complicated, and it does not need to consume more memory.

3.2. A Framework for English Teaching Evaluation Based on the Optimized BP Neural Network with the Gray Wolf Algorithm. Organisms in nature have gradually evolved the most suitable way of survival for their own species in the process of adapting to the environment, and humans have learned a large number of working methods that can be used in production and life by observing the information exchange characteristics or life styles of other species. The gray wolf algorithm, as a new type of a group intelligence optimization algorithm, is proposed by scholars based on the strict hierarchy and a precise cooperative hunting mode of the gray wolf population. It is inspired by the prey hunting behavior of the gray wolf pack. The gray wolf algorithm simulates the bottom-up pyramidal social hierarchy in the gray wolf population and the mechanism of information sharing during the hunting process of the gray wolf population. This algorithm has fewer parameters, strong convergence, and easy to implement global search. Since the gray wolf algorithm was proposed, it has achieved good results in the fields of parameter optimization and image classification.

The optimization of the BP neural network using the GWO algorithm can effectively improve its convergence speed and accuracy. The optimal solution of the BP neural network is obtained when the gray wolf reaches the location of the prey, i.e., when the gray wolf is in the best hunting position. Gray wolf optimization algorithm is a swarm intelligence algorithm that can find the global optimal solution. It has the characteristics of accelerating the convergence speed of the model and improving the accuracy. It takes the weight and threshold of the BP neural network as the position information of gray wolf. According to the position judgment of gray wolf on the prey, constantly updating the position is equivalent to constantly updating the weight and threshold to finally find the global optimal solution.

The gray wolves not only have a strict social hierarchy within the group but also have an extremely orderly mechanism of command transmission and information sharing in the hunting process. In the process of predation, the gray wolf firstly determines the target and chases it. In the process of chasing, it gradually approaches the prey and surrounds it and tries to interfere with it. When the disturbance is successful, it tries to attack the prey until it is successfully captured. During the hunting process of the gray wolf pack, when the head wolf in the layer captures the position of the prey, it will unite with the other two leaders and direct the whole pack, so that the whole pack will surround the prey from all directions and further hunt the target. The mathematical expression describing the above behavior is

$$\begin{cases} D_\alpha = \left|C_1 \cdot X_\alpha(t) - X(t)\right|, \\ D_\beta = \left|C_2 \cdot X_\beta(t) - X(t)\right|, \\ D_\delta = \left|C_3 \cdot X_\delta(t) - X(t)\right|. \end{cases} \tag{6}$$

There are many kinds of excitation functions for BP neural networks, and the excitation function chosen in this paper is logsig function, which is expressed as follows. The expressions are as follows:

$$f(x) = \frac{1}{1 + e^{-x}}. \tag{7}$$

The optimization of the BP neural network by the GWO algorithm can effectively improve its convergence speed and accuracy, so that the neural network can quickly jump out of the local optimal solution in the operation process. When the gray wolf reaches the location of the prey, that is, when the gray wolf is in the best hunting position, the optimal solution of the BP neural network is obtained, the structure is shown in Figure 4.

4. Analysis of Test Results

4.1. Experimental Environment and Simulation Settings. In order to test the effect of the BPNN network framework optimized based on the GWO algorithm on the quality of engineering English teaching, 150 non-English majors from a university were selected for this experiment. A preschool test was administered to the students before the experiment, and the students were grouped according to their preschool test scores, so that the overall mean scores and standard deviations of each group were consistent. The students in these three groups were divided into experimental, control, and standard groups, with 50 students in each group. The experiments were conducted to compare the student performance of the traditional teaching model with that of the new classroom quality monitoring model, so as to compare the effectiveness of the teaching method in this paper. Before the experiment, the students in the experimental class and the control class were tested on their English proficiency with the full-scale CET-4 questions to understand the basic situation of the students in each class. The test results were calculated and analyzed with SPSS, and the significant difference was $p < 0.05$.

4.2. Verification of the Superiority of the Algorithm Analysis of English Teaching Quality Evaluation Indexes. After many experiments, the neural network parameters optimized by GWO are as follows: the number of wolves is 200; The upper and lower bounds of the initial position are 3 and—3; The maximum number of iterations is 150; The network structure is 10-9-1, that is, the input layer has 10 nodes (number of variables), 9 hidden layer nodes, and 1 output node.

In the teaching process, the teacher's behavior was studied to determine the impact of different aspects of the teacher's teaching on the students' abilities in various areas. The teacher's teaching skills were divided into four main areas: teaching objectives, teaching content, teaching methods, and teaching effect. Figure 5 shows that teaching objectives had the greatest overall impact on students and had a more significant impact on students' independent learning ability and listening and speaking ability, and it can be seen that teaching objectives effectively mobilized students' motivation and improved their learning motivation. However, their ability to improve reading in the learning process is not enough, probably because the motivation process avoids a lot of reading training. The second major influence on students is teaching content, which is well prepared by teachers to improve students' learning efficiency and thus reduce learning time. Good teaching content can effectively improve students' reading ability, which makes up for the lack of teaching objectives, and the teaching effect has less influence on the students' learning effect.

Figure 6 shows that the variation of different optimization algorithms on the suggested accuracy of AI repository shows that the optimization effect does not improve significantly with the increase of optimization generations using the traditional optimization algorithm, which means that the number of generations to be optimized needs to be much more than that of the BPNN network to achieve better results. The original BPNN converges after about 45 iterations while the improved BPNN network based on the GWO algorithm needs about 30 iterations. In contrast, for the original BPNN network and the improved degree BPNN network, the improved BPNN network is generally better than the original BPNN network in terms of the effect of iterations, and the improved BPNN network yields better results with the same number of iterations. On the other hand, the improved BPNN network based on the GWO algorithm occupies relatively less system resources during iteration and requires less hardware computing power, which has more potential for portability to different platforms.

4.3. Convergence and Utilization Analysis of Optimal Response Strategy. Figure 7 shows that specific differences and changes in the effectiveness of the GWO algorithm-based optimized BPNN network and the original BPNN network in the English learning process were used. The four aspects of the learning process in the class, namely listening, speaking, reading, and writing, were assessed for their effectiveness. Assessments were conducted every two weeks, up to ten weeks in total. During these ten weeks, it can be seen that the learning model provided by the improved BPNN network has a significant improvement in learning effectiveness over the model provided by the original BPNN algorithm, especially in the area of writing, as shown in Figure 7. However, the overall learning efficiency in writing is still lower than the other three areas. The best learning efficiency is in listening, which can reach 90.83 after ten weeks of learning with the modified BPNN network, as shown in Figures 7(a) and 7(c). As for speaking, the overall improvement is relatively small, which may be caused by the lack of motivation of students to express themselves actively in the learning process influenced by their previous learning habits, as shown in Figures 7(b) and 7(d). This improvement was gradual, with a relatively small improvement in the first six weeks, while the change in learning effectiveness was more clearly demonstrated as time went on.

In order to test the optimization effect of ESP education influencing factors based on the BPNN network optimized

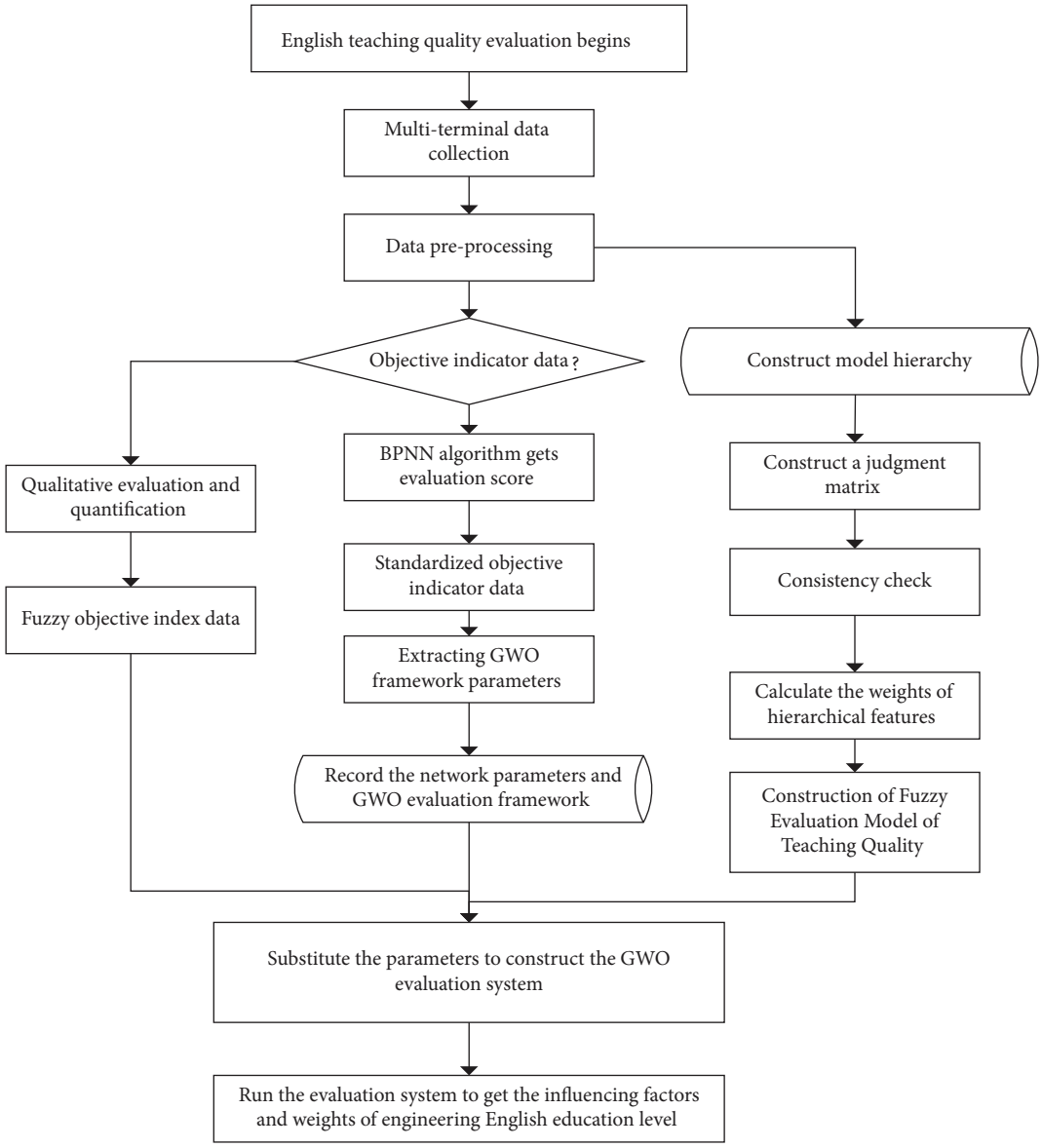

Figure 4: An evaluation framework for English language teaching based on improved BPNN.

by the GWO algorithm, a questionnaire was conducted anonymously, asking 18 independent English pedagogical experts to objectively and impartially rate the comprehensive English teaching process involving students' listening, speaking, reading, writing, and independent learning skills, thus providing a comprehensive response to the actual effect of the teaching framework designed in this paper. The weighted average was then converted to an exact value between (0, 1). As shown in Figure 8, the optimization effect of the improved BPNN network will keep improving as the

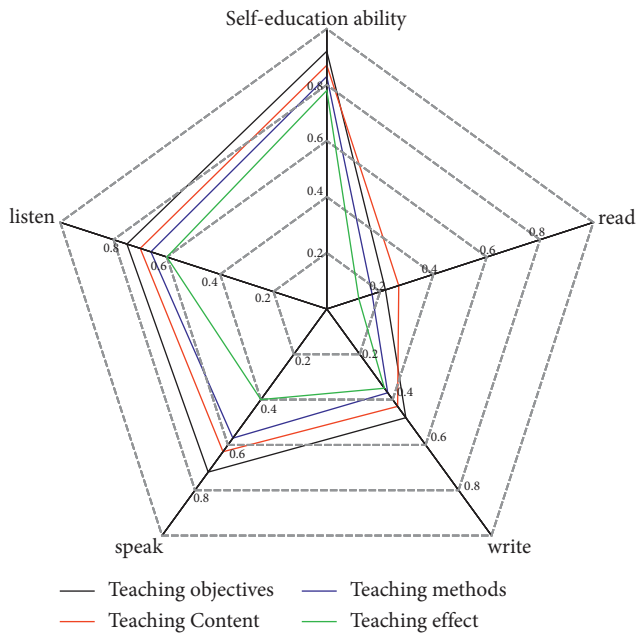

Figure 5: Criterion level indicator affiliation.

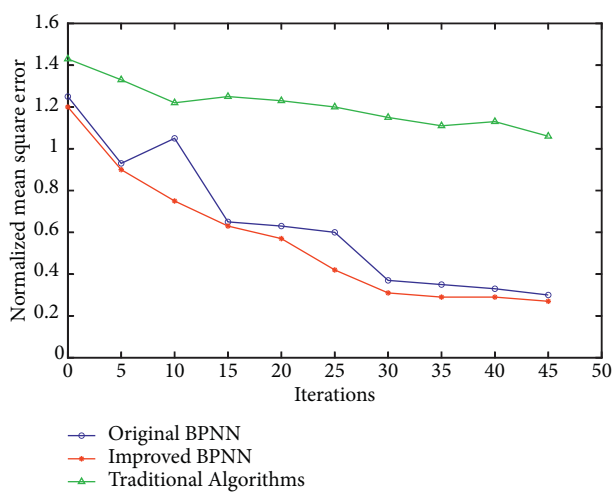

Figure 6: Mean square error curve of the model.

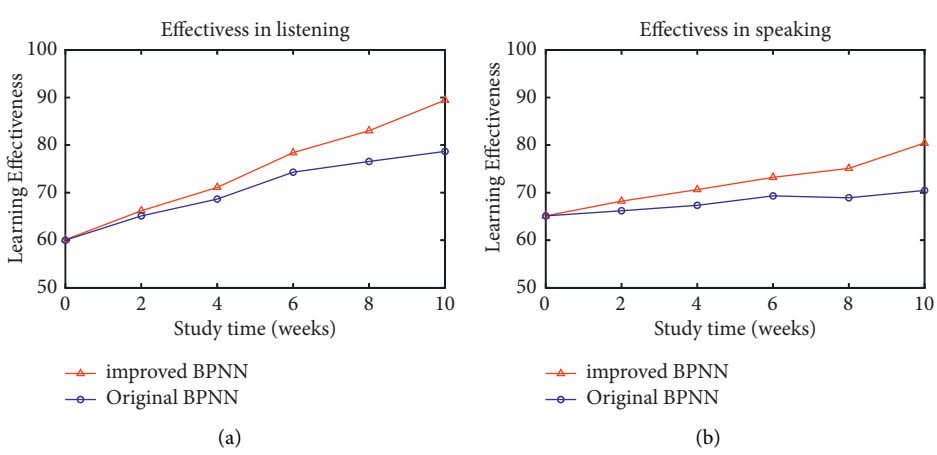

Figure 7: Continued.

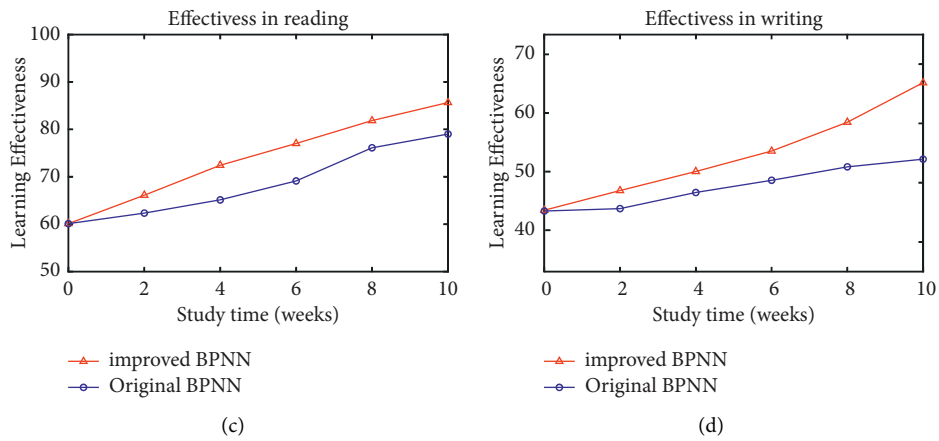

Figure 7: Evaluation accuracy curve of the model.

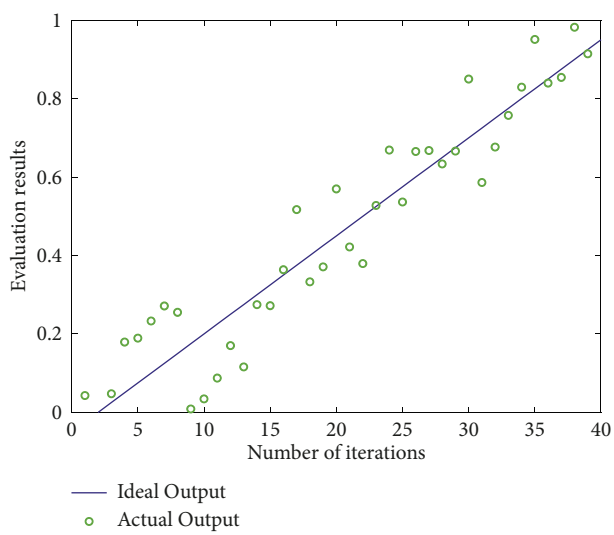

Figure 8: Theoretical expectations and expert evaluation of the effectiveness of ESP teaching based on an improved BPNN network.

number of iterations keeps increasing, and it shifts roughly above and below the theoretical curve, which can indicate that the actual measured changes in the teaching level match the theoretically predicted output results of the teaching level.

5. Conclusion

Artificial intelligence oriented real-world problem solving. In this paper, we propose a BPNN network approach based on the improved GWO algorithm, and its utilization in the ESP teaching process can effectively help veteran teachers to discover potential problems identified by students during the teaching process. At the same time, the mechanism of interaction between teachers and students is combined with the inclusion of an AI resource library, which allows teachers to make timely additions after discovering potential blind spots in students' knowledge. Then this paper organized teachers and students to conduct experiments according to the teaching framework proposed in this paper, and found that the teaching objectives, teaching content, teaching methods, and teaching effect of the output of the mathematical model established using the improved BPNN network have a greater impact on the teaching process, while the error between the recognition value and the true value obtained by the improved BPNN method based on the GWO algorithm is very small, which can evaluate teachers' teaching quality and effect more scientifically and accurately and provide useful reference values for further improving the ESP teaching level. In the process of modeling, we find that the GWO algorithm can achieve global optimization, but its convergence speed is slow in the later stage. Considering the influence of other factors, we will further improve the network model in the future research.

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.

Acknowledgments

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Research Article

Optimal Control of the Logistics Automation Transmission System Based on Partial Differential Equation

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In this paper, the finite difference scheme of the spatiotemporal fractional convection-diffusion equation is established, and its stability and convergence are proved. Furthermore, this discrete technique is extended to solve nonlinear spatiotemporal fractional convection-diffusion equations. By using the Krylov subspace method to solve the discrete system, the numerical solution of the spatiotemporal fractional convection-diffusion equation can be obtained quickly. In this paper, an efficient optimal control algorithm is proposed to solve the free control problem of a class of nonlinear time-delay systems. We obtained the optimal control law of the system through the Bellman optimality principle, obtained the asymptotic stability criterion of the system in the form of LMI under the optimal control input by using the Lyapunov stability theory, and discussed the effect of the delay parameter on the system stability. Using the principle of intelligent neural network approximation function, the evaluation neural network and the execution neural network are used to approximate the optimal performance index function and optimal control input, respectively, the optimal control strategy of the system is obtained, and the convergence of the weight estimation error is proved to be optimal. On the basis of optimal state adjustment, the optimal tracking control problem is further solved. Numerical example results verify the effectiveness of the proposed method in terms of stability analysis, optimal state control, and optimal tracking control for the nonlinear time-delay system proposed in this paper. We calculate the parameters of the conveyor and select a reasonable transmission and sorting mechanism to realize the speed regulation of the driving motor of each mechanism. Through the work of each part, the design scheme of the automatic transmission system is formed, and the reliability, practicability, and economy of the system are guaranteed.

1. Introduction

Relying on the current trend of deepening development of the market economy, not only in terms of logistics business and logistics management concepts, but also in the traditional marketing model of enterprises, has undergone a large degree of reform, reducing the total logistics cost of enterprises, especially in the business world [1]. It has become an important way of evaluating factors in the logistics system. A certain change in the development mode of the logistics economy can be used as not only a comprehensive evaluation factor to measure the improvement of the quality and efficiency of the national economy, but also an important component of China's business transformation [2]. Data show that the total cost of logistics in developed countries in Europe and the USA accounts for about 10% of the GDP, but in China, this ratio accounts for about 20%. It can be predicted that in China's economic transformation in the future, the comprehensive development of the logistics industry and the reduction of the total cost of distribution channels will become a new economic growth point [3].

With the rise of the global national Industry 4.0 strategy and the increasingly fierce competition in the face of business, the demand for low-cost and value-added services based on the demand for production and efficient business activities will also increase more and more urgent [4].

Logistics activities include various basic activities such as classification, packaging, handling, loading and unloading, warehousing, automatic transmission, storage, information contact, and processing of items. Among them, automatic transmission is to change the spatial position of items to create its place utility, which is an indispensable and important link in logistics activities. With the development of society and economy, automatic transmission has become more and more complex, and the amount of automatic transmission is sometimes very large. Scientific organization of automatic transmission can effectively reduce the cost of logistics activities and realize the change of the space position of the required items in time to effectively improve its space [5, 6].

Compared with the time fractional partial differential equation, the theoretical analysis of the numerical format of the space-time fractional partial differential equation is more difficult. And because the structure of its discrete system is more complex than that of the time fractional partial differential equation, it will be more difficult to design a fast solution algorithm on the basis of this discrete system. The third work of this paper is to establish a finite difference scheme with a second-order convergence rate in both space and time for the fractional convection-diffusion equation in space and time and design a corresponding fast solution algorithm. To speed up their convergence, a loop preprocessor is proposed. Several numerical examples are given to verify the convergence order of the numerical scheme and test the numerical performance of the proposed loop preprocessor. The main innovation of this work is that on the basis of some previous research work, a numerical scheme with a higher time convergence order is proposed, and the stability and convergence of the scheme are proved. For this type of temporal higher-order numerical format, a fast algorithm is designed with good results.

For a class of nonlinear systems with time-delays, the online ADP algorithm is used to solve the continuous HJB equations with time-delays. By approximating the control input and performance index function simultaneously by two intelligent neural networks, the related optimal control problem of the system under infinite time is studied and analyzed. For a class of nonlinear systems with time-delay and saturated actuators, the control constraints are effectively handled by defining a new performance index function, the online ADP algorithm is used to obtain the optimal control input signal of the system, and a single intelligent neural network is used to approximate the optimal control at the same time. The optimal control of the system is obtained by a more convenient and effective method based on the input and performance index functions. The effectiveness of the algorithm is verified by numerical simulation. This paper analyzes the kinematics of the logistics automation transmission system studied, establishes the rod coordinate system of the logistics automation transmission system, and establishes the linkage kinematics model of the logistics automation transmission system through the Denavit–Hartenberg rule.

2. Related Work

The research on material handling problem is mainly carried out for the design of handling route and handling equipment. With the continuous progress and development of modern logistics, there are many features that are closely related to the automation of handling equipment. Informatization is the basis for realizing automation, and mechatronics is its core. The so-called automation, from the outside, is unmanned, achieving the effect of labor saving. In addition, automation has many advantages, which can improve work efficiency, strengthen logistics operations, and avoid errors in logistics operations. There are many facilities in logistics automation, such as barcode radio frequency automatic identification systems, automatic access systems, and automatic tracking of goods.

Relevant scholars believe that intelligence refers to a higher-level application of logistics automation and informatization [7]. In the process of logistics operations, a lot of decision-making and operational research work will be involved. For example, the determination of inventory levels, the selection of automatic transmission paths, the control of operations, the decision support for the operation and management of logistics distribution centers, and many other issues require the help of intelligent expert systems to be better solved. According to the current trend, it is said that logistics intelligence has become a new hot spot in the development of logistics in the new economic era, and it is the product of the development of the new era. The pros and cons of the AGVS path planning and scheduling control system can determine to a large extent whether the advantages of AGVS can be brought into full play [8]. As far as the current situation is concerned, there are a lot of researches on scheduling algorithms and control technologies. In terms of path planning, the algorithms mainly include Dijkstra algorithm, genetic algorithm, simulated annealing algorithm, and neural network algorithm. In terms of control technology, the algorithms mainly include the fuzzy control technology and forward prediction neural network.

At present, when establishing algorithms and control methods, it is generally necessary to carry out a lot of assumptions and model simplification work in order to better analyze the work [9]. Generally speaking, the AGV speed is constant and the AGV has no faults; however, these assumptions made by us cannot be satisfied by our colleagues. Therefore, how to develop practical algorithms and control methods has become a hot issue in AGVS path planning and control [10].

Regarding the research work on the location selection of logistics planning, there are many methods that are relatively mature at present [11]. According to the space allowed by the facility, they can be mainly divided into two methods: continuous model and discrete model. The so-called continuous model considers that the location of the facility can be arbitrarily selected on the plane, and the location can be selected anywhere on the feasible continuous space. The representative method of this model is the gravity center

method [12]. It is regarded as the best point among the number of feasible points, and it can only allow site selection on some specified discrete points. There are many representative models, such as Kuehn–Hamburger model, Blson model, and mixed 0-1 planning model [13].

Relevant scholars pointed out that the research of automated logistics system is mainly divided into two aspects: the development of traffic planning and design, and the research and development of components of paths and processing equipment [14]. In recent years, automated guided vehicles (AGVs) are important equipment for realizing flexible and fast material handling, due to their high flexibility, automation, easy-to-control integration, and high reliability pursued by many enterprises [15]. The design and control design of AGV automatic transmission route have become the focus of many scholars [16, 17]. Whether the specific advantages of AGV in specific aspects can be fully applied in production practice activities can achieve practical results by optimizing and improving the AGV path planning algorithm and scheduling control system method.

At present, a lot of research and analysis work has been carried out on scheduling algorithm and control technology, and a predictive neural network structure has also been constructed for fuzzy control technology [18]. Considering the currently established algorithms and control methods, in order to achieve better control and analysis work, many assumptions and model styles have been constructed to simplify processing such as autonomous vehicles, but in actual production and life, these assumptions are very difficult [19]. The work is carried out at the same time, so how to adapt the algorithm and control method to the actual development situation has become the research of AGV path planning and has attracted more attention [20].

3. Methods

3.1. Construction of Electronic Map. Existing WLAN positioning principles can be divided into time-of-arrival (TOA)-based, angle-of-arrival (AOA)-based, and received signal strength-based (RSSI). Among them, the positioning technology based on location fingerprints is widely used indoors. First, the technician plans several positioning points indoors, then traverses all the positioning points, and saves one or more features of the wireless signal time, angle, and strength of each positioning point in the database. Afterward, when the device moves to a certain location, the location algorithm can be used to compare and match the real-time received wireless signal time, angle, strength, and other information with the information stored in the database, and then the location of the device can be calculated.

The principle of the two-dimensional code positioning scheme and the RFID positioning scheme is roughly the same. First, technicians plan several positioning points in the positioning environment, then encode and paste the positioning labels at the positioning points, store the encoded information and the position information in a one-to-one correspondence, and store in the database. After that, when the code scanner or card reader on the device reads the code information of a label, the location information of the device can be obtained by comparing and matching the read code information with the information stored in the database using the positioning algorithm.

There are also differences between the two-dimensional code positioning scheme and the RFID positioning scheme, such as label encoding form and label identification method. As far as the electronic map of the rail logistics transmission system is established in this paper, the RFID positioning scheme has the following advantages over the two-dimensional code positioning scheme:

(1) Strong Antipollution ability

Since the radio frequency identification technology completes information exchange and storage without contact with radio waves, when the RFID tag is covered with dust and other pollutants, the RFID card reader can still accurately identify the encoded information in the tag to ensure the stability of location identification without the need for labels which are cleaned regularly using a dedicated vehicle.

(2) Reusable

RFID technology has a long service life, and the encoded information in the tag can be rewritten by the encoder.

Considering factors such as positioning accuracy, ease of use, and maintenance costs, this paper uses the RFID positioning scheme as the basis for building an electronic map.

The construction method of the electronic map is as follows:

First, stick the coded RFID tag on the track at a suitable position, and install the RFID reader on the trolley frame 1-2 cm away from the tag on the track.

Second, the location, distance, and other information of each RFID tag are stored in the location database.

Finally, when the trolley moves to a certain area above the RFID tag, the RFID card reader automatically reads the encoded information stored in the RFID tag and writes it into the automatic transmission controller. By comparing the location database information in the memory, the current specific location of the car can be known and corresponding actions can be performed.

At the same time, the automatic transmission controller will also send the read RFID code information to other devices through the communication network, which is convenient for the overall scheduling of the control system and the control of other devices.

3.2. Research and Analysis of Control System Structure. When the system performs the shunting task, since the station touch screen does not know the status and position of all the trolleys, the node controller will send the shunting command of the station touch screen to the PC host computer. The PC host computer finds the nearest idle car by querying the database and sends the task and task destination information to the car. The trolley will go to the shunting station autonomously after receiving the mission and mission destination information.

The hardware architecture diagram of the subregional controller structure is shown in Figure 1. The whole system has a general controller and several regional controllers. The general controller is responsible for the overall scheduling of all regions and reports the system operation to the PC host computer. An area controller is installed in each area, and the area controller is responsible for controlling all the equipment in the area, including the rail switch, the windproof door, the rail breaker, and the trolley traveling in the area. The general controller sends task information to the regional controllers in the form of communication, including the ID of the task car, and the entrance and exit information of each area the car passes through. The regional controller also reports the status information of each device to the main controller in the form of communication, including the status information and position information of the trolley, the status information and current position information of the rail switch, and the opening and closing information of the windproof door.

The trolley does not belong to the equipment in a specific area, so RFID tags are attached at the entrance and exit of each area. When the trolley reads the RFID tag at the entrance of an area, the automatic transmission controller will interrupt the communication with the previous one. The main controller in an area is the area controller, so the trolley has only a simple built-in control board, which is responsible for controlling the motor drive, receiving data from various sensors and touch screens on the trolley, and establishing communication with the area controller. The area controller and the automatic transmission controller will exchange data periodically. The information sent by the area controller to the automatic transmission controller includes forward, backward, and stop commands, and the area controller receives the information from the automatic transmission controller, including the car status information.

The nonmobile equipment (rail transfer device, windproof door, and rail breaker) in each area except the trolley is directly controlled by the controller of each area.

Under this control structure, the scheduling of the system is completed by the station and the PC host computer, while the specific control of the equipment is completed by the automatic transmission controller and the node controller. When the trolley needs to be derailed, the trolley will establish communication with the current node controller and drive to the destination site with the cooperation of the derailleur.

3.3. Comparative Analysis of Control Structures. On the one-way track, RFID tags and control tags correspond one-to-one. When the corresponding RFID tags are read, the trolley and the rail switch have only one action. On the two-way track and rail switch, when an RFID tag is read, the trolley and rail switch will perform a variety of different actions according to different destination information. In order to distinguish different actions, control tags need to be extended based on destination information to meet diverse control requirements.

When choosing a control structure in practical applications, it is necessary to reasonably evaluate the strengths and weaknesses of the two control structures according to the actual project to make the best choice. When designing and debugging the control system of the two control structures, this paper finds that the two control structures have their own advantages and disadvantages in different aspects.

(1) The control system under the subregional control structure can run independently of the PC host computer, and the control system under the subdevice control structure cannot run independently of the PC host computer. The dynamic scheduling of the control system under the subregional control structure is completed by the general controller, and the specific control tasks are completed by the regional controller. Therefore, when this control structure is used, the lower computer can run independently of the PC upper computer. When the PC upper computer fails, you can still complete shunting, starting, and parking tasks. The scheduling of the control system under the subequipment control structure is completed by the PC host computer and the site touch screen. When the PC host computer fails, the system can only complete the task of starting trains, but cannot complete the tasks of shunting and storing cars.

(2) The reliability of the system under the subregional control structure is lower than that of the subequipment control structure. The control system under the subregional control structure consists of a general controller and a regional controller. Therefore, when the regional controller fails, all equipment in the area will not work, and when the general controller fails, the entire system will be paralyzed. At the same time, when the trolley performs a task, it will pass through different areas. At the joint of the two area controllers, the trolley is easily out of control due to communication or other factors. The control system under the control structure of the subequipment assigns the controller to the trolleys and nodes, so when one controller fails, it only needs to cut off the faulty trolley and nodes, and other trolleys and nodes can operate normally.

(3) The operating efficiency of the subregional control structure system is higher than that of the subequipment control structure. The regional controller in the subregional control structure controls all the devices in the region. At the same time, the regional controller also knows the status information of all the devices before issuing the control command, such as the driving state of the car and the current position of the rail switch. Therefore, the zone controller can directly control all the devices in the zone according to the control algorithm and the device status information, which can save the time for the controllers of the trolley and the rail switch

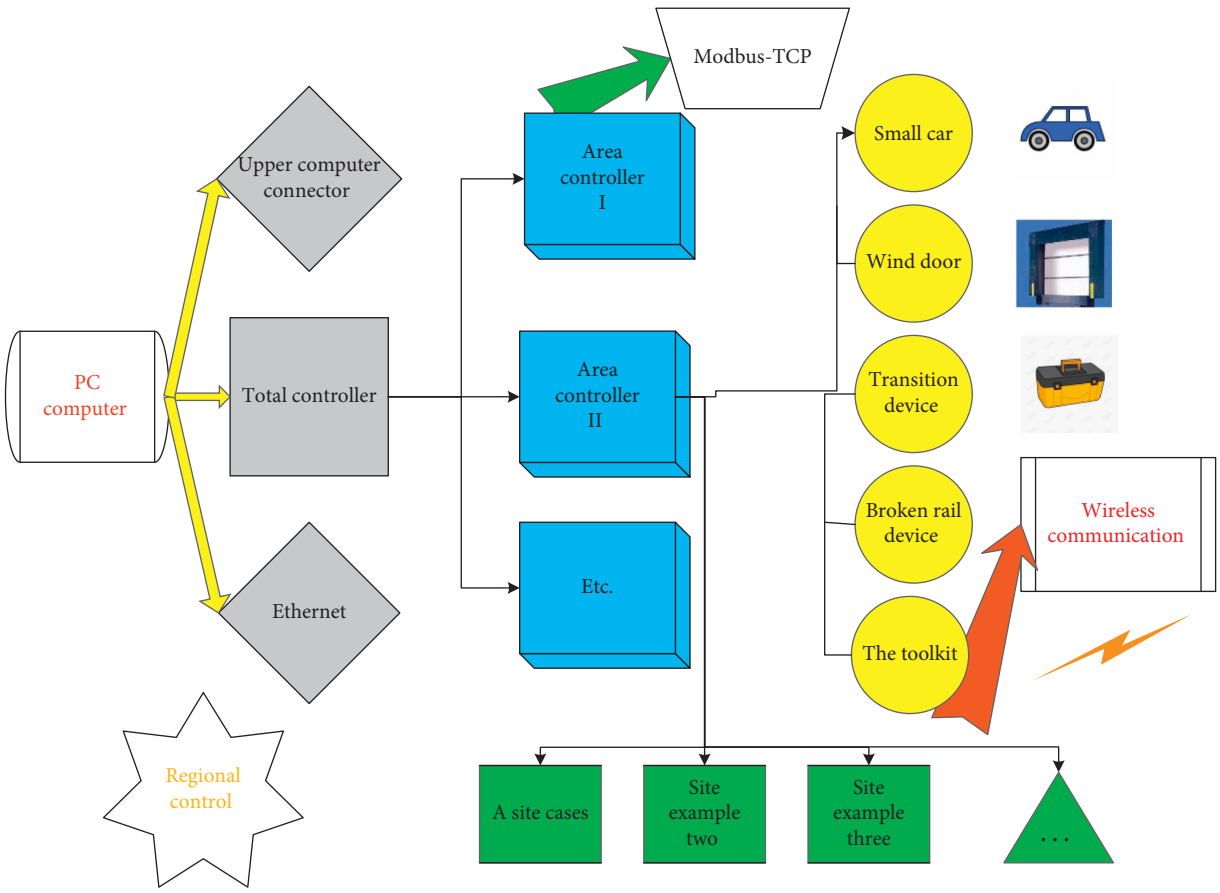

Figure 1: Subregional control structure hardware architecture diagram.

and other devices to communicate and exchange information. For example, in the subzone control structure, when only one trolley needs to pass the rail switch and the rail switch is already in the position of the rail, the zone controller can directly control the trolley to drive on the rail switch without stopping to ask the rail switch position. Under the subequipment control structure, in the face of the above situation, the automatic transmission controller must slow down and communicate with the node controller to inquire about the position of the derailleur and wait for the response of the node controller before proceeding to the next step.

In terms of control flow, the subregional control structure is a top-down three-level control structure.

The first level is the master controller, which is responsible for scheduling. The second level is the zone controller, which is responsible for zone control. The third level is the controller of the trolley and the controller of the rail switch, which is responsible for the specific control of the motor, electromagnetic lock, steering gear, and the data collection of various sensors.

The subequipment control structure is a parallel control structure. The node controller and the automatic transmission controller are not divided into primary and secondary, but collect their own sensor data and control their own motors, electromagnetic locks, and steering gears. When the two controllers need to exchange data, a communication connection can be established to inquire and return various data information instead of issuing instructions or uploading data.

In terms of communication structure, the three-level control structure of the subregional control structure determines that its communication structure is more complicated than the equipment control structure. The subregional control structure needs to establish two layers of communication to ensure that the controllers at each level establish communication connections with the controllers at other levels to issue control commands or upload sensor data.

At the same time, there is a one-to-many communication structure between the general controller and the regional controller, and a one-to-many communication structure between the regional controller and the controller of the trolley and the controller of the rail switch.

In the subequipment control structure, the automatic transmission controller and the rail switch controller in the parallel control structure only need to establish a layer of communication to meet the communication requirements between each controller.

Considering the advantages and disadvantages of the above three points and the actual debugging and verification, this paper finally decides to use the subequipment control structure to complete the design of the control system.

3.4. Communication Scheme. The control system of the intelligent logistics transmission system designed in this paper is a distributed control system, so an effective communication network supporting distributed control and embedded systems is needed to complete the data exchange among various devices. At the same time, the communication network should also have the characteristics of high reliability, high anti-interference ability, strong real-time performance, and high compatibility ability to meet the data exchange requirements of automatic transmission controller, node controller, PC host computer, and other equipment.

At present, the communication schemes applied to the rail logistics transmission system mainly include industrial Ethernet communication, Zigbee wireless communication, and CAN bus.

3.4.1. Industrial Ethernet. Industrial Ethernet is a network communication technology that can meet the needs of industrial sites for strong real-time, good interoperability, high reliability, and strong anti-interference ability of communication networks and is compatible with commercial Ethernet (IEEE802.3 standard). Industrial Ethernet is widely used due to its low cost, fast transmission rate, high stability, and reliability.

Using industrial Ethernet, enterprises can achieve seamless information integration from the field control layer to the management layer, such as the totally integrated automation (TIA) concept proposed by Siemens, and industrial Ethernet supports remote access and remote diagnosis, while the current field bus cannot meet the requirements of the above aspects.

3.4.2. Zigbee Wireless Communication. Zigbee wireless communication technology is a short-range wireless communication technology for inexpensive fixed, portable, or mobile devices and can be used for industrial control, sensing, monitoring, and remote control. It has low power consumption, low cost, large network capacity and security, reliability, and so on. At the same time, Zigbee wireless communication modules can be embedded in various hardware devices, which can meet the diverse design and usage needs of developers.

3.4.3. CAN Bus. With the improvement and development of CAN bus technology, the characteristics of low cost, high reliability, high anti-interference ability, and strong real-time performance help CAN and CAN-based high-level protocols to be widely used in automobiles, process control, numerical control, and medical and electric power. The standard protocol of CAN only defines the physical layer and the data link layer and does not standardize the application layer. Therefore, CiA (CAN in automation) develops an open and standard based on CAN, which provides distributed control and embedded system applications.

Considering the advantages and disadvantages of various communication technologies, this paper decides to use CAN bus technology to construct the communication network of the control system.

The use of CAN bus to build the communication network of the control system is mainly based on the following reasons:

It has high reliability, anti-interference ability, and strong real-time performance.

Its controller using CAN bus technology can easily control some devices that support CANopen communication, such as some high-performance stepping motors that support CANopen communication.

At the same time, other devices that do not support CAN communication can also be connected to the CAN bus through the connection protocol converter, such as CAN to USB, and CAN to TCP/IP.

The nodes on the CAN bus network are not divided into master and slave, and any node can actively send information to other nodes at any time. At the same time, the network nodes can be expanded arbitrarily, and the automatic transmission controller and node controller can be connected to the CAN bus at any time as needed to expand the number of trolleys and stations in the intelligent rail logistics transmission system.

3.5. An Implicit Difference of the Spatiotemporal Fractional Convection-Diffusion Equation. In this paper, a fast second-order implicit difference numerical approximation scheme is proposed to solve the following space-time fractional pair.

Flow-diffusion equation is

$$\begin{cases} {}_0^C D_t^{\theta} u(x,t) = f(x,t) - \left[d + (t)0D_x^{\alpha} u(x,t) + d_{-}(t)xD_L^{\alpha} u(x,t)\right]\left[e + (t)0D_x^{\beta} u(x,t) + e_{-}(t)xD_L^{\beta} u(x,t)\right], & (x,t) \in (0,L)\times(0,T), \\ (t,0) = u0(t) & u0 \le t \le L, \\ u(0,x) = u(L,x) = 0, & 0 \le x \le T. \end{cases} \tag{1}$$

It can be regarded as a generalized form of the traditional convection-diffusion equation. That is, in the traditional convection-diffusion equation, the time first derivative is replaced by the derivative order as the time fractional derivative.

Only very few fractional partial differential equations can give expressions for analytical solutions, and these expressions for analytical solutions are often impractical. This is because there are transcendental functions or infinite series in these expressions. As a result, researchers have turned to

the numerical solutions of fractional partial differential equations and have achieved certain results.

Regarding the numerical methods for solving fractional convection-diffusion equations, most of the early numerical solutions were proposed for spatial or temporal fractional convection-diffusion equations.

In order to obtain an unconditionally stable numerical format, traditional numerical methods for fractional partial differential equations usually produce discrete systems with dense coefficient matrices. In order to reduce the amount of computation, the discrete system obtained by using the displacement, its coefficient matrix is a dense matrix and has a Toeplitz-like structure. More precisely, this coefficient matrix can be written as the sum of some diagonal matrices multiplied by Toeplitz matrices. This also means that its matrix-vector multiplication can be computed quickly by FFT.

In this paper, two preprocessing iterative methods are used to quickly obtain numerical solutions. The two methods are the PBiCGSTAB method and the preprocessed generalized product method based on biconjugate-orthogonal residuals.

3.6. Cyclic Preprocessors for Discrete Systems. Regarding the approximation of the Riemann–Liouville fractional derivative, this paper adopts the WSGD formula.

$$
\begin{aligned}
{}_0D_x^{\gamma}u(x,t) &= h^{-\gamma}\sum_{k=1}^{[x/h]+2}\omega_k^{(\gamma)}u(x-(k-1)h-(k-2)h,t-1)+\mathcal{O}\left(h^2\right),\\
{}_xD_L^{\gamma}u(x,t) &= h^{-\gamma}\sum_{k=1}^{[L-x/h]+2}\omega_k^{(\gamma)}u(x+(k-1)h+(k-2)h,t-1)+\mathcal{O}\left(h^2\right).
\end{aligned}
\tag{2}
$$

This subsection considers the nonlinear case of the equation:

$$
\begin{cases}
\Delta_{0,t_{j+\sigma}}^{\theta}u_i^{j+\sigma} = u_i^{j+\sigma}+\delta_h^{\alpha,\beta}g_i^{j+\sigma}, & 1\le i\le N-2,\ 0\le j\le M-2,\\
u_i^0 = u_i^M, & 1\le i\le N-2,\\
u_0^j = u_0\left(x_j\right)=0, & 0\le j\le M-2.
\end{cases}
\tag{3}
$$

Regarding the construction of the preprocessor, the most basic principle is that the preprocessor should be reversible. Therefore, it is necessary to first prove that the preprocessor is nonsingular.

$$
F^{j+1(l)} = \left[g\left(\sigma u_0^{j+1(l)}-\sigma u_0^j,x_0,t_{j+\sigma}\right),\ldots,g\left(\sigma u_N^{j+1(l)}-\sigma u_N^j,x_N,t_{j+\sigma}\right)\right]^T.
\tag{4}
$$

In this linearized iterative format, each iteration still needs to solve a linear system of equations. This article will directly apply the fast algorithm designed for the linear case.

3.7. Stability Analysis under Optimal Control Input. Through the optimal control theory and the ADP algorithm, we have obtained the optimal performance index function and optimal control strategy of the system under the performance index function. However, whether the stability of the system has changed under the optimal control strategy needs further discussion, so the system stability under the optimal control input needs to be considered next.

$$
\dot{x}(t) = Ax(t-\tau)^2+f(t-1,xt(t-1),x(t-\sigma))u*(t-1).
\tag{5}
$$

Transform the system into

$$
\frac{\mathrm{d}}{\mathrm{d}t}\left(x(t-1)-A\int_{t-\tau}^{t-1}x(u)du\right) = Ax(t-1)+Ax(t-\tau)^2+f(t-1,xt(t-1)(t-\tau),x(t-\sigma))u(t-1).
\tag{6}
$$

It is assumed that no additional dynamics are considered here; that is, the stability of the system is completely equivalent.

Bringing the optimal control strategy into the system, we can get

$$\frac{\mathrm{d}}{\mathrm{d}t}\left(x(t-1)-A\int_{t-\tau}^{t-1}x(u)\mathrm{d}u\right)=Ax^{-1}(t-1)+\frac{1}{2}f(t-1,xt(t-1)(t-\tau),x(t-\sigma))R^2f^TJ_x^*. \tag{7}$$

Suppose the nonlinear function satisfies the following inequality:

$$\left\|\mathscr{F}(t,x,y)-\mathscr{F}^2(t,x_1,y_1)\right\|\leq\alpha\left\|x-x_1\right\|^2+\beta\left\|y-y_1\right\|^2-\gamma\left\|(x-x_1)(y-y_1)\right\|. \tag{8}$$

With the help of tools such as matrix inequality and model transformation, an effective LMI stability judgment method is provided for the system with time-delay. Next, another inequality method (Gronwall's inequality) will be applied to generate a more effective and convenient system stability condition.

According to the lemma (Gronwall's inequality), we obtain the following inferences about the delay parameters, which make the system stable, and obtain the maximum allowable delay range limited by the system matrix by proof.

It should be pointed out here that the obtained stability conditions have nothing to do with the delay parameters of the nonlinear part of the system, which means that the delay parameters can be as large as possible, as long as the parameters satisfy the stability conditions. This shows that the stability of the system under the optimal control strategy has a large enough stability space. In any case, the inference is relatively conservative, and other methods such as matrix inequalities can be used to reduce the system stability conditions in the future.

3.8. Optimal Tracking Controller. The optimal performance index function and optimal control strategy expression of the system are obtained, and the system stability condition under optimal control input is obtained by Lyapunov theory.

It is not difficult to find that the optimal control strategy is a partial differential equation, so it is very difficult for us to solve the optimal control law of the system.

Therefore, the content of this section mainly uses the characteristics of the neural network approximation function to approximate the performance index function and control strategy, respectively.

We use a two-layer neural network composed of an evaluation network and an execution network to achieve online real-time update of the weights of the two neural networks.

This subject uses intelligent neural network to approximate the performance index function, so the square error minimization method is adopted. We need to find a suitable optimal weight adjustment law to minimize the squared error of the definition. Next, based on the Levenberg–Marquardt algorithm (LMA), the weight adjustment rate of the evaluation network is obtained.

So far, we have obtained the dynamic equation of the weight adjustment rate and the weight approximation error of the evaluation network. The weight adjustment law and weight approximation error of the execution network will be solved in a similar way.

After obtaining the dynamic equations of the weight adjustment rate and weight error of the evaluation network and the execution network, it is necessary to further consider the convergence of the neural network. In fact, due to the ubiquitous error of neural network weights, the method of using intelligent neural network to approximate the function can only achieve approximate optimal control.

If an appropriate learning rate is selected, with the continuous convergence of the weight estimation error of the neural network, the control law based on the neural network proposed in this topic will be close to the real optimal control strategy. If the number of neural network layers is continuously increased and the training time becomes longer, the actual control law will be infinitely close to the optimal control strategy until it is consistent.

It is desirable to minimize the system state with the smallest control energy, that is, the optimal state regulation for a class of nonlinear systems with time-delays. According to theoretical research and practical engineering application, the system tracking problem also has very rich research and important significance.

The tracking system selects an appropriate control law so that the actual output of the system tracks the desired output trajectory, and the specified performance index is extremely small. The state regulation problem can be directly transformed into a system tracking problem, and this method is also applicable to the system in this paper.

4. Results and Analysis

4.1. Numerical System Simulation. No matter in the economic system model, the population system model, the ecosystem model, or the growth behavior model, there is a common feature; that is, they are all nonnegative constraint dynamic system models. The nonnegative constraint

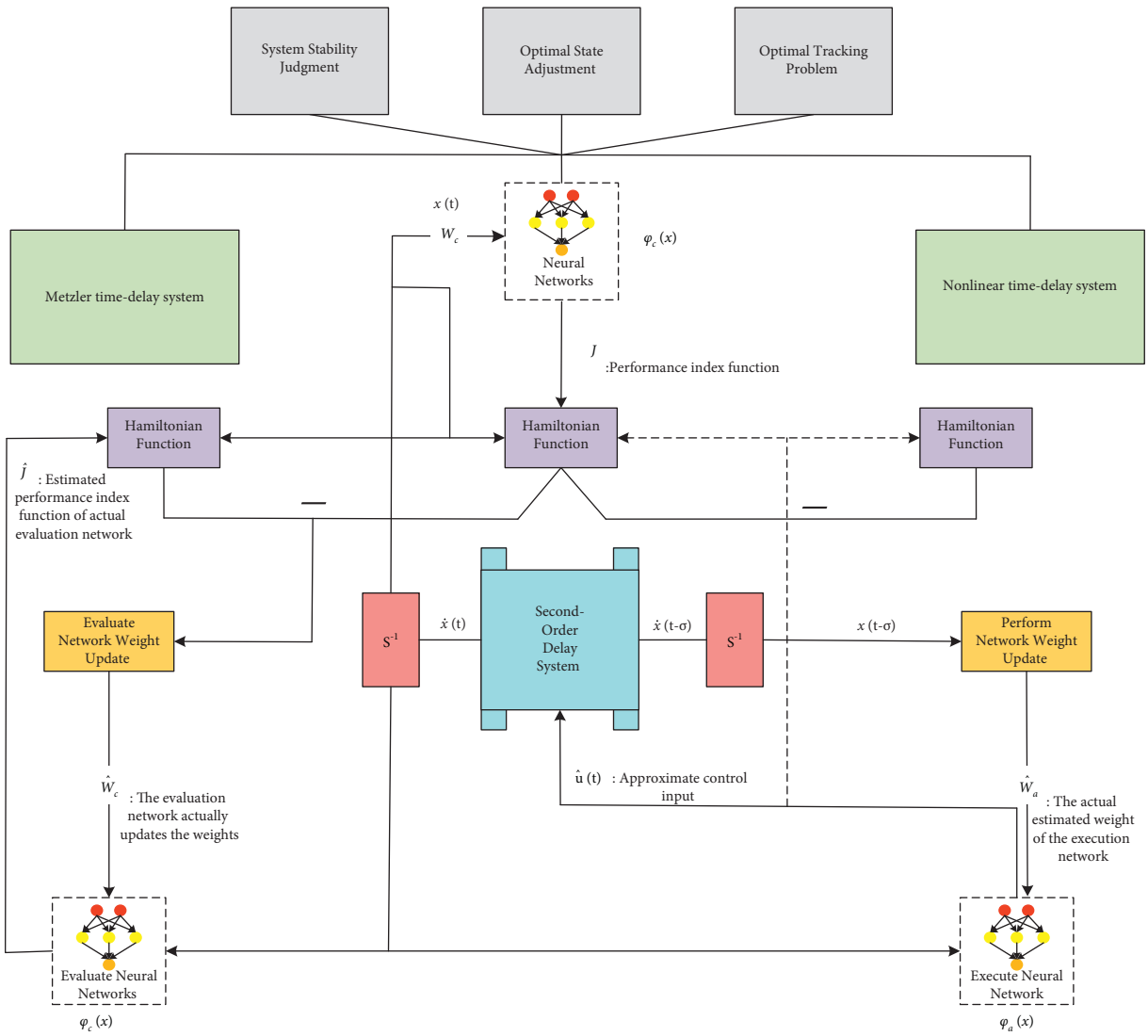

Figure 2: System Simulink simulation module.

dynamic system model is also a common model in the social and humanistic fields. In this paper, the MATLAB software/Simulink module is used to build the system dynamic model. For the system, the simulation module diagram under the optimal control is shown in Figure 2.

In order to better verify the system stability determination method proposed in this subject, we also verify the system state response of the system delay parameters, respectively. Figure 3 shows the control input curve of the system. We can clearly find that the system reaches the optimal control in about 7 seconds, the system reaches the control target in about 21 seconds, and the state response has obvious overshoot.

Figure 4 shows the weight training trajectory of the evaluation network under the time-delay parameter, which shows that the optimal control method based on the neural network proposed in this topic converges to the control law of the actual simulation training. The above simulation results show that the stability analysis method proposed in this paper is effective.

It should be pointed out here that the linear part of the system is the same, and the stability conditions we deduce are valid. The simulation results shown in Figures 5 and 6 show that, for the system proposed in this paper, selecting the state variables and control variables as the performance index function parameters can effectively control the system state to the equilibrium point. This optimal control scheme based on neural network makes the system unstable. The system is finally asymptotically stable, which proves the effectiveness of the proposed optimal control algorithm.

4.2. Simulation of the Logistics Automation Transmission System. This paper is to use the Robotics Toolbox module in MATLAB to carry out the kinematics simulation of the logistics automation transmission system.

Before carrying out the motion simulation of the logistics automation transmission system, the corresponding logistics automation transmission system object should be constructed first. In the MATLAB environment, the

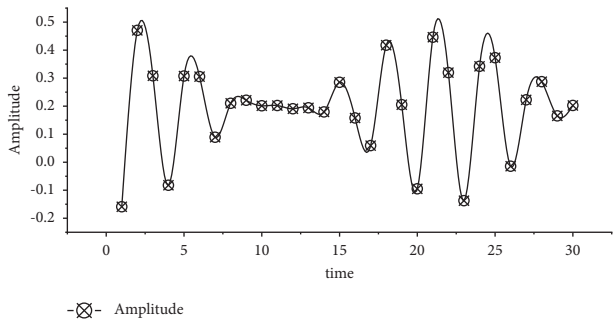

Figure 3: System control input signal curve.

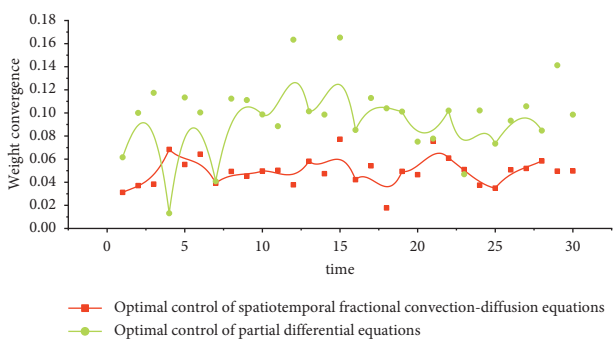

Figure 4: Convergence curve of network weights for system evaluation.

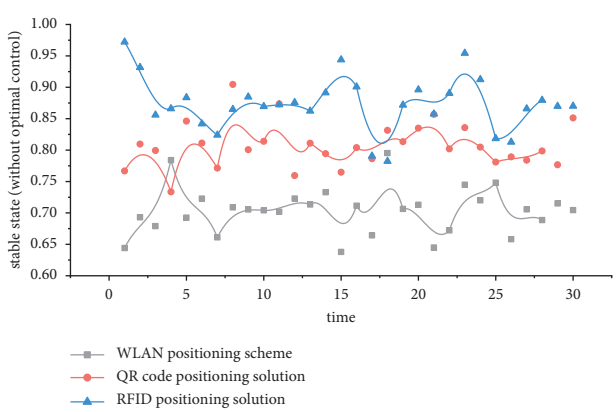

Figure 5: System stability state response curve (without optimal control).

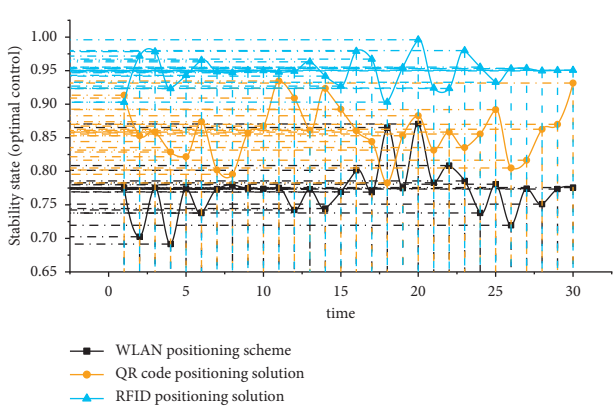

Figure 6: System state stability response curve (optimal control).

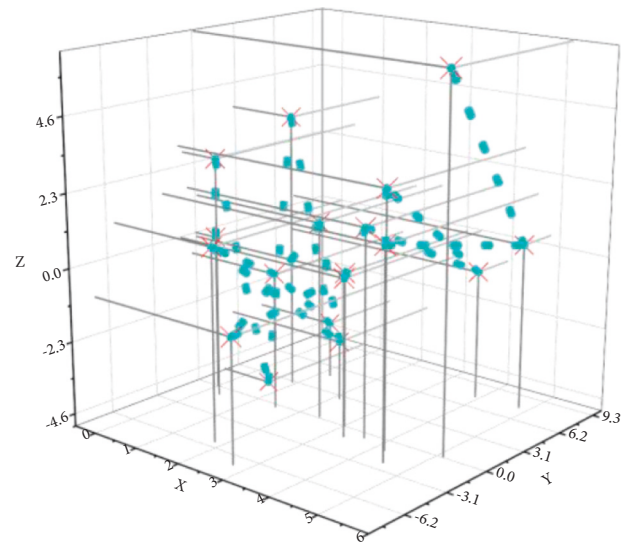

Figure 7: 3D model of the logistics automation transmission system.

Robotics Toolbox module is used to construct each joint through the LINK function to construct the logistics automation transmission system object. The general form of the LINK function is $L = \text{LINK}$ ([alpha A theta D sigma], CONVENTION). "alpha" represents the length of the member, "A" represents the torsion angle of the member, "theta" represents the joint rotation angle, "D" represents the joint distance, and "sigma" represents the joint type (0 means rotating joint, 1 means moving joint). Using D-H method, "CONVENTION" uses "standard." The handling logistics automated transmission system in this paper is constructed by the following statement, named robot:

$L1 = \text{LINK}$ ([0 pi/2 0 0 1], "standard");
$L2 = \text{LINK}$ ([0 pi/2 0 0 0], "standard");
$L3 = \text{LINK}$ ([0 pi/2 1.5 0 1], "standard");
$L4 = \text{LINK}$ ([0 −pi/2 0 0 1], "standard");
$r = \text{robot}$ ({$L1$ $L2$ $L3$ $L4$}, "robot"); % build a logistics automation transmission system and name it plot (r, [0 0 0 0]).

The created three-dimensional model of the logistics automation transmission system is displayed through the plot function, as shown in Figure 7.

Further, the Drivebot command can be used to display the 3D model diagram of the logistics automation transmission system, and at the same time, the logistics automation transmission system can be moved manually by adjusting the slider in the figure. Each variable range sliding bar represents a variable of the logistics automatic transmission system. By manually adjusting the slider, each joint of the logistics automatic transmission system is driven to achieve the purpose of driving the end effector of the logistics automatic transmission system.

The motion simulation can describe the motion process of the logistics automation transmission system in a more detailed and intuitive way. In this paper, the point-to-point motion of the joint in space is simulated, the starting point is

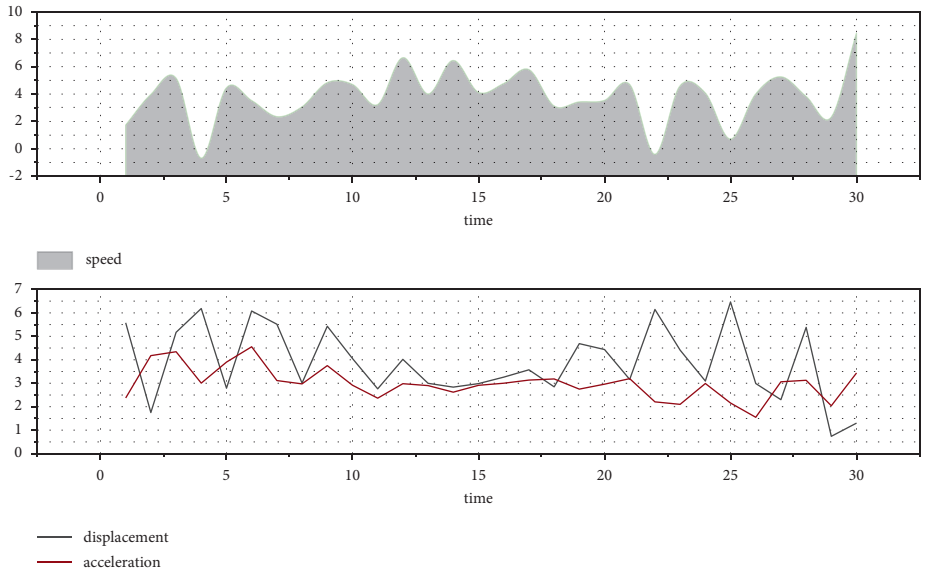

Figure 8: Displacement, velocity, and acceleration curves of the logistics automation transmission system.

qz = [0 −1 0 1], the end point is qr = [4 pi/4 0.2 0.1], and the motion time is 2 s.

Draw the displacement curve of each joint in this process by calling the function [q, qd, qdd] = jtraj (q0, q1, t) and plot (t, q (:, i)), where q represents the displacement and i represents the joint number; this study is the 4th joint. The velocity time curve can also be plotted by calling the function plot (t, qd (:, i)). The acceleration curve is plotted by calling the function plot (t, qdd (:, i)). The displacement, velocity, and acceleration curves of the logistics automation transmission system are shown in Figure 8.

5. Conclusion

The time and space of the linear and nonlinear spatio-temporal fractional convection-diffusion equations are approximated, respectively, and their numerical discrete forms are obtained. Theoretical results show that the two numerical schemes are stable and the space-time convergence order is second order. The linear and linearized systems derived from these two numerical formats, respectively, have a coefficient matrix structure that can be represented at each time step in the form of an identity matrix plus a dense Toeplitz matrix. Aiming at this structure, a Strang loop preprocessor is designed to solve such systems quickly. Numerical experiments verify that the two numerical discrete schemes can indeed achieve second-order convergence in space and time. For a class of nonlinear systems with state time-delay, an adaptive dynamic programming algorithm based on neural network is used to propose an optimal control method, which ensures the stability of the system and makes the performance index extremely small. The HJB equation of the system is obtained through Bellman's principle, and the optimal control strategy of the system is obtained. The stability conditions of the system under the optimal control law are obtained by using tools such as Lyapunov's second method and linear matrix inequality, and the time-delay parameters are obtained. According to the action sequence of the logistics automation transmission system, the reasonable driving mode and control mode are determined to improve the reliability of the control system. The layout of the conveyor is determined according to the requirements of the conveying line, and the model and transmission mode of the conveyor are determined by the parameters such as the size and weight of the automatically conveyed goods, so as to design a reasonable sorting mechanism. The sufficient conditions for neural network convergence are obtained by constructing Lyapunov functions. The optimal state regulation problem is transformed into an optimal tracking problem, and the optimal tracking control of a class of time-delay nonlinear systems is realized. The simulation results verify that the algorithm has a good control effect.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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Research Article

Design and Application of the Digital-Oriented Interactive System for Teaching Preschool Art Education

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In this paper, the design of a teaching interactive system for preschool art education is digitally studied and analyzed, and the teaching interactive system is designed to be applied to the teaching process of preschool art education. It is to design and implement a convenient and feasible art education study and research mutual aid system. The art teaching mutual study and research system is based on the three-layer architecture of NET as the main system structure. The main function of the representation layer is to process the data requested by users and realize the interaction between users. The data layer is mainly to realize the processing of data logic, through the call and operation of the database, to realize the interactive access function of the database. The business logic layer is a relationship in the middle and plays the function of carrying on the top and bottom, realizing the logical processing of the database, and then realizing the business objectives of the system. The design and implementation of the multitier mechanism are of great importance in terms of improving system reliability as well as system compatibility. In the framework of activity theory research, the concept of dynamic integration of digital learning resources is proposed in conjunction with relevant research on digital learning resource integration. The intermediary of the interaction between subjects and digital learning resources in the digital learning process establishes the connection between different subjects through the interaction between elements in the activity system, promotes the accumulation of the number of digital learning resources and the two-way interaction of effective information, and thus realizes the orderly organization and management of the digital learning resource system. The theoretical basis of dynamic integration of digital learning resources, including activity theory, knowledge organization theory, and feedback principle, is discussed in detail in the study to provide a basis for the construction of the theoretical model of dynamic integration of digital learning resources.

1. Introduction

With the continuous progress of curriculum reform, increased kindergarten art teachers have begun to realize that positive teacher-child interaction can mention the teaching quality of art education activities. However, according to the information we have and what we have learned in kindergartens, there are few effective and high-quality teacher-child interactions in art education activities [1]. The common problems are generally divided into two kinds: one is that teachers simply take art education activities to teach art knowledge and art skills and only focus on teaching children's relevant skills in the activities, turning children into a passive role of receiving learning, so they seldom interact with children as teachers and children. The other is that although teachers consciously engage in teacher-child interaction in art education activities, they often select artworks based on their perceptions of children's favorites and preferences, ignoring children's actual understanding and acceptance, and thus even if they do interact with them, it only remains at a shallow level [2]. This study focuses on the art teaching activities of kindergarten middle class and combines the classroom assessment scoring system-preschool version to study the current situation of teacher-child interaction in middle-class art teaching activities, summarizes the characteristics and influencing factors of teacher-

child interaction in kindergarten middle-class art teaching activities, and then puts forward some suggestions and strategies. On the one hand, the study aims to improve teachers' awareness of teacher-child interaction and their professional ability and provide some practical basis for them to carry out art teaching activities effectively; on the other hand, it aims to establish support for teachers to organize art teaching activities more reasonably, carry out teacher-child interaction more effectively, and improve the quality of teacher-child interaction [3].

In this paper, we design and develop a rebel tracking system for digital teaching resources through various technologies, generating digital fingerprints through user registration information, embedding them into the host images, extracting the fingerprints by the distributor to find relevant user information, and confirming the privacy identity information by a trusted third party to track the rebels [4]. The introduction of a monitoring mechanism achieves the purpose of protecting the legitimate rights and interests of distributors and users and achieves the effect of co-existence of usability and transparency of teaching images. Classroom teaching is the most basic component of school education activities, and the development of its teaching activities will directly determine the quality of education and the living conditions of teachers and students in the classroom. Teacher-student interaction is the most effective form of classroom teaching, emphasizing the interaction and mutual influence between teachers and students and students and students in the implementation of educational and teaching activities. This breaks through the shackles of the original "one-way" education and teaching model and promotes the development of education and teaching towards "two-way" interaction, which has a positive effect. At the same time, by tracking the traitor for punishment, it also indirectly protects the copyright of the distributor, brings more freedom to the copyright owner for network distribution and user use, maintains the normal order of the copyright market, reduces the economic loss of the distributor, promotes the reasonable dissemination of digital information, and finally brings inestimable value to the copyright market [5].

2. Related Jobs

The Internet has become the main technical basis and the carrier of access to resources in modern education, and the modern form of education has undergone important changes [6]. The Montessori education system founded by Maria Montessori, which had a great influence on the world, suggests that the environment is the first element of education and that a good or bad environment can influence the cognitive growth of children, so the developmental stage must prepare a suitable environment to match the development of children so that children can develop their instinct of imitation and activity without restriction [7]. Howard Gardner, a representative scholar in art education theory research, suggests that art education can enhance and nurture children's sensitivity at the level of thinking while promoting the harmonious and stable overall development of both mental and physical aspects [8]. In the art teaching classroom environment, he emphasizes that children's ability to create on their own needs to be combined with teachers' guidance and inspiration. The teacher needs to guide children to learn to play independently and, on this basis, provide effective guidance and inspiration, prepare creative materials and relevant theoretical knowledge, and encourage children to develop their ability to create their own opinions and associations about art [9]. Aesthetic education and art education are closely related. As we all know, art is the concentrated and typical form of aesthetics. Of course, the aesthetic education as aesthetic education also takes art education as the main way. However, aesthetic education and art education are not equivalent, but intersecting. They have overlapping parts and different parts.

On this basis, a foreign language information resources integration and optimization model based on autonomous learning research framework is proposed [10]. The main guiding principle of this approach is to use the campus network, which has a large internal bandwidth, as the transmission medium to avoid the problem of insufficient bandwidth in the wide-area network and to take care of the internal users of the school [11]. The campus network-based curriculum teaching aid system is an online teaching platform researched and developed based on the reality that modern education technology and multimedia teaching and computer-assisted teaching are commonly used in schools [12]. The interactive education system currently used is not able to realize the supervision of education research and development, and students can learn through the interactive education system but indeed cannot realize the function of interactive research and development education [13]. Intelligence needs to be further optimized, and there are still certain problems with the intelligent interactive education function [14]. The function is not perfect; the intelligent interactive education system has made certain achievements in recent years, but the interactive education system currently used in China is not yet able to meet this requirement. Therefore, in general, although the interactive education system has achieved great development, there are still great problems, which to a certain extent affect the modernization process of education and teaching, and for this reason, the design of a fully functional interactive education system has important practical significance for the development of modern education.

After-class reviews help students consolidate what they have learned throughout the day. Then, each class should be carefully prepared and designed, the textbooks and teaching materials should be carefully read before class, and multimedia network resources should be used appropriately. Furthermore, in the introduction of excitement, classroom procedures, after-school tutoring, and homework assignments, attention should be paid to students' willingness to learn and acquire knowledge and skills. It provides a new and effective means of solving complex problems through features that can simulate and represent the real or conceived world with high accuracy and assist users in their analysis. The VR system creates a more autonomous learning environment, where users can explore knowledge

through their interaction with the virtual environment, which is conducive to changing the passive learning mode of "teaching for learning" in traditional still life placement teaching.

3. Analysis of the Design and Application of Digital Preschool Art Education Teaching Interactive System

3.1. Design of an Interactive System for Teaching Digital Art Education. Digital learning resource integration belongs to the longitudinal expansion of digital resource integration research in the field of education. Through the previous review of integration and digital resource integration research, this study defines digital learning resource integration as the resource organization and reorganization activity of optimizing the combination of distributed and heterogeneous digital learning resources to meet the diversified learning needs of learners. It includes the class clustering and reorganization of the knowledge content, functional structure, and interactive relationships of digital learning resources.

Digital learning resource integration is a way to effectively organize and manage resources [15]. Analysis of the literature reveals that the current relevant research emphasizes the use of new technologies and the scientific systematization process of research, and the integration model is relatively static and predetermined. However, due to this static characteristic of the integration model of digital learning resources, digital learning resources do not play the expected role, which seriously affects the in-depth development of education informatization construction and the smooth development of learning activities.

In the theory of cognitive development, Piaget mentioned that children in the preoperational stage can think with the help of representations of things because of the emergence of language and symbols, and at this stage, language and representations can be used as tools for children to describe the external world. In the concrete operation stage, children begin to perform logical operations in concrete situations but are limited by concrete objects, so visual instruction is used as much as possible to smooth the transition to the next stage. Children are gradually influenced by concrete objects such as environments and people between each of the two stages. By analyzing children's psychology from this perspective, we can correctly recognize children's cognitive structure in the design process, clarify children's cognitive level for specific objects and the influencing factors in the environment on the one hand, and provide the correct educational psychological basis for the subsequent construction of users, environment, and equipment in the children's art education service system, as shown in Figure 1.

Among them, the login management module can determine the type of user to determine the next page content that can be displayed to the user; the user management module, course management module, and notification management module are under the authority of the administrator; the oil painting masterpiece management module, photography work module, and teacher work management can be operated by both the teacher and the administrator. The administrator is responsible for the forum management function [16]. The login management function module provides a user login page to users when they start using the system, asking them to enter their user name and password, determining their identity based on their name, and displaying the corresponding page on the user interface according to their identity.

The dataset can be considered as a cache, the main role of which is to save the data by querying it. The dataset object is on top of the DataAdapter object, and the dataset object cannot communicate with the data source. The teaching and research support system is a requirement for students to be able to realize the purpose of self-education and learning [17]. The Art Teaching Cloud Platform is a B/S architecture-based teaching network system software, which contains an online teaching system, a work display platform, an assessment system, and a digital teaching resource library. The cloud platform adopts the latest Internet cloud technology and requires no installation or maintenance. The system can be seamlessly integrated with virtual desktop programs or accessed and used directly through a browser. The mobile phone is equipped with an art literacy assessment system developed specifically for secondary school candidates. The textbook editorial committee and outstanding teachers provide an authoritative question bank, with automatic error correction and intelligent scoring to help the secondary school examinations and improve literacy.

The main topic of this paper is to design and implement an art education study and research system. The main function of the representation layer of the system is to process the data requested by the users and to realize the interaction between them. Its data layer is mainly to achieve the processing of data logic, through the call and operation of the database, to achieve the interactive database access function. The business logic layer is in the middle of the relationship, realizing the logical processing of the database and the business objectives of the system. The design and implementation of a multilayer structure can improve the reliability of the system as well as its compatibility of the system. The Art Teaching and Research Mutual Aid System combines the relevant technologies of NET and SQLSERVER to ensure application security through the design of access rights and control of user roles. The system can achieve the functions of login, online learning, forum exchange, online homework, and online testing in art teaching, as shown in Figure 2.

Detailed refinement is initially established by the system analyst after a detailed analysis of the system's requirements, the functions, and the scope of the system, as well as the structure of the system in the design and implementation process and decision options. Through the system, you can further clarify the system performance and system functionality on this basis, and at the same time, you can clarify the element interfaces needed for the system interfaces and constraint software [18]The requirement analysis provides a detailed analysis of the data model and other functional

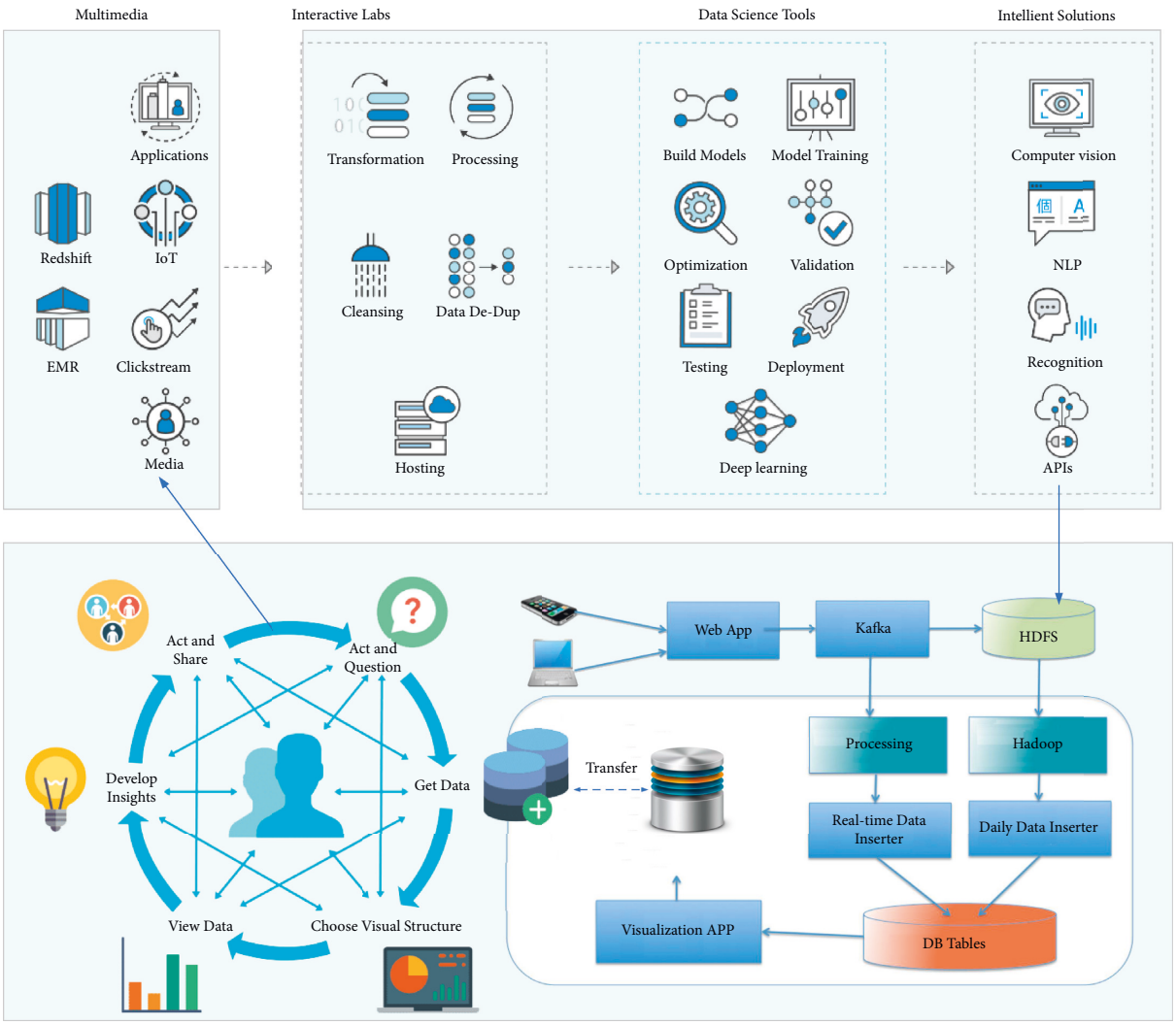

Figure 1: Digital system framework.

models of the software system. NET technology is flexible, secure, scalable, accessible, and browser-independent. The test uses a browser-server architecture, consisting of a database server [19]. In the process of art design teaching, teachers introduce virtual reality technology, which helps students to observe operations and changes that they cannot usually see and transform abstract teaching knowledge into intuitive and specific teaching content, making it easier for students to accept and grasp quickly. At this stage, the application of virtual reality technology is more and more extensive, and the application in the structural design of pictures, text, and space can help students to deepen their understanding of knowledge.

3.2. Experiment on the Application of the Interactive System for Teaching Preschool Art Education. Analyze the user's network environment configuration before design, so that the architecture designer can design a feasible system architecture according to the user's specific situation; investigate user preferences and provide relevant basis for system designers.

Many information systems pay more attention to the system in the design process, and it seems to meet the basic needs of users, but often when the system is put into use, many problems are found, and many functions are not able to meet the needs. Proficiency in professional knowledge is also not ideal, and the system often ignores these aspects of the requirements in the design process, thus bringing great trouble to the use of the system. Therefore, it is very important to determine the corresponding indicators in advance in the design process of the system, so we provide a detailed analysis of the basic business processes of each module.

The function of the parent side is to receive classroom feedback and brand promotion, while the teacher side assumes more of an assistant role in the whole service model than the parent side. Since most of the situations are in the field studio, the App has a wide and shallow hierarchical distribution, which is easy for teachers to operate quickly.

Based on the research at the Storybrooke Children's Art Studio, we made a service blueprint as a reference basis for user trajectory, mainly from 4 stages: enrollment, class, and after class. Among them, the research focused on the review

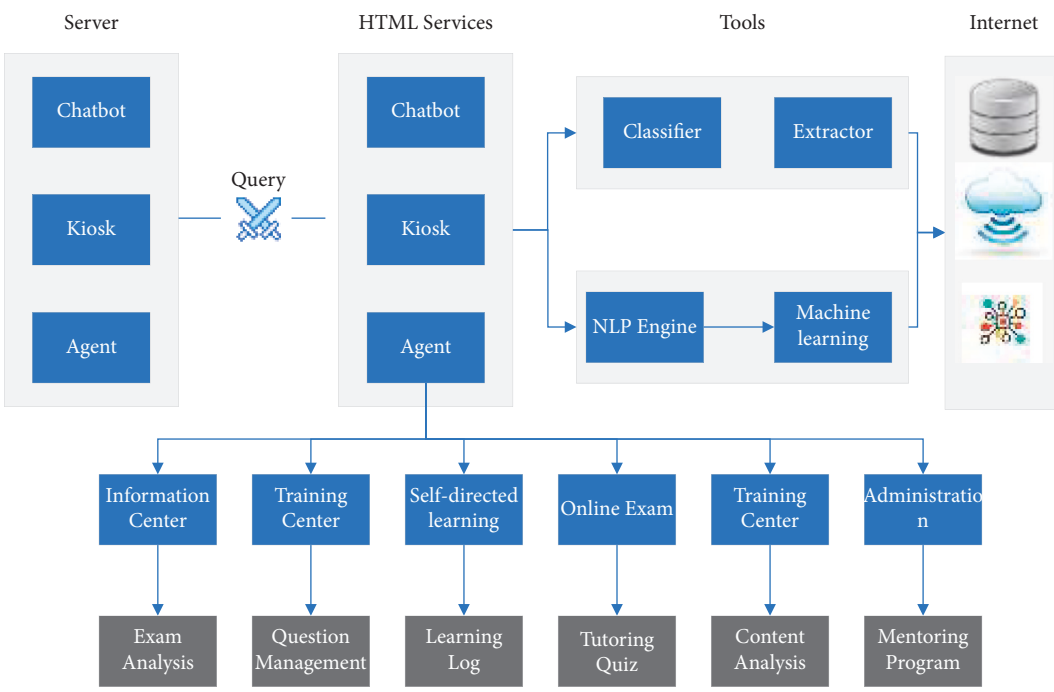

Figure 2: Overall scheme.

and feedback of the studio students after the class [20]. In the three stages of registration, class, and after class, students are guided by their parents and teachers, and their self-cognition consciously follows the guidance and is established, which is a gradual process, while in the after-class stage, the knowledge students learn from the classroom is developed, and their cognitive ability is gradually substituted into areas other than the studio environment, such as handwriting assignments and artwork competitions assigned by the school class, the gradual rise of examinations, that is, the assessment of art teaching through the generative assessment system, has also become an important basis for assessing ability, as shown in Figure 3.

First, the usability of the whole system is tested, and the causes affecting the usability of the whole system are analyzed vertically. Secondly, the usability of three functional modules was tested, the reasons affecting the usability of each functional module were analyzed vertically, and the contribution of the usability of each functional module to the usability of the whole system was analyzed in a horizontal comparison. The content and usage of the scale were briefly explained in the previous section. To facilitate the use of the scale by the participants, the authors made appropriate modifications to the presentation of the questionnaire to indicate that it was an evaluation of the virtual system of still life placement, for example, in the scale for the copying function, the word "system" in each question was changed to "copying function."

Based on the conceptual connotation, this study expands the research framework of the third generation activity theory, and the dynamic integration of digital learning resources is divided into two different dimensions, which are the implementer dimension and the learner dimension so that when analyzing the relevant elements, it is necessary to

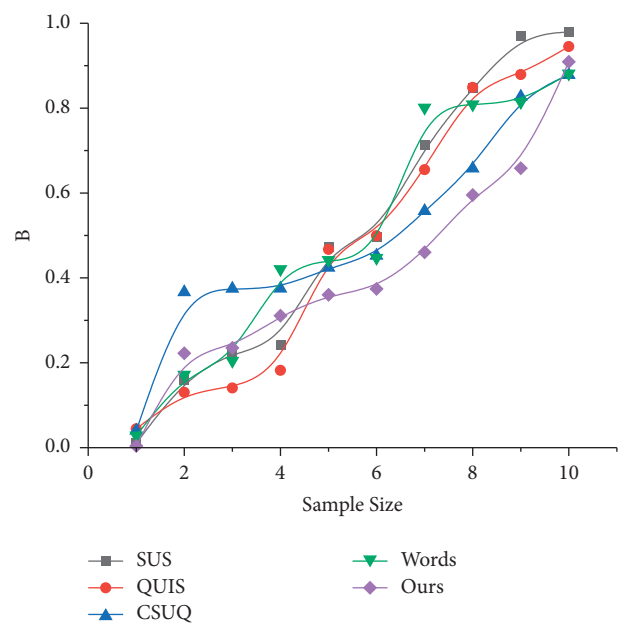

Figure 3: Accuracy of each scale at different sample sizes.

discuss them from these two dimensions. The sharing and co-construction of educational resources is the only way for teaching reform, educational innovation, and social development. As the core foundation of educational resource sharing and co-construction, digital curriculum resources must undertake the important mission of building a digital curriculum resource sharing mechanism. How to achieve the sustainable development of digital curriculum resources as the primary goal requires the sharing and co-construction of digital teaching resources to continuously innovate and improve. The digital curriculum resources established on the

premise of sharing and co-construction are disseminated through the Internet platform, with points leading to areas and local areas promoting the whole. Link the resources of the national education system, create a new educational concept of sharing and cooperation, and promote the deeper, more autonomous, and more sustainable development and sharing of digital curriculum resources.

The objects in the dynamic integration of digital learning resources include open learning resources distributed in the future, digital learning resources in commercial databases, and other forms, which are the basis for the learning process of learners and the target objects of the dynamic integration of digital learning resources. The dynamic integration of digital learning resources is the "intermediary" for the implementer and digital learning resources, i.e., the tool used by the implementer in the process of integrating digital learning resources, and in the implementer dimension, its role is mainly to achieve the accumulation of quantity, as shown in Figure 4.

In the implementer dimension, learning resources are based on the knowledge characteristics of digital learning resources, and knowledge organization tools and methods are used to classify, cite, and deepen the knowledge content of related resources, thus forming a collection of related resources. The community in the implementer dimension includes relevant elements such as teachers and learners, who are in the same learning context and have the same learning goals. Driven by the teaching objectives, teachers collect, select, and use digital learning resources to carry out a variety of teaching activities, which include digital learning resource management and other activities in the process, and are the backbone of learning resource design and construction [21]. Learners use digital learning resources to carry out their usage, and we used evaluation information directly to reflect the effective degree of integration of digital learning resources.

The tool is the intermediary used by the subject of the activity to complete the corresponding activity, and the intermediary connects the subject and the object of the activity and guides the interaction between them. The subject uses the tool to complete the specific operation of the object, and the operation triggers the corresponding action, thus completing the process of the subject's activity. In this study, the dynamic integration of digital learning resources serves as a tool for effective organization and management of related resources. Under the role of different activity subjects, the dynamic integration of digital learning resources plays its role, establishes the connection between different activity subjects by the learning platform, and realizes orderly organization.

In the process of dynamic integration of resources, knowledge organization theories and methods provide corresponding rules and specifications, especially in the organization, which provide learners with effective information about the learning process and enhance the learning experience through multidimensional descriptions of attribute characteristics and knowledge content based on characteristics of digital resources. Conducting scientific training is another important function of the Science Museum. Compared with the conventional training methods,

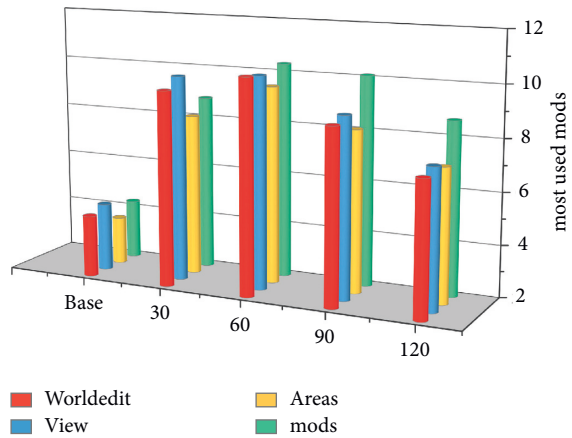

Figure 4: The cumulative effect of digital learning resources in quantity.

the virtual laboratory established by using virtual reality technology can conduct virtual training for people, with a realistic environment and a sense of "immersion."

4. Analysis of Results

4.1. Design Performance Analysis of Teaching Interactive System. Therefore, form testing is very important to determine the correctness of the form operation function through form testing. For example, users need to submit their user names and passwords in the process of logging in to the system. If the form accepts only specific information, then it must be tested, for example, if it accepts only characters, then the system will see if the error is realistic by skipping characters. The form in this article was tested and found to be able to perform its operation.

White-box testing is also known as structural testing, transparent box testing, logic-driven testing, or code-based testing. White-box testing is an approach to test case design where the box refers to the software being tested and the white box means that the box is visible and you know exactly what is inside the box and how it works. The "white-box" approach provides a comprehensive understanding of the internal logic of the program and tests all logical paths. The "white-box" method is an exhaustive path test. When using this option, the tester must examine the internal structure of the program and start by examining the logic of the program to produce test data.

At present, most online examination systems are implemented by structured analysis and design, which inevitably leads to shortcomings in code reusability and readability, and all functions are implemented on the server side. There is also a lack of experience. Database testing has a very important role in the website, the database is the most important part of the information system, and the correctness of the database function is directly related to the whole website function. Through the test related to each function of the database, we found that the database of the art teaching and research system established in this paper can realize the operation of the system. High performance and multifunctionality are the important goals pursued in

the design and implementation of information systems. The system was tested in terms of functionality and performance, and the forum function was selected as one of the system functions. Through the survey of system users and their feedback information, it is known that the platform is relatively good in the use of various functions, but the overall design of the system still has certain defects and needs further improvement. After a large-scale trial, quantitative tests will be implemented to obtain more detailed data, as shown in Figure 5.

Figure 5 shows a cross-sectional comparison of the usability scores of the theoretical, copying, and practical functions of SUS. The authors believe that the three main reasons for the difference in usability are that the theoretical function involves a more common graphic display, the copying function involves a simpler interaction, and the practice function has a more novel form of interaction. Overall, the first functions contribute more prominently to the usability of the overall system.

We know that light and shadow have an important role in the embodiment of beauty. In the traditional still life placement, the volume relationship and texture characteristics of still life are more obvious, but this constant light source is also difficult to stimulate students' perception desire. Natural light is sometimes unchanging and sometimes suddenly variable, with subtle, harmonious, and vivid effects on the form, tone, and spatial level of the still life, but this instability also brings some trouble to the learners' observation.

Adjusting the intensity of the light can achieve the effect of sunshine on overcast clouds. As the light covers the whole scene, the control of the color of the light will affect the tone of the whole group of still life, which has the effect of unifying the tone, and the user can change between cool and warm light at will. Dividing the dynamic integration of digital learning resources into two dimensions is for the need of theoretical analysis and activity design, but in fact, these two dimensions are closely intertwined with internal consistency, goal consistency, and close correlation, as shown in Figure 6.

On the one hand, dynamic integration is the accumulation of the number of digital learning resources in different activity systems through the interaction of basic elements such as activity subjects, objects, tools, rules, communities, and division of labor. On the other hand, the dynamic integration of digital learning resources is achieved through the interaction of different activity subjects, i.e., in the process of education and teaching practice, learners carry out a certain amount of resources, and with the help of the functional design of the dynamic integration of digital learning resources, effective evaluation and feedback information about the digital learning resource system in the learning process are transmitted to the implementer. The two-way interaction of information realizes the orderly organization and management of relevant resources.

Specifically, the left dimension is the basis of the right dimension and the right dimension is the test of the left dimension, both of which are designed to better play the supporting role of digital learning resources in the digital

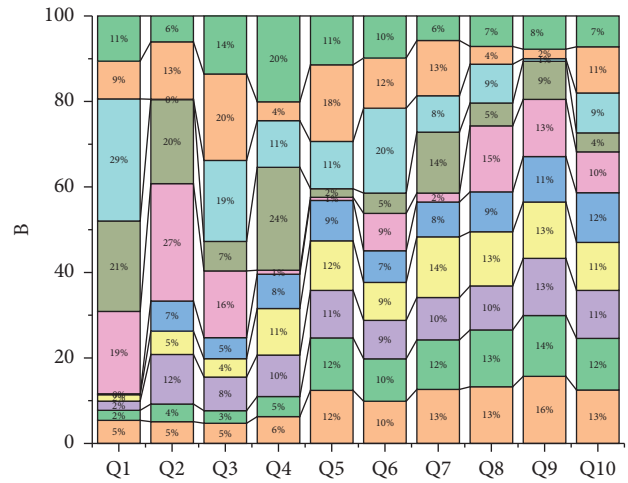

Figure 5: Usability evaluation of the whole system.

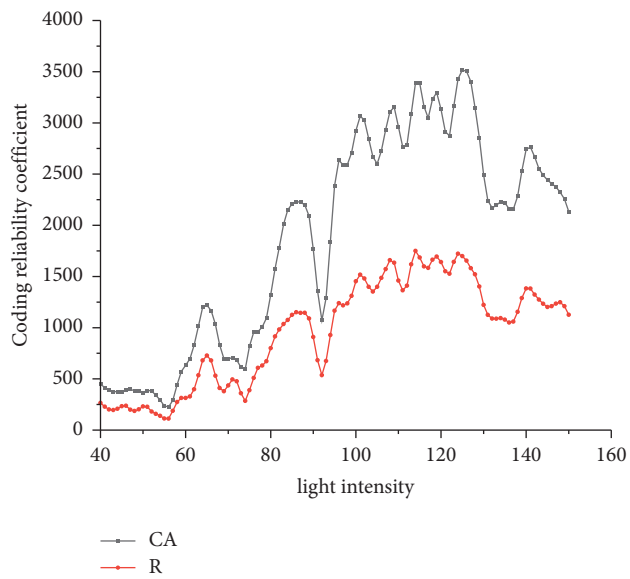

Figure 6: Categorization consistency and coding confidence coefficient.

learning process and are dynamically mapped in the digital learning activities, reflecting the "learner-centered" design concept and making it a reality. This means that the resources are dynamically mapped onto activities, reflecting the "learner-centered" design concept and turning it into reality. In the specific study, the process of dynamic integration of digital learning resources is expressed through the specific operations of different activity subjects and thus provides an operational practice for teaching applications. On the basis of relevant research, the research method combining qualitative and quantitative research is adopted, and the concept of "dynamic integration of digital learning resources" is innovatively proposed, and starting from the research problem, the concept of dynamic integration of digital learning resources is defined. Construct the theoretical model of the dynamic integration of digital learning resources and carry out research on the teaching application

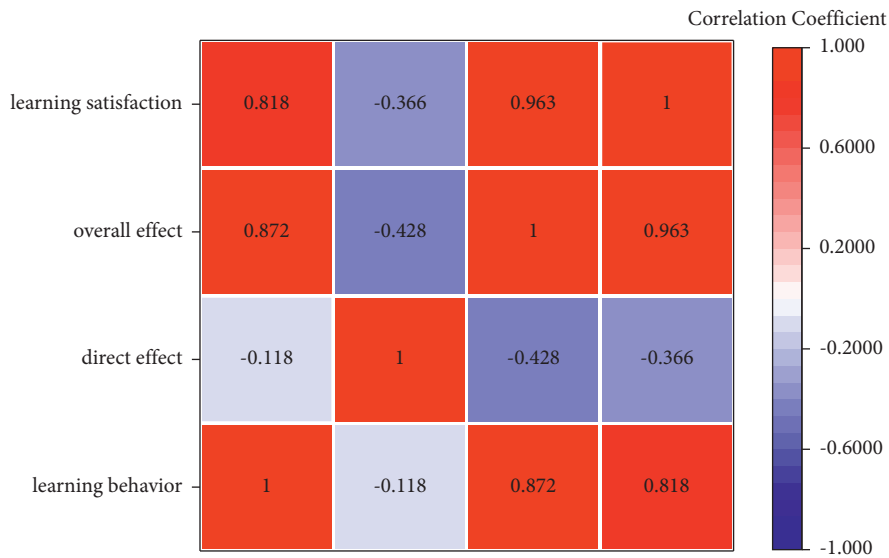

Figure 7: Latent variable effect relationship.

of the dynamic integration model of digital learning resources and the evaluation and analysis of the dynamic integration model of digital learning resources.

4.2. Analysis of Application Experiment Results. Although the dynamic integration effect model of digital learning resources proposed in this study is based on the relatively mature technology acceptance model and the information system expectation confirmation model, the two models are combined and new influencing factors are added in the specific study. To explore the path relationships of effects more accurately among the variables in the theoretical hypothesis model, this study first adopts an exploratory-oriented structural equation analysis based on the partial least square method to conduct an exploratory analysis of the survey data and initially test the reasonableness of the overall fit of the theoretical model and the assumption of path relationships among the variables. The VIF should be less than 5, and then the model estimation is more accurate. SmartPLS uses the variance inflation factor as a diagnostic indicator to test the covariance of the model, as shown in Figure 7.

The indirect effects of external factors on learners' satisfaction, continuous use intention, and learning behavior were 0.25, 0.33, and 0.15, respectively, by positively influencing perceived ease of use and expectation confirmation, i.e., the higher the quality of content and ease of use of the dynamically integrated digital learning resources system are, the more it is conducive to increasing satisfaction and continuous use. The higher the expectation confirmation is, the more conducive it is to enhance learners' satisfaction, which in turn enhances their willingness to continue to use and their continued use behavior.

The indirect effect of the degree of expectation confirmation on learners' willingness to continue using the system and their learning behaviors was 0.50 and 0.23, respectively,

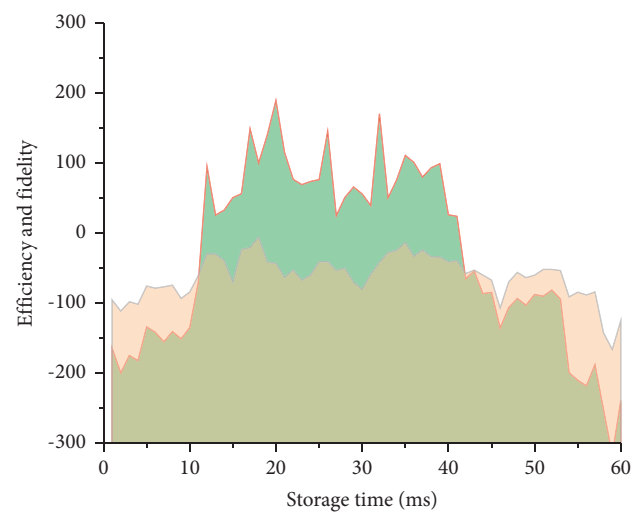

Figure 8: Analysis of experimental results.

which means that the higher the degree of satisfaction of learners' psychological expectations before using the system, the more they think that using the system is valuable for improving their learning performance and accomplishing their learning goals, and the higher their satisfaction, the more their willingness to continue using the system.

The learner satisfaction indirectly influences learners' continuous use behavior by affecting learners' willingness to use, and their indirect effects are 0.17, 0.20, and 0.24, respectively, i.e., convenient platform operation, perceived usefulness due to system content quality, and satisfaction due to effective use continuously increase learners' intrinsic willingness to use and indirectly promote continuous use behavior, as shown in Figure 8.

Overall, the scale and effect of digital learning resources construction are related to the deepening of informatization construction. After years of construction and development, in the construction of digital learning resources, the

emphasis on infrastructure construction in the initial stage has developed to the joint participation of multiple forces in the construction until the current abundance of various types of resource libraries and high-quality resources in quantity, which all provide a solid resource foundation for learners to carry out various forms of digital learning.

5. Conclusion

This study aims to address the instructional feedback problem that exists in the children's art teaching system, to positively reinforce the motivation of children with instructional evaluation, create a positive and enjoyable teaching experience for them, and visualize feedback information for teachers and parents. Based on the cognitive development theory, the feedback method of obtaining prizes with quantitative teaching evaluation makes the children pay equal attention to the results of teaching and learning after class. Teaching phonics, physical education, and aesthetics have always been key areas of extracurricular teaching for children. Along with the upgrading of the education industry and the renewal of the market, the future teaching evaluation feedback is more diversified and the evaluation criteria tend to be more comprehensive. Parents and teachers can visualize children's teaching process and cognitive development stage process with the help of the teaching evaluation feedback system, and children are rewarded based on the results of teaching evaluation feedback, thus positively reinforcing learning behavior and forming a virtuous cycle. Interactive teaching and learning are characterized by a focus on developing specific, concrete strategies to promote understanding. In practice, interactive teaching values mutual support and facilitation between learners; teachers should help students to discuss their understanding of the text rather than just repeat words and phrases; they should be flexible in using students' understanding and linking it to new knowledge; conversations should be thematic and directed; both students and teachers should understand the objectives of the teaching, and teachers' comments on students' statements should lead to more positive constructive responses. Interactive teaching and learning is a method of teaching and learning in which the teacher's teaching and the students' learning interact equally and autonomously around a particular problem or topic in a micro-teaching situation and on a multipoint free-cutting teaching platform.

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

Research on Super-Resolution Relationship Extraction and Reconstruction Methods for Images Based on Multimodal Graph Convolutional Networks

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This study constructs a multimodal graph convolutional network model, conducts an in-depth study on image super-resolution relationship extraction and reconstruction methods, and constructs a model of image super-resolution relationship extraction and reconstruction methods based on multimodal graph convolutional networks. In this study, we study the domain adaptation model algorithm based on chart convolutional networks, which constructs a global relevance graph based on all samples using pre-extracted features and performs distribution approximation of sample features in two domains using a diagram convolutional neural network with maximum mean difference loss; with this approach, the model effectively preserves the structural information among the samples. In this study, several comparison experiments are designed based on the COCO and VG datasets; the image space information-based and knowledge graph-based target detection and recognition models substantially improve recognition performance over the baseline model. The super-pixel-based target detection and recognition model can also effectively reduce the number of floating-point operations and the complexity of the model. In this study, we propose a multiscale GAN-based image super-resolution reconstruction algorithm. Aiming at the problems of detail loss or blurring in the reconstruction of detail-rich images by SRGAN, it integrates the idea of the Laplace pyramid to complete the task of multiscale reconstruction of images through staged reconstruction. It incorporates the concept of a discriminative network with patch GAN to effectively improve the recovery effect of graph details and improve the reconstruction quality of images. Using Set5, Set14, BSD100, and Urban100 datasets as test sets, experimental analysis is conducted from objective and subjective evaluation metrics to effectively validate the performance of the improved algorithm proposed in this study.

1. Introduction

With the continuous development of information technology and the popularity of intelligent terminal devices, people's demand for information is also rising: from images in the 2G era to pictures in the 3G era, then to images in the 4G era, and then to holographic images such as AR and VR in the 5G era, the amount of information is rising, while the occupied storage is also exploding [1]. This considerably impacts the daily dissemination of information—the network speed cannot keep up, and the hard disk cannot store it. Therefore, there is an urgent need for an efficient means of information compression to help compress information to improve transmission efficiency and reduce the storage footprint [2]. With the development of high-performance processors, high-definition screens are becoming more and more popular with the emergence of intelligent devices. However, most media information on the Internet is still dominated by low-definition images, resulting in data quality not keeping up with display quality, thus reducing the user experience [3]. In addition, due to the limitations of image storage hardware, the resolution of images is limited, and the size of the smallest pixel determines the details that can be displayed. But the real world is often infinite, so people also want to much detail as possible in the image they can get. The solutions to the above pain points can be

summarized as the compression and decompression of information. The most immediate and effective solution to reduce the image size is to store and disseminate multimedia information, especially the most informative image information, and reduce the image's resolution.

Super-resolution reconstruction (SR) technique is to reconstruct a single or multiframe low-resolution (LR) image into a high-resolution (HR) photo by applying specific image processing and other methods to achieve high-quality images. Usually, CNN-based target detection and recognition models use sliding windows or anchors to extract possible foregrounds and hardgrounds [4]. Then, the final localization frame is generated by identifying and regressing all possible foregrounds. By relying on the graph convolution network, we can obtain more abundant information about the location of the object picture. For example, by relying on the inference of the spatial map, we can roughly determine the object's position and then fine-tune it according to work. Therefore, we can design more flexible and efficient positioning methods to generate positioning frames [5]. This study develops several graph convolutional network detection models acting in spatial, beyond-pixel, and knowledge graphs. We extract features beyond pixels to assist pixel information for accurate target detection and recognition. Finally, the experimental and comparative analyses of the model on the COCO dataset and VG dataset prove that the target detection and recognition model based on a graph convolutional network can break the bottleneck of image pixel recognition to a certain extent and help the target image to achieve better object recognition and localization [6].

Image super resolution is used to solve the problem of recovering low-resolution images to high-resolution images. Image super resolution aims to up-sample a series of low-resolution photos output by a deterministic or uncertain degradation model to high resolution while providing more detail than low resolution [7]. Traditional upsampling algorithms have a solid prior relationship, considering that there is a specific mathematical relationship between neighboring pixel values so that the original pixels can be recovered by interpolating adjacent pixels. In the forward propagation process, each sample feature is transformed independently, which may lead to the separation of target domain features that are initially in the same class under the influence of the distribution difference function and eventually classified into different categories [8]. It enables problems with unstructured relationships, such as citation networks, to be well trained by importing correlation graphs between samples [9]. This feature also helps to compensate for the shortcomings of existing domain adaptation algorithms. Graph convolutional networks can be considered as a particular case of graph networks. In this study, we intend to study the scheme and practice of introducing chart convolutional networks into domain adaptation problems to improve the learning performance of domain adaptation problems, make a new direction to explore migration learning tasks, and provide a feasible solution for learning scenarios where labeled information is challenging to obtain [10]. The study of domain adaptation algorithms can effectively reduce the need for data annotation and enable various algorithmic models to have fast learning performance for similar tasks and improve their generalization and robustness, which is of great significance in various real-world tasks, where annotation information is not readily available.

2. Related Works

The graph convolution layer is a simple extension of the fully connected layer that integrates valuable information from the knowledge graph into the feature vector, and the intuitive understanding of the graph convolution layer is simple. By importing a relevance graph (knowledge graph) into the neural network, the graph convolution layer can change the distribution of the feature vectors through the relevance variable of the relevance graph so that the relevant samples are closer to each other [11]. This feature facilitates the data to obtain and maintain useful structural information during the distribution approximation process, thus avoiding the loss of similar structures in the source domain caused by migration learning and improving the network performance. Some scholars have already researched migration learning using relevance graphs and convolution layers. When using local relevance graphs obtained by random sampling, neighboring samples may not be sampled simultaneously, making the graph convolution performance degrade. Altinkaya et al. first identified a few pieces by random sampling, they then added both the first-order and second-order neighbors of these samples to the set to be selected before selection, and the sampled set was guaranteed to correlate with the models [12]. Chadha et al. interpret graph convolution as an integral transformation of the embedding function under probability measures and use Monte Carlo methods to estimate the critical values [13]. They propose an important sampling method, in which the sum of the relevance weight values of each sample to other samples is used as the sampling weight. The above sampling is performed once in each graph convolutional layer; good results are obtained in the referenced network dataset.

Among the reconstruction-based methods, projection onto convex sets (POCS) is proposed by Hong et al. This algorithm is based on the set projection theory of mathematical sets and can converge relatively quickly [14]. The iterative back-projection (IBP) method proposed by Kocsis et al. projects the error value between the input low-resolution image and the low-resolution image obtained from the degradation model backward onto the corresponding high-resolution large print, and the error converges continuously to reconstruct the sizeable high-resolution image [15]. Yanshan et al. proposed the maximum a posteriori probability (MAP) algorithm, which solves the image super-resolution reconstruction by probabilistic estimation in mathematics, the prerequisite is the low-resolution image sequence, and the goal of the algorithm is to obtain the maximum a posteriori probability to reconstruct the sizeable high-resolution image [16]. Chen et al. proposed the

neighborhood embedding method, which first maps the local geometric information of the low-resolution image block to the corresponding high-resolution photo and then uses the linear combination to map the neighborhood to produce the high-resolution image block [17]. Many subsequent researchers have made optimization improvements to the neighborhood embedding-based method. The super-resolution algorithms have been explored around how to recover more OK texture information and edge details based on higher super-resolution magnification. Although traditional methods have low complexity, it is not easy to make a significant breakthrough in super-resolution reconstruction quality and visual effect [18]. Deep learning methods require a large amount of training data compared with traditional learning-based methods. Still, they can recover more full image details and texture information by using neural networks' powerful feature representation capability to learn the complex mapping relationships between low- and high-resolution images [19]. In recent years, many results have emerged in the field of deep learning and achieved better performance and performance compared with traditional algorithms, especially the introduction of a new and more challenging generative model: generative adversarial networks, which opens a new world in the field of image super-resolution-based research.

The multi-image super-resolution task is also known as the image super-resolution task. The significant difference between a multi-image super-resolution task and a single-image super-resolution task is that the single-image super-resolution task mainly models the image scene and the mapping between pixel distributions by learning a priori knowledge from the training data and inferring the pixel distribution of the image after super resolution by the pixel distribution of the target image [20]. The information that the model can ingest is the pixel mapping learned from the training data; when the pixel distribution of the test image does not appear in the training image, it will lead to significant degradation of the image's super-resolution quality [21]. In the case of multi-image image super-resolution tasks, or image super-resolution tasks, additional information about the before and after frames of the image is introduced. From common sense, the data between photos in consecutive image frames are continuous and gradual, and it is entirely possible to use such an incremental information mechanism to extract the information that was discarded during the downsampling of the target image in the adjacent frames of the image to recover the target image after downsampling [22]. The convolutional graph networks are highly vulnerable to adversarial attacks, which makes their prospects for industrial applications challenging. Combining graph convolutional networks with target detection and recognition is difficult, as graph convolutional networks can obtain certain features based on the graph structure. However, there is still no fixed solution for using these features to complement or identify localized targets. Finally, as more and more graph convolutional networks are designed, selecting a suitable network based on the graph structure characteristics is also a significant issue.

3. Model Design of Super-Resolution Relationship Extraction and Reconstruction Method for Images Based on Multimodal Graph Convolutional Networks

3.1. Multimodal Graph Convolutional Network Model Construction. Convolutional operations can extract structural features of structured data by using convolutional kernels with shared parameters. Single-modality image alignment refers to the floating of two images acquired with the same imaging device. It is mainly applied to the alignment between different MRI-weighted images and the alignment of image sequences, etc. Multimodal image alignment refers to the floating of two images from other imaging devices. Increasing the number of convolutional kernels can obtain multidimensional structural features to characterize the data. For unstructured data such as molecular structure and recommendation system, the information cannot be extracted directly by fixed convolutional kernels because they do not have uniformity. Therefore, the graph neural network (GNN), which simulates convolutional operations to remove features efficiently on unstructured data, emerged and continues to evolve. Like convolution on images, the information of each node is extracted by picking the perceptual field [23]. The most direct way is to aggregate the node whose features are to be removed with its neighbor nodes within a fixed number of hops, based on the idea of message passing to extract parts of the graph for subsequent scenarios such as node classification, graph classification, and edge prediction. GCN has been mathematically rigorous in reasoning and proof. Combining spectral convolution and Chebyshev polynomials and simplifying the operation by constraining $k = 1$ to obtain a first-order linear approximation to the graph spectral convolution, an expression for the graph convolution neural network is derived as follows:

$$h_{(l+1)} = \sum \frac{\sigma + h^{l-1} + \sqrt{h^l - w^l}}{\sqrt{\sigma - d + ad}}, \tag{1}$$

where H^l denotes the graph convolution network at layer $l\,(H0 = x)$; $\widetilde{D}$ is the degree matrix $(\widetilde{D}ii = \sum \widetilde{A}ijj)$; $\widetilde{A} = A + I$ denotes the adjacency matrix introducing its information; Wl is the training parameter, and σ is the activation function. Therefore, the output of the two-layer graph convolutional network is as follows:

$$z = \sum \operatorname{softmax} \frac{(d - ad - xw^o)w}{\sqrt{d - 1/2ad - \sigma}}. \tag{2}$$

The graph convolution neural network defines the graph convolution operation. It can achieve convolution-like feature extraction on unstructured data, and subsequent research on it is done based on graph convolution.

During node updates, weights are determined based on the interrelationship between neighboring nodes and the current node, thus enhancing the ability to extract meaningful information and attenuating the weight of irrelevant knowledge. Like the graph convolutional neural network,

the graph attention network introduces the calculation of attention. It adds it to the update operation, while the node weight value is determined by its interrelationship with the controller node. The node weights are calculated as shown in the following equation:

$$\alpha_{ij} = \sum \frac{\exp\left(\sigma - a^t wh_i + a^t wh_j\right)}{\sigma\left(a^t\left[wh_i - wh_k\right]\right)}. \tag{3}$$

In the above equation, α_{ij} denotes the attention weight of node j with respect to node i; N_i denotes the set of nodes adjacent to node i; h_i is the feature of node i; the attention value α_{ij} denotes the degree of association between nodes, which can be obtained either by learning or by a similarity measure. The attention weights are introduced into the graph convolution process to emphasize the importance of different neighboring nodes to the current node so that the next layer of feature values can be calculated and updated as follows:

$$h_i = \sum \frac{\sqrt{a_{ij} + wh_j}}{\sigma - \sqrt{(j - n_i)}} + \sigma, \tag{4}$$

where h_j is the feature of node j in the current layer of the graph convolution network; h_i is the feature of node i in the next layer of the graph convolution network. The graph attention network quantifies and introduces the relationship between nodes into the graph update process, and this relationship is equivalent to the adjacency matrix in the graph convolution a. Because of its ability to construct adjacency matrices based on node relationships can be applied to graphs without explicit edge concepts, such as graphs describing sample relationships. In essence, the principles of GCN and GAT are similar; the former uses Laplacian matrices and emphasizes the role of graph structure information in graph convolutional networks. At the same time, the latter introduces attention coefficients to enhance the role of correlation information between nodes. The last is suitable for a broader range of scenarios, such as inductive tasks, by calculating each node one by one, free from the strong constraints of the graph structure.

The interaction enhancement between local information includes the interaction between the internal elements of local target information and local image information and the interaction between local target information and local image information. The principle of internal element interaction enhancement is that a subset of elements that are relatively important or create a common theme can be calculated using the interrelationship between the interior features [24]. The principle of interaction enhancement between local target and image information is that both information initially corresponds to the same scene theme, so there is a constraint and guidance between the data. Local target information can guide local image information to make the selection and fusion of a subset of crucial image elements. At the same time, local image information can also locally target information to make the selection and fusion of a subgroup of critical target elements. The graph convolutional neural network is a prevalent network model. Many algorithms use it as the basis for modeling and solving practical problems, whether in recommendation algorithms, computer vision, or natural language processing. In this study, we need to enhance the interaction and fusion between local information elements, so we design a practical information fusion module based on a graph convolutional network.

First, the graph node feature is defined as $r = \{f_1, f_2, \ldots, f_m\}, f_i \in r^d$ the feature vector corresponding to the i node and m the number of nodes. The graph network constructed with local target information elements can be represented as the graph network built with local target information elements, which can be defined as $r_o = \left\{f_{o1}, f_{o2}, \ldots, f_{0p}\right\}$. The graph network created with local text information elements can be described as $r_t = \left\{f_{t1}, f_{t2}, \ldots, f_{tp}\right\}$ The graph network made with both parts together can be represented as $r_{ot} = \left\{f_1, f_2, \ldots, f_{p+q}\right\}$ The graph convolution operation in this study is defined as follows:

$$\begin{aligned} r_l &= \int r_{l+1} - \frac{w_{r-t}}{h}, \\ h &= \int_{l=1} \frac{w_h - w_t}{\sqrt{m_r - r_l}} \times \frac{w_h - w_t}{\sqrt{m_r - r_l}}, \\ m_r &= \int_{l=1} \left(r^{l-1} + w_{(t-k)} + r^{l-1} \times w_{t-q}\right). \end{aligned} \tag{5}$$

This study's multimodal local information interaction module consists of two branches, the independent graph convolution branch and the joint graph convolution branch. The separate graph convolution branch is a graph convolution operation for r_o and r_t respectively, which enables the enhancement of information elements of the other modality through intermodal attention while preserving the information differences between the two different modalities. In contrast, the joint graph convolution branch is a graph convolution operation r_{ot}, enabling the two modal information to automatically learn the interaction model in the same graph network. The design and computation of the two graph convolution branches are described in detail, as shown in Figure 1.

The independent graph convolution branch consists of a groups of identical computational modules. The following computations are implemented in each computational module. First, the local target information graph network r_o and the local image information graph network r_t each perform a graph convolution operation to achieve an interactive fusion of information within a single modality. Then, the two unimodal information graph networks perform a crossmodal attention enhancement operation to accomplish the necessary computation and information enhancement between different modal nodes. Finally, a new graph node information is generated after a fully connected layer FC with the following modular computational flow:

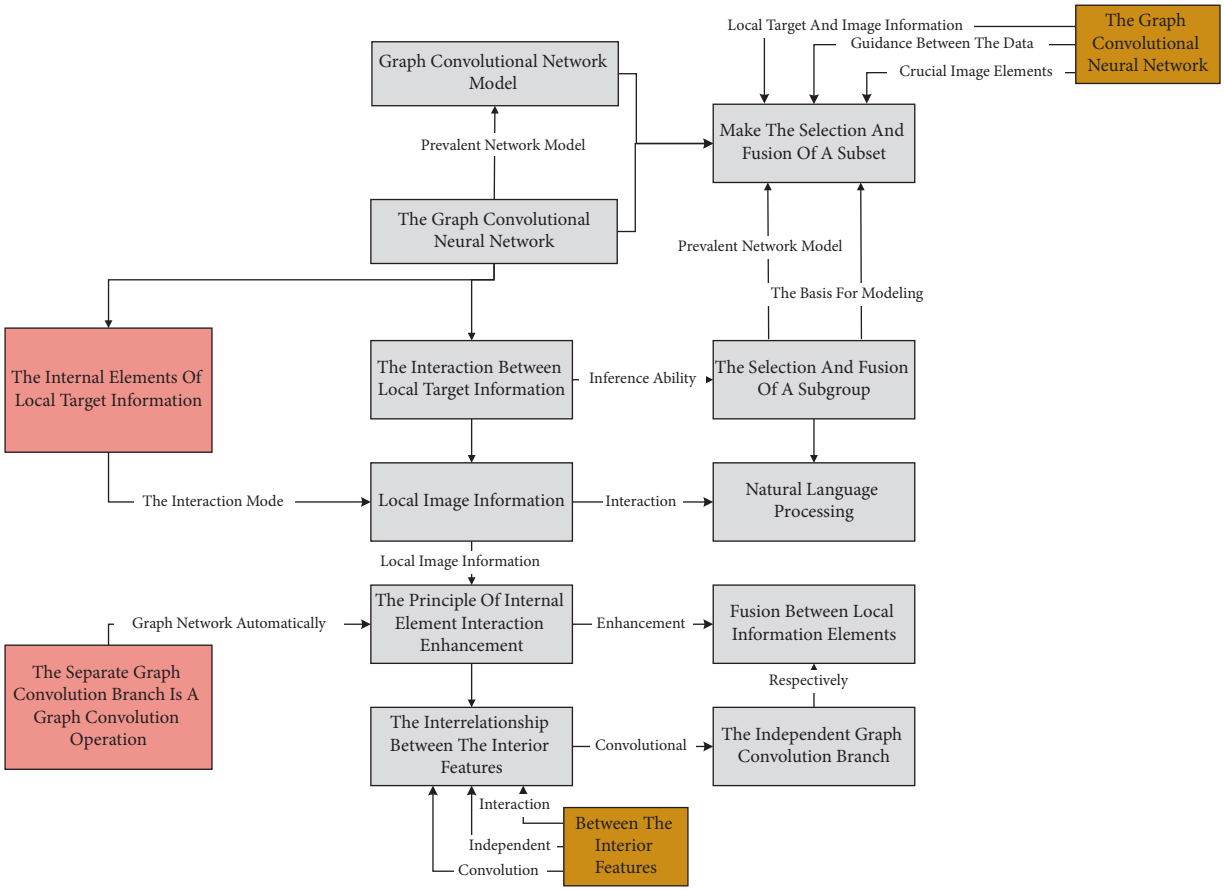

Figure 1: Multimodal local information interaction module.

$$
\begin{aligned}
r_{(a-o)} &= fc\left(h_{a+o} - 1\right) + \sum\left(a_{ij} + h_{a-t}\right),\\
h_{(a-o)} &= \sum\left[gcn - r_{a+o} + \left(r_{a+o} - 1\right)\right],\\
a_{i-j} &= \sum\left(h_{a-o} + w_{a-1}\right) \times \left(h_{a-t} - w_{a-2}\right).
\end{aligned} \tag{6}
$$

3.2. Image Super-Resolution Relationship Extraction and Reconstruction Method Model Construction. The core idea of the image super-resolution reconstruction algorithm is to process the low-resolution image using various technical software. The detailed information not available in the low-resolution print is extracted through some algorithms, and a clear, high-resolution image is reconstructed. This section mainly introduces the theoretical basis of image starting resolution reconstruction, some SFI reconstruction techniques, and the recognized image quality evaluation criteria for image super-resolution reconstruction. The evaluation criteria are the criteria for this study's subsequent experimental results. Image resolution is expressed in computer storage as the resolution that digital images displayed and stored in a computer have, and the resolution refers to the amount of information stored in a snap [25]. Specifically, it relates to the number of pixel points stored per unit of the image, and the resolution team is expressed in PPI (pixels per inch). In general, the more pixel dots per unit of an embodiment, the higher the resolution of the image and the larger the image will be, thus allowing for a richer representation of detail. For example, a picture with a resolution of $160 * 120$ pixels has a resolution of 19,200 pixels or 200,000 pixels. The super-resolution image reconstruction algorithm can be divided into two types: image and static image, and this study focuses on the super-resolution reconstruction algorithm for static images. The original high-resolution image generates a low-resolution image due to some extraneous culmination of the imaging process, and the HDR image must be built. The low-resolution bong image is processed into a high-resolution image according to specific super-resolution techniques. In this process, the image degradation model degrades high-resolution photos into low resolution images.

The structure of the domain adaptation model based on graph convolutional networks proposed in this study is shown in Figure 2. Overall, we first extract the high-dimensional features of the input data using a pretrained deep convolutional network fine-tuned with the source domain dataset or some manually designed feature extraction algorithms. Then, to consider the correlation graph of the data, we obtain the correlation structure between the samples based on the extracted features by the k-nearest neighbor (KNN) method, thus introducing the correlation between the pieces in the source and target domains into the learning model. After that, we apply a convolutional graph network to learn similar feature representations based on the samples

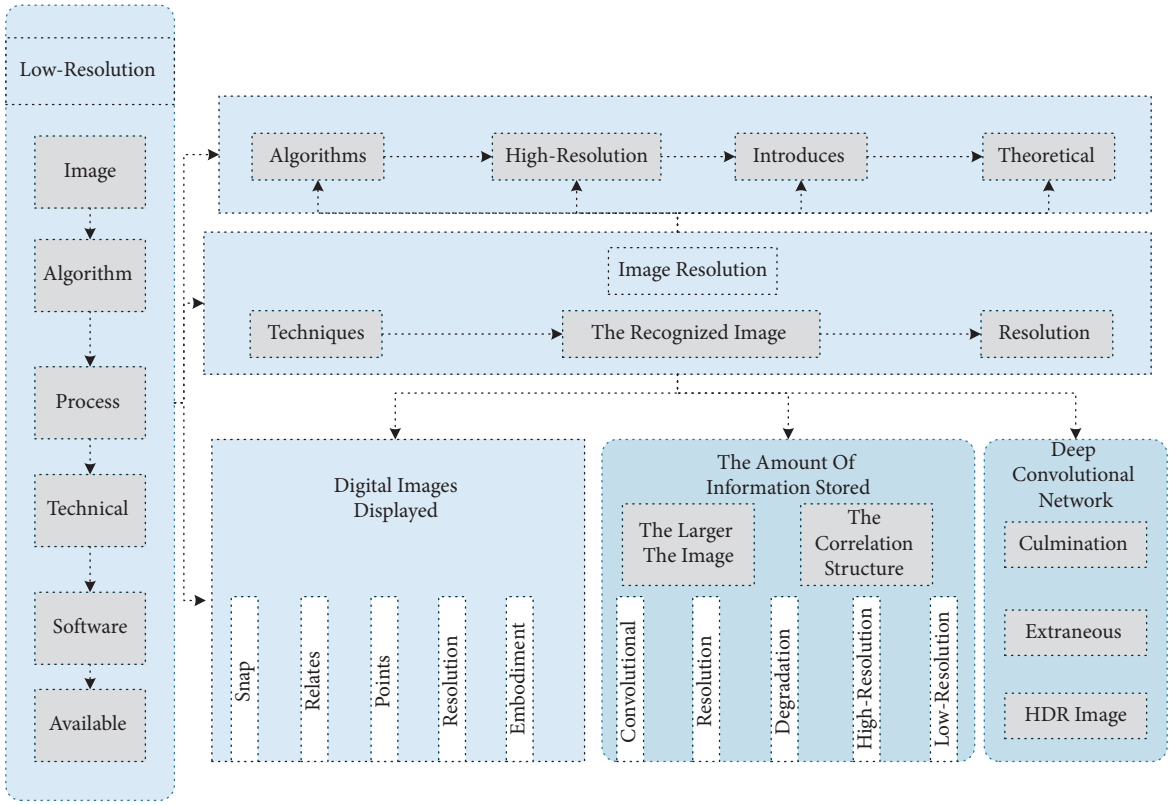

Figure 2: Domain adaptation model based on graph convolutional network.

and their neighboring samples. Finally, we reduce the difference in distribution between the known source and target words using the maximum mean difference to ensure the migratable nature of the features.

Because the traditional gcnt network cannot represent the relationship data such as vertices and edges, graph convolution neural network can solve the problem of such graph data, which belongs to the application of gcnt in the direction of graph expansion. In the training process, GNN will notice the graph structure, and there will be a gating mechanism to enter the graph structure, and convolution will be introduced into the graph structure to learn by extracting spatial features. The GNN that introduces convolution is the GCN, which knows by removing spatial features. GCN is a graph convolutional neural network, a kind of GNN; the difference is mainly in using convolutional operators for information aggregation. The structure of the SRCNN model is straightforward; the input image on the left is a low-resolution image generated by bi-triple interpolation, which is the exact resolution of the actual high-resolution image. However, the input image without image enhancement is still a low-resolution idea to distinguish between the two. The size of the convolution kernels for the three layers of convolution used in the model are, from left to right, 64, 32, and 1 for the output channels. The loss function used in this network is the mean square error, which is given by the following equation:

$$\mathrm{mse}_{(x-y-\theta)} = \sum \frac{\sqrt{h \times w - 1}}{y(i-j) + x(i+j)}, \tag{7}$$

where X denotes the high-resolution image output from the web, Y represents the actual high-resolution image and denotes the network parameters, and w and h denote the length and width of the output image, respectively. The proposed model broadly lays down the structural composition of the whole super-resolution network, and all convolutional networks doing super-resolution tasks after that largely follow the combination of these three modules.

As important auxiliary information, the higher the accuracy of depth information, the more accurately it can reflect the geometric relationships between viewpoints, which helps to solve the artifacts and distortions that appear in the synthesized views. The existing view synthesis methods based on depth information generally have the following problems: the synthesized view is highly dependent on the quality of the depth map, but the predicted depth map suffers from insufficient accuracy due to the inability of the depth estimation module to capture long-range spatial correlations [26]. Therefore, it is essential to obtain effective feature representations to improve the depth map quality for subsequent operations. This module can thoroughly learn effective high-resolution feature representations and always keep the feature resolution uniform throughout the process. The multiscale fusion mechanism is designed to fuse the relevant features to obtain rich feature representations fully. This enables the proposed depth estimation module to fully capture the long-range spatial correlation. The predicted depth map can more accurately reflect the spatial distribution of the scene and provide information support for the

next operation. The specific structure of the depth estimation module is shown in Figure 3.

To address the computational inefficiency of prior upsampling, some researchers have proposed to perform most of the mappings in low-dimensional space with last. Unlike the prior upsampling, this class of models replaces the traditional upsampling operation in the prior upsampling with a learnable upsampling house at the end of the network. Since this class of models performs many linear convolution operations in the low-dimensional space, the time and space costs are significantly reduced, and training and testing are much faster. Progressive upsampling models reduce the learning difficulty of the model by decomposing a complex task into small, simple tasks. Such models provide an elegant solution to the multiscale super-resolution problem without adding time and space costs.

4. Analysis of Results

4.1. Image Super-Resolution Relationship Analysis of Multimodal Graph Convolutional Networks. The image super-resolution task is based on the single-image super resolution, in the case of having the most basic original low-resolution image, to acquire its neighboring low-resolution image frames, which is used to help the original image more quickly to obtain more information to help the image recovery. This section proposes a deep neural network module for image reconstruction, enhanced reconstruction block (ERB). This module is redesigned for the reconstruction module in the ultradeep model in image super resolution using a roll-up group plus a dense connection. It adds jump connections from shallow to deep features while maintaining the existing network depth to better-fit feature extraction and image reconstruction in deep networks. Meanwhile, to improve the deformable convolution in the feature alignment module during image super-resolution model training, a weight normalization layer is wrapped around the convolution operation in the PCD alignment module, and the stability against noise during network training is greatly improved after the replacement [27]. This section uses the classical image super-resolution model EDVR as the module framework based on the above work. It proposes a new image super-resolution model—enhanced reconstruction model for video super resolution (ERM-VSR). In practical experiments, the ERM-VSR image super-resolution model presented in this section achieves excellent performance that significantly exceeds that of the baseline EDVR model.

With the development of deep learning techniques, the complexity of graph convolutional networks is increasing, and the number of layers of the network is also growing. Deepening the number of layers of the network within a specific range will make the web more expressive and richer in the features learned. However, in practical applications, increasing the number of layers of the network does not necessarily lead to better output results. The loss rate variation curve of the graph convolutional network versus the number of pieces of training is shown in Figure 4.

During the algorithm validation training on this dataset, it was found that EDVR's feature alignment module, PCD alignment module, often failed to converge due to excessive offsets. In the subsequent investigation of the reasons for the network convergence failure and the in-depth analysis of the training dataset, it was further found that for processing videos with too drastic scene switching (usually corresponding to the rapid movement of the filming equipment) and camera switching such as off-cut and jump-cut in transitions, PCD alignment module cannot effectively limit the size of the learned motion vector offset. Once it jumps out of the effective range and is input to the deformable, the motion vector is out of the compelling content. It is input to the deformable convolution, leading to the failure of feature extraction and loss of the whole feature alignment module.

The performance of graphical convolutional neural networks depends on various factors such as network structure and depth. Studying how parameters affect the performance of super-resolution reconstruction networks can effectively guide the model design. It can fully exploit the performance of the networks. Since the network structure is crucial to the algorithm's convergence, this section first conducts experiments on the effect of residual learning on the performance of the RLSR algorithm. All three experiments used T1-weighted imaging of the brain web dataset as the test set and PSNR as the evaluation index to test the results of the RLSR algorithm when there was super-resolution reconstruction of anisotropic 3D-MRI images with a resolution of 2mm×2mm×2mm. The effects of residual learning, network depth, and width are shown in Figure 5.

The best method among the interpolation methods is the B-spline interpolation algorithm. Still, the PSNR and SSIM of this algorithm are 3.95 dB/0.0059 and 3.36 dB/0.0407 lower than those of the RLSR algorithm for layer thicknesses of 2 mm and 5 mm, respectively. Due to the fixed parameters of the interpolation method, the image is only upsampled based on the spatial information of the pixels without using any a priori information. The NLM and SC methods exploit the self-similarity and sparsity of the image for super-resolution reconstruction, respectively, improving the super-resolution reconstruction effect [28]. Still, the PSNR and SSIM of the reconstructed image are not as good as the RLSR based on the residual learning deep convolutional neural network. The SRCNN method is driven by many training samples and directly learns the intrinsic mapping relationship between high and low resolutions without relying on artificially designed feature extraction methods. Its super-resolution reconstruction effect is significantly better than the interpolation method, NLM, and SC algorithms. Since the RLSR algorithm uses residual learning to alleviate the problem of difficult training of deep networks faced by SRCNN and effectively improves the nonlinear fitting ability of the network, the quality of super-resolution reconstructed images at a slice thickness of 2 mm is better than those reconstructed by SRCNN and VDSR methods, with PSNR values 1.28 dB and 0.06 dB higher than those of SRCNN and VDSR method approaches, respectively. The quality of the super-resolution reconstructed 3D-MRI images decreased to different degrees with the increase of the slice layer thickness. The SSIM of the 3D-MRI images reconstructed by the RLSR algorithm was 0.004 higher than that of the SRCNN

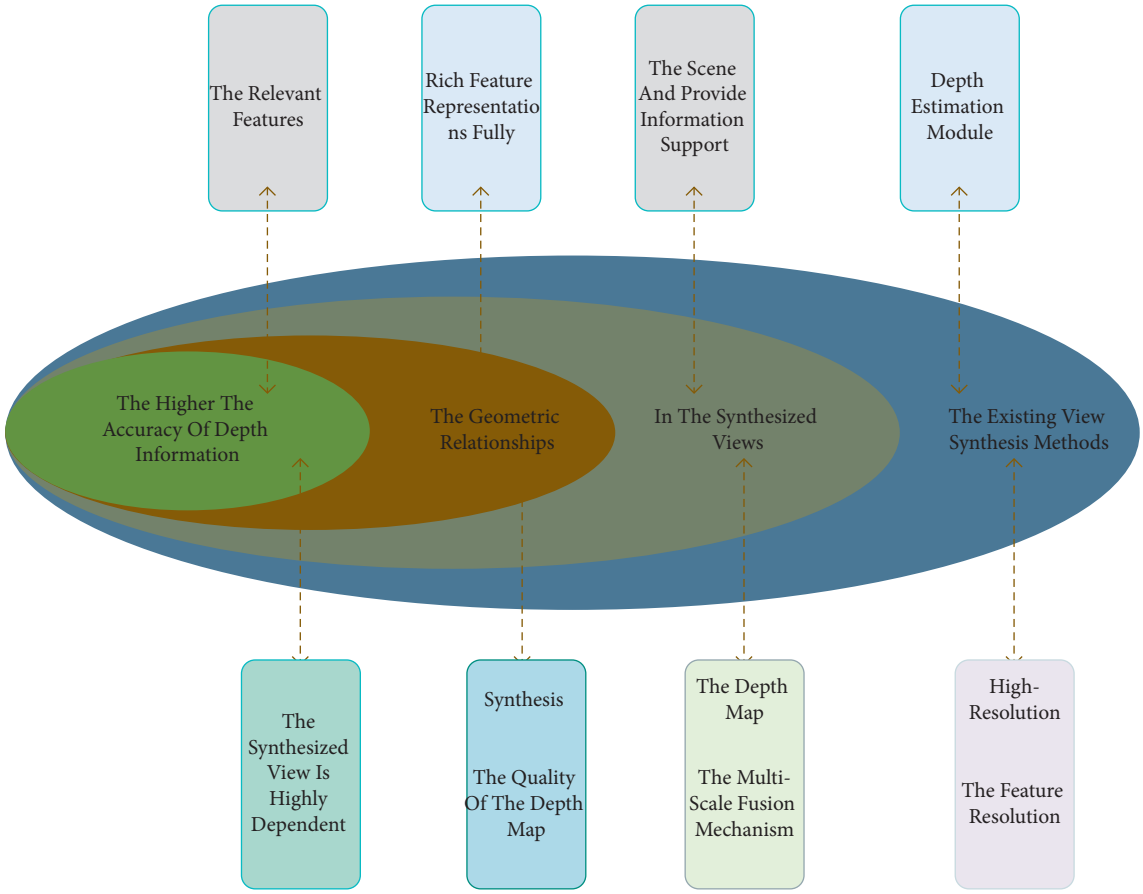

Figure 3: Specific structure of the depth estimation module.

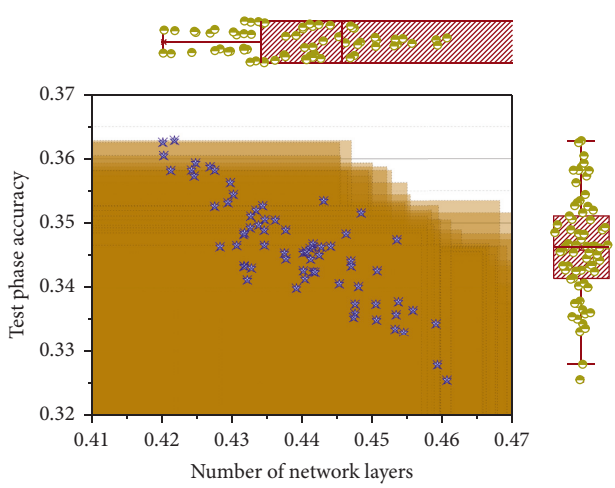

Figure 4: Effect of the number of network layers on the accuracy of the training and testing phases.

method when the layer thickness was 2 mm, but the difference reached 0.0254 when the layer thickness was increased to 5 mm. The above experimental results indicate that the RLSR algorithm can achieve good T1-weighted imaging super-resolution reconstruction results and has good robustness for reconstructing different slice thicknesses.

4.2. A Multimodal Graph Convolutional Network-Based Approach for Super-Resolution Relation Extraction and Reconstruction of Images Implementation. For the overall performance comparison, the number of SUB modules in SUGNet is set to 20, and the output channels of the convolutional layer are set to 64. Considering the performance and model parameters, the depth of the backbone branch in the SUB module is set to 3. During the training period, a randomly cropped 48×48 image block is used as the model's input. To avoid overfitting the SUGNet algorithm during training, this section uses data enhancement techniques such as rotation and horizontal and vertical flipping for all fundus data sets. The Adam optimizer is used to train the network parameters with an initial learning rate of 0.0001, and the learning rate is reduced by half for every 100 rounds. For the same reconstruction factor, the generator loss of the algorithm in this study is lower than that of both SRRes Net-V54 and SRGAN. For different reconstruction factors, the generator losses of SRRes Net-V54 and SRGAN are in the order from small to large: $4\times < 6\times < 8\times$, while the order of the algorithm in this study is as follows: $4\times \approx 6\times < 8\times$. It proves that the generator network in this study can be used well for 4× and 6× reconstruction. Still, the other two algorithms are only suitable for 4× reconstruction and have more significant errors for 6× and 8×. Using feature matching loss (F-Loss) and Wasserstein distance loss (W-Loss) can improve

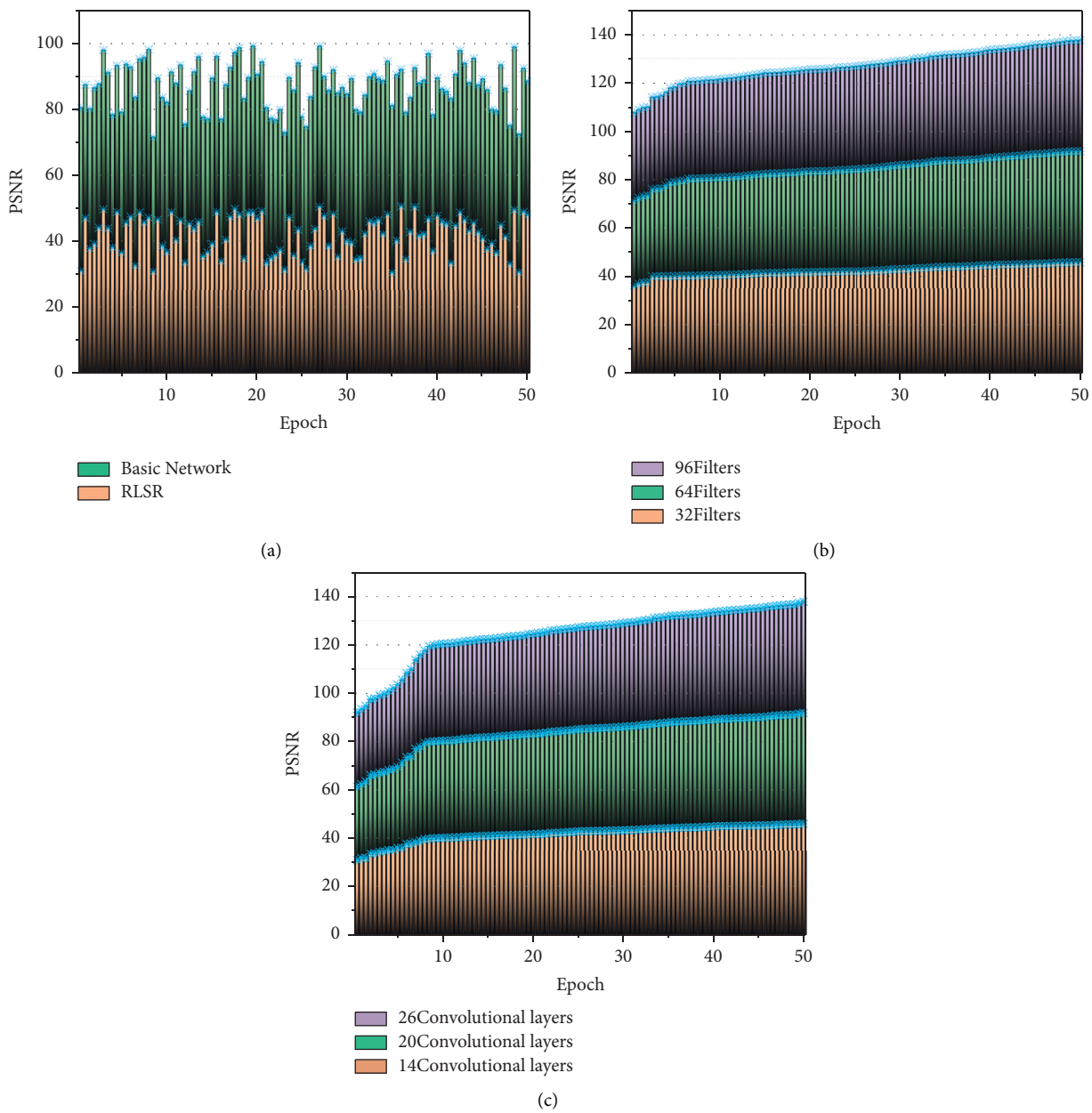

Figure 5: Effect of residual learning, network depth, and width. (a) Effect of residual learning. (b) Effect of network width. (c) Effect of network depth.

the reconstruction quality and solve the gradient dispersion phenomenon that may occur during the training process. In addition, the multiplex conditional generator structure and the multiscale discriminator structure make the generator's performance in this section almost the same as that of the reconstruction factor 4 when the reconstruction factor is 6. Therefore, the algorithm in this section can cope with more prominent reconstruction factors, while the performance of other algorithms decreases sharply when the reconstruction factor increases. The dynamics of the different network loss function values are shown in Figure 6.

This study uses a network structure with only one hidden layer to simplify and prevent overfitting. The number of neurons in the hidden layer is as small as possible. Meanwhile, the graph convolutional network algorithm uses each node's k-nearest neighbors to describe each vertex's local information on the image model. 2D is also called two-dimensional, flat graphics. 2D graphics content X-axis and Y-axis. 2D three-dimensional sense, light, and shadow are artificially drawn from the simulation. 3D is also called three-dimensional graphics content; in addition to the horizontal X-axis, vertical Y-axis, and the depth of the Z-axis, three-dimensional graphics can contain 360 degrees of information. Therefore, like the 2D reconstruction of images based on graph convolutional networks, determining the number of neurons in each subneural network and the number of k-nearest neighbors is also essential for the 3D reconstruction of faces. Therefore, in this study, from the

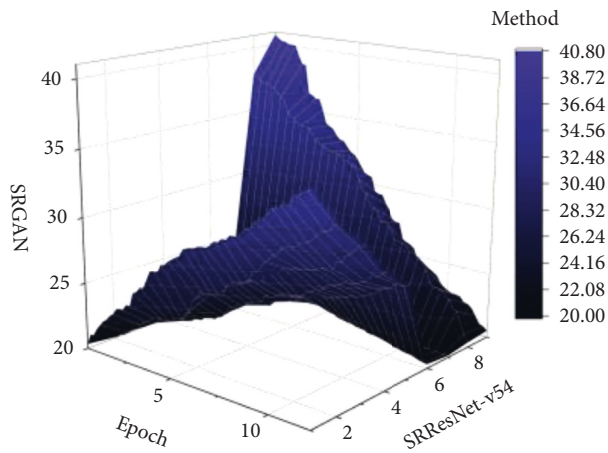

Figure 6: Dynamics of different network loss function values.

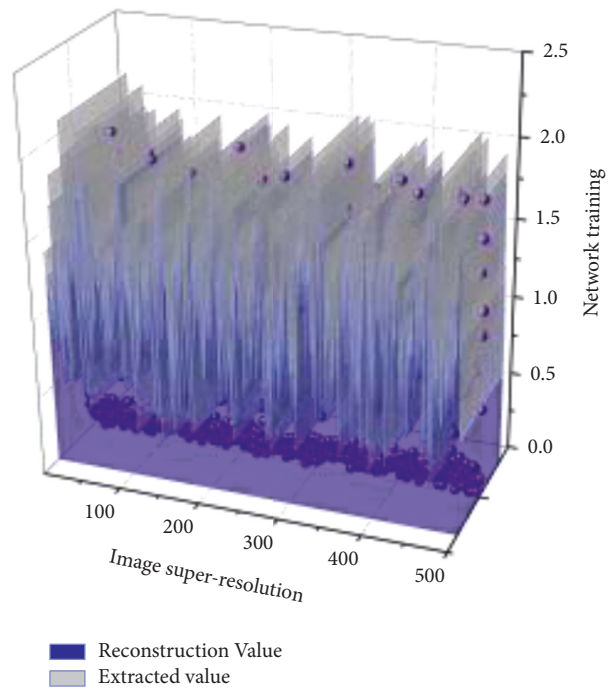

Figure 7: Network training results of image super-resolution relationship extraction and reconstruction method.

2,800 strictly aligned 3D face models obtained during the face data generation, 1,000 are randomly selected as the training set and 500 as the test set. First, we test the prediction results of the network under different k values. In the network initialization phase, the network weight parameters for the first forward propagation of the generator network can be initialized with the DGP-SRGAN network parameters by using the minimized mean square error MSE loss function, which is obtained by pretraining the network. Because of this, the following training process is chosen to "synchronize" the alternate iterative training of the generator network and the discriminator network; in the general GAN model, the generator network training learning speed is often slower than the discriminator network, which will cause the network parameters to update early end, and it will not get a robust generator model. In the training phase of the network, the discriminator network is updated once, followed by the generator network to update the parameters once. The super-resolution image of the output of each forward propagation of the generator network is compared with the original high-resolution image HR to obtain an error signal. This error signal is back propagated to produce a gradient (or derivative) for learning, which is used to readjust the weight parameters for the subsequent forward propagation. The discriminator network then compares the output probability score of the input super-resolution generated image with 0 and the original high-resolution extensive image HR with 1. It updates the discriminator network parameters by back propagating the error through a back-propagation mechanism to create the gradient used for network learning. The results of the network training for the image super-resolution relationship extraction and reconstruction method are shown in Figure 7.

DRCN is equivalent to SRCNN with a deepened network hierarchy. The DRCN network is more expressive and can be seen to have more apparent edge details than SRCNN. The SRGAN and the optimized and improved DGP-SRGAN algorithm in this section can reconstruct more texture details than the general GNN because they use the perceptual loss function to guide the network training, and the experimental results of the previous algorithms have better image visualization and more explicit edge details compared to each other. The proposed DGP-SRGAN has better subjective visual perception quality than the original SRGAN algorithm. The essence of graph convolution is to learn relevant information, so the learning effect of this network must include the neighbors of the sampled samples in the same training step; on the other hand, the distribution difference metric requires that the models in both domains can be as rich as possible and cannot be limited to only some categories. Balancing the needs of both in a limited batch training size is another critical issue in enhancing the effectiveness of graph convolution in deep learning frameworks. According to the scheme proposed in this section, the update relevance graph with the training trick allows the global relevance graph to be updated throughout the network training process and no longer overly dependent on fine-tuning the features extracted in the network. Class-label and pseudo-class-label sampling ensure, to some extent, the amount of data available for each class of samples when the model is trained in small batches, thus improving the performance of the overall model. The proposed two schemes enable the graph convolution model to be successfully integrated into the deep learning framework for end-to-end learning and achieve good results in experiments comparable to cutting-edge algorithms.

5. Conclusion

With the development of deep learning technology, more and more tools have been derived from continuously bringing new products and experiences to the public. Many

technologies that were previously unlikely to be realized based on traditional methods are increasingly coming into the typical home. Image recovery, a classic task in computer vision, has a critical position in practical applications. As an essential carrier of information transmission, the quality of the image directly affects the ability of information expression. Image super-resolution reconstruction aims to recover high-quality photos, so it has a wide range of applications in many fields. We conducted comparison experiments on COCO and visual genome datasets in this study. By analyzing the experimental data, we can see that the target detection and recognition models based on graph convolutional networks significantly improve the correct average rate of the whole class of objects. In this study, Set5, Set14, BSD100, and Urban100s datasets are taken for experiments and compared with their algorithms Bicubic, SRCNN, VDSR, and SRGAN in the cases of reconstruction scales of 2× and 4× to verify the practical effect more fully. This algorithm increases the network's nonlinear representation capability while acquiring multiple features than single-scale convolutional networks. The algorithm finally outputs reconstructed high-resolution images using the deconvolution layer, which obtains more high-frequency information during the upsampling process. The algorithm is experimentally demonstrated to have an advantage of super-resolution reconstruction compared with neural network algorithms of the same level of depth.

Data Availability

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

Conflicts of Interest

The author declares no conflicts of interest.

Acknowledgments

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Research Article

Construction of Credit Assessment Model for International Import and Export Trade Based on Fuzzy Hierarchical Analysis

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With the continuous expansion and development of import and export trade, the problem of credit risk faced by foreign trade enterprises has received increasing attention. This thesis focuses on the credit risk problem in import and export trade based on fuzzy hierarchical analysis; international import and export trade credit risk management risk is measured and evaluated to derive the ranking of key risk factors; the risk factors in the guideline layer are ranked from largest to smallest in order of legal risk, market risk, financial risk, and policy risk. The main purpose of this study is to build a fuzzy AHP international import and export trade credit evaluation model, which can provide reliable credit evaluation when enterprises conduct import and export trade and can better help enterprises to complete the trade. The analysis algorithm implemented in this study is a common and effective algorithm used for credit modeling, and more exploration and research on foreign trade credit modeling using existing modeling techniques are needed. The modeling techniques for credit evaluation of international import and export trade should be based on the credit information available to the enterprise to select the most appropriate modeling techniques and propose the most practical evaluation model. This study uses qualitative and quantitative, theoretical, and empirical comprehensive analysis methods based on fuzzy hierarchical analysis, draws on theories and models of credit risk management of 100 well-known enterprises around the world, and combines the actual situation of import and export trade. The credit evaluation model of international import and export trade based on fuzzy hierarchical analysis is constructed with certain operability and can make the credit evaluation of international import and export trade more accurate and reliable.

1. Preface

In today's world, the process of globalization is deepening, and since China acceded to the WTO, the government has vigorously encouraged import and export trade. Many foreign trade enterprises also actively participate in the import and export trade industry. However, many foreign trade enterprises have suffered huge losses in import and export trade because they are not aware of the existence of credit risk or have not taken effective measures to avoid credit risk [1]. The issue of credit risk is a great concern for foreign trade enterprises. Credit risk management is also a link that foreign trade enterprises always want to strengthen [2].

Credit refers to a social relationship. The grantor trusts the recipient and thus establishes a relationship of trust, in which the judgment of the grantor and the creditworthiness of the recipient play a decisive role. In economics, it refers to the economic activity in which two parties lend money to one another using a contract and also guarantee in the contract that the money will flow back to the other party.

The concept of credit in economics is the concept of credit in a narrow sense, which generally refers to lending credit. With the deepening of import and export trade, the risks in the import and export trade industry are also diversifying and complicated. The risks in import and export trade mainly include credit risk, foreign exchange risk, contract risk, and so on. And now the international market is a buyer's market based on the market economy, providing credit lines for customers has become a trend and practice, and many foreign trade enterprises are studying how to both expand trade volume and effectively avoid credit risks. Its focus is on credit risk management in import and export

trade, and for the specific situation of foreign trade enterprises, through the analysis of the current situation of credit risk, problems, methods of assessment, effective measures, etc., through a combination of qualitative and quantitative analysis methods, foreign trade enterprises understand the current advanced credit risk management techniques at home and abroad [3]. This study uses the Fuzzy Analytic Hierarchy Process (AHP) to evaluate the credit evaluation model of international import and export trade, which can build the model at a deeper level, and the efficiency is faster.

The fuzzy hierarchical analysis method is to decompose the elements related to decision making into levels such as goal level, criterion level, and indicator level by clarifying the problem, on which qualitative and quantitative analysis is performed. Its calculation steps include constructing a judgment matrix, hierarchical single ranking, checking the consistency of the judgment matrix, and hierarchical total ranking. Among them, the construction of the judgment matrix is the key link of the hierarchical analysis method, and whether the construction of the judgment matrix is scientific or not directly affects the decision-making effect of the hierarchical analysis method. Based on Fuzzy AHP, the credit of international import and export trade can be better evaluated and the construction of the model can be promoted [4]. With the development of many statistical methods such as computers and machine learning methods in recent years, numerous statistical learning methods and machine learning methods have been applied to individual credit assessment models in recent years. Through the research on international import and export enterprises and the study of related literature, it is found that the current credit data present a kind of nonlinearity, high dimensionality, as well a wide distribution of features, and sparse data. The research goal of this study is to build a credit assessment model for international import and export trade, which can make it easier for international trading companies to better assess risks when conducting business transactions and promote trade exchanges.

2. Related Discourses

Earlier credit evaluation models include the 55C model, 5P model, 5W model, etc., which mainly assess the creditworthiness of individuals or enterprises qualitatively or quantitatively. The 5 C factors include asset collateral, business ability, borrower's character, capital, and economic environment; the 5P factors include the business prospect factor, repayment source factor, capital use factor, personal factor, and debt security factor; and the 5 W factors are: content analysis, audience analysis, effect analysis, media analysis, and control analysis.

Calabrese et al. [5] argue that the hierarchical analysis method has four shortcomings: first, the consistency test of the judgment matrix is difficult. Second, if the judgment matrix does not pass the consistency test, it needs to be adjusted repeatedly. Third, the criteria of consistency test of judgment matrix lack scientific basis. Fourth, the consistency of the judgment matrix is significantly different from the consistency of human thinking. The e-commerce credit development index constructed by Zavadskas et al. [6] divides e-commerce credit assessment into online trust risk (security transaction risk, privacy protection risk, service convenience factor), offline trust risk (subject gets qualification, enterprise financial status, operation, and management level, subject honesty and responsibility), and development comprehensive index (industry development background, enterprise development status, development strategic planning). Gnanavelbabu and Arunagiri [7] argue that "Capturing the Political Imagination: Think Tanks and the Policy Process" analyzes the effect of think tanks on influencing policy at the meso-level, laying the foundation for positivist think tank research. Rajasekhar et al. [8] offer a series of insights into the construction of university think tanks through a study of the staffing and management model of the Hoover Institution. They mainly include the mutual reliance on strong research fields and superior disciplines, adherence to research characteristics, attracting and gathering renowned scholars and political and business people, reforming the research organization model, and supporting university talent training. Using literature analysis and comparative analysis, Sirisawat and Kiatcharoenpol [9] analyzed the problems in the construction of university think tanks in China in terms of quantity, composition, and funding, and made suggestions on improving the access mechanism of talents, optimizing funding allocation, and improving the management mode. Taking the background of economic globalization, world multi-polarization, and in-depth development of social informatization, Li et al. [10] elaborated on the achievements of university think tanks in serving the general situation of the Party and the State, promoting healthy economic and social development, guiding correct social opinion guidance, enhancing public diplomacy capability and international discourse, and accumulating experience in the construction of new-type think tanks with Chinese characteristics. On this basis, five suggestions are put forward for the future development of the new type of think tanks in universities, such as ensuring the correct direction, improving research level, enhancing the international influence, strengthening professional development, and improving talent guarantee. Based on the results of previous studies, Karasan et al. [11] comprehensively introduce the basic contents of investment analysis and portfolio management, and the monograph is also used as a textbook by many higher education institutions to elaborate investment principles.

Stanković et al. [12] systematically compose how to manage personal assets to get the most out of their income. It combines investment tools, capital markets, evaluation of investments, and opportunities to meet risk-reward and provides research on how investment practices and theories have been affected by globalization to provide a solid foundation for investment decisions. Bhatt et al. [13] indicate that the problem of siting multiple facilities with capacity is a complex and imprecise decision problem that incorporates both quantitative and qualitative factors. Many objectives for optimizing multiple logistics networks are

described in the literature: first, minimization objectives such as cost, inventory, transportation time, environmental impact, and financial risk; and second, maximization objectives such as profit, customer satisfaction, flexibility, and robustness. However, only a few papers have considered quantitative and qualitative factors and imprecise methods. Unlike traditional cost-based optimization techniques, the approach proposed in the study evaluates these factors in an integrated manner while considering different perspectives. Decision makers have to deal with both factors to simulate complex structures. Suganthi [14] indicates that mimicking biological evolution and exploiting its adaptive capabilities is a problem. This has attracted the interest of computer scientists. Xie et al. [15] elaborate on the problem of gray systems, derive an analytical method, give its geometric meaning, illustrate the solution method, and discuss certain derivatives. Soui et al. [16] studied the stability and stability of gray systems with triangular state matrices, where the displacement operator and the established transfer are indispensable tools for gray systems.

3. Credit Assessment Model of International Import and Export Trade Based on Fuzzy Hierarchy Analysis

3.1. Fuzzy Hierarchical Analysis Method

3.1.1. Hierarchical Analysis Method. Analytic Hierarchy Process (AHP) is an easy-to-apply multi-principled resolution planning approach. When people deal with decision problems [17], they usually need to consider multiple factors. Before a decision can be made, the best solution needs to be selected from a variety of possible solutions, and many elements must be compared. The importance of most of these factors is difficult to quantify precisely, making it difficult for general mathematical approaches to solve such resolution problems explicitly [18]. This method provides a new easy and applicable way to combine qualitative and quantitative approaches to such problems. Hierarchical analysis in practice is mainly used to deal with specific programs, through multi-level, methodical analysis to complete a multi-purpose resolution plan research approach. The method is widely used because it is practical, simple to use, and can analyze problems systematically. The hierarchical analysis contains mathematical principles, but in essence [19], it is a decision-making method. First, a highly complex problem is decomposed and the decomposed components are combined into a hierarchy of progressive relationships with the help of certain dominant relationships; then the importance of each factor is determined by pairwise comparison and analysis, and finally, the importance of the factors is ranked by combining expert judgment. The specific operation steps are shown in Figure 1.

3.1.2. Fuzzy Hierarchical Analysis Evaluation Method. The fuzzy comprehensive evaluation method takes fuzzy mathematics as the theoretical basis, takes the difficult-to-quantify and fuzzy influencing factors existing in the research object as a collection, constructs the corresponding affiliation function by using the affiliation theory [20], and presents the evaluation results in the form of fuzzy collection. Its principle formula is

$$U = \sum_{i=1}^{n} X + \frac{1}{n} \sum_{i=1}^{n} \left(X_i - \overline{X}\right)^2. \tag{1}$$

This formula principle can better build an evaluation model, with higher accuracy and faster speed. The fuzzy comprehensive evaluation method has the advantages of easy to understand, easy to grasp, and reasonable evaluation indexes. Compared with other mathematical methods, the fuzzy evaluation method can make the evaluation results more objective when studying complex multi-factor and multi-level problems. When using the fuzzy comprehensive evaluation method, the algorithm of taking the larger and smaller amount is generally used because the comprehensive influence of each evaluation index needs to be calculated [21]. However, in the specific operation, using this algorithm will lead to unreasonable evaluation results. Meanwhile, when analyzing the fuzzy comprehensive evaluation result vector, the principle of maximum affiliation is commonly used analysis. However, this principle may lead to the loss of effective information in the case of too many evaluation indicators, thus making the results of fuzzy comprehensive evaluation deviant or even wrong [22]. The specific operation steps are shown in Figure 2.

3.1.3. Fuzzy Hierarchical Analysis Method and Operation Process. Fuzzy hierarchical analysis (FAHP) is proposed based on combining the respective characteristics of hierarchical analysis and the fuzzy comprehensive evaluation method. Its operation steps are the same as those of the hierarchical analysis method, the difference is that when comparing the influencing factors, the hierarchical analysis method usually uses the method of two-by-two comparison to construct a judgment matrix, while the fuzzy hierarchical analysis method constructs a fuzzy consistent judgment matrix more in line with human thinking through two-by-two comparison. This can better reflect the fuzziness of the problem and avoid the influence of subjective factors in the analysis of the evaluation object. Compared with hierarchical analysis and the fuzzy comprehensive evaluation method [23], the fuzzy hierarchical analysis method determines the weights of fuzzy indicators based on the hierarchical analysis method that solves complex qualitative problems layer by layer and then combines the mathematical principles of fuzziness [24]. By combining the use of hierarchical analysis and fuzzy comprehensive evaluation method, the negative impact on the system scoring due to different personal opinions of experts is largely avoided, thus making the process of data collection and collation more flexible and the evaluation process more accurate and realistic.

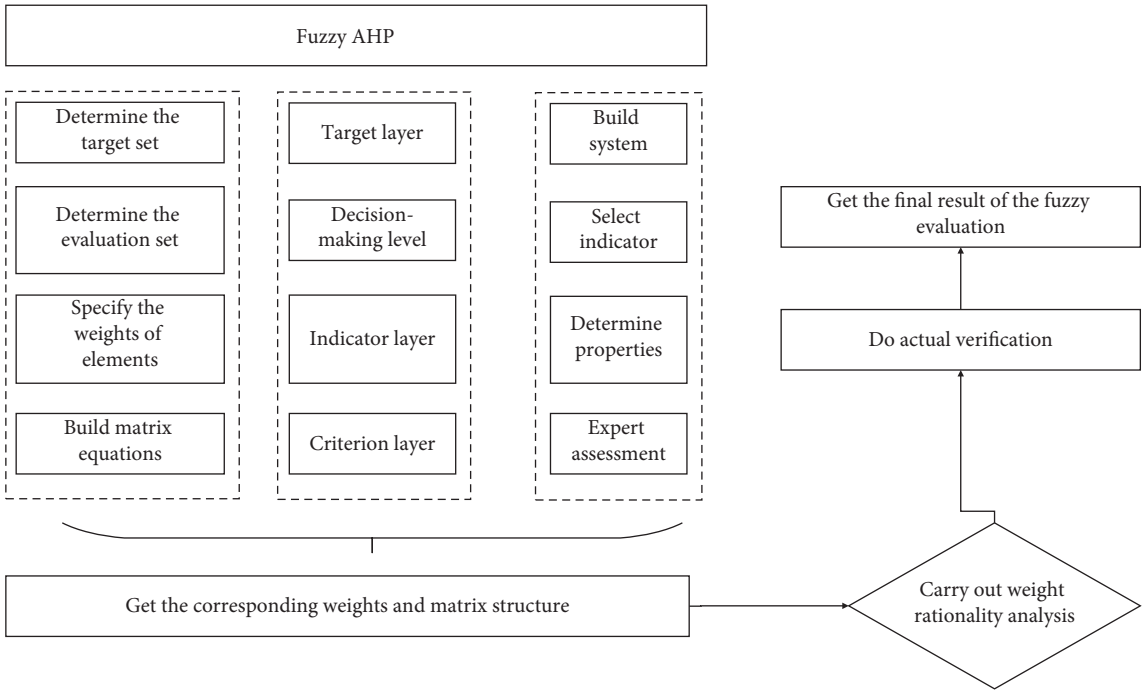

Figure 1: Hierarchical model.

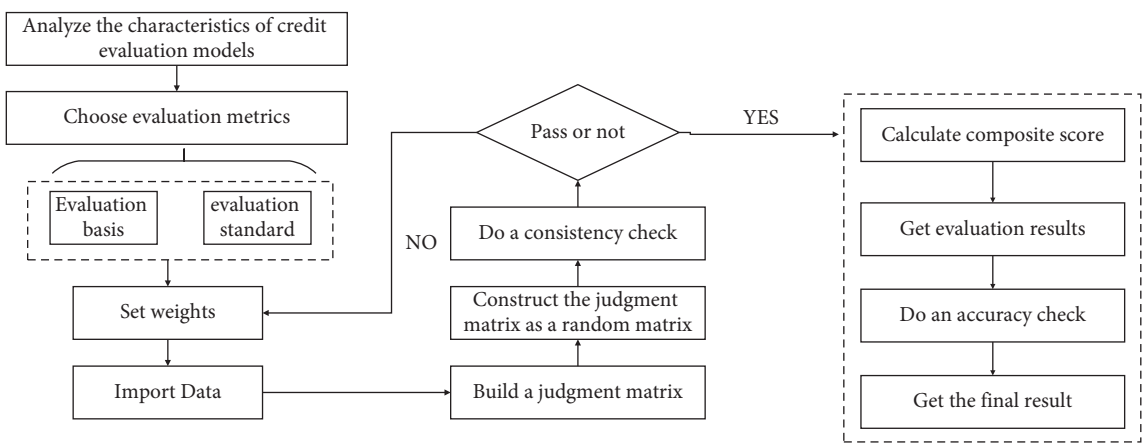

Figure 2: Operation steps of fuzzy comprehensive evaluation method.

The general operation process of fuzzy hierarchical analysis is as follows: determine the set of factors. The set of influencing factors of the evaluation object is called the set of factors, which is generally represented by U. We establish the hierarchical structure; decompose the influencing factors layer by layer and construct a bottom-up hierarchical model of evaluation indexes; establish a fuzzy discriminant matrix of influencing factors at each level; distribute expert questionnaires; compare the questionnaire results between two; determine the importance of the influencing factors, used to quantitatively describe the relative importance between two different elements in the same hierarchy; and construct a fuzzy discriminant matrix, fuzzy complementary discriminant matrix A-consistency test and convert to fuzzy consistency matrix R. When comparing two factors, there is judgment subjectivity and problem complexity influence, so it is necessary to test and discriminate the consistency of the matrix; determine the degree of affiliation and perform the evaluation; develop the evaluation set; use the maximum subordination method; determine the subordination function; evaluate the subject through the single-factor evaluation matrix; and draw the final evaluation results and conclusions.

3.2. Credit Assessment Model for International Import and Export Trade. A credit assessment model is a model established for customer credit assessment, based on the analysis of customer credit factors, using expert experience and a large amount of credit data, and employing scientific

credit assessment methods. It is the carrier of the customer credit assessment content and the external expression of the customer's credit status. Credit assessment models are usually designed to predict a certain characteristic of a customer, such as the likelihood of bankruptcy, default rate, performance rate, and ability to perform, or to use knowledge of the customer's credit status to support credit management decisions. So depending on the purpose of the credit assessment model, credit assessment models can be broadly classified into predictive and management models. Credit assessment models are usually designed to make predictions about a customer's characteristics, such as the likelihood of bankruptcy, default rate, performance rate, and ability to perform, or to use knowledge of the customer's creditworthiness to support credit management decisions. Therefore, depending on the purpose of the credit assessment model, credit assessment models can be broadly classified into predictive and management models.

While assessment of credit risk is important, comprehensive and effective credit risk management goes far beyond the concept and scope of assessment. More and more credit risk management experts are realizing the importance of establishing a credit risk management system. This includes not only the identification and assessment of credit risk but also emphasizes the comprehensive and systematic management of credit risk. Assessment is only one aspect of management, what is more, important is how to link the assessment results with the real situation and formulate the right management measures, which means that foreign trade enterprises can effectively avoid credit risks in imports and export.

The main problems of credit risk management of foreign trade enterprises in import and export trade can be analyzed from three aspects: macro-level, meso-level, and micro-level, so the corresponding credit risk management measures are also carried out from these three aspects. The macro-level mainly refers to the management of the national risk of target customers, including preventive, operational, and remedial management methods; the meso-level mainly refers to the management of credit risk in China's foreign trade industry, which is mainly discussed in terms of institutional aspects and personnel training; the micro-level refers to the credit risk management of individual foreign trade enterprises in China, which is mainly analyzed in terms of the construction of internal credit risk department and customer credit risk management system. The micro-level refers to the credit risk management of individual foreign trade enterprises in China, which is mainly analyzed from two aspects: the construction of an internal credit risk department and the customer credit risk management system, as shown in Figure 3.

If a foreign trade enterprise is trading with an overseas company that has a multi-year relationship, its credit risk is much smaller than the credit risk arising from trading with a new company that it does not know. This is precise because through long-term cooperation, there is a relative understanding of the other party's credit situation and a certain degree of trust is generated. Of course, a foreign trade enterprise cannot judge the credibility of the target customer only by direct experience, which has the disadvantage of high cost and may face the other party's default; it is also because the market needs a group of professional credit risk assessment, management institutions and talents to regulate the foreign trade industry, professional credit risk assessment agencies were conceived and born. The so-called cost of default refers to the benefits received by the fiduciary party because of default not to repay the principal and interest of the grantor, and the cost paid by the fiduciary party to obtain this benefit. China's foreign trade industry generally has the phenomenon of the low cost of a breach of trust. The low cost of a breach of trust will lead to an increase in the probability of credit risk. This is because people will weigh the gains and losses before making a decision. The cost of a breach of trust and the benefit of a breach of trust is a major criterion for whether an enterprise defaults on a contract. A comparison of the cost of a breach of trust (CL) and the benefit of a breach of trust (RL) is shown in Figure 4.

4. Experimental Design

The experiment designed in this study lies mainly in the credit assessment of enterprises engaged in international trade activities, and its credit indicator system is the most important part of the overall credit assessment model. A key factor in the work of the credit assessment model in this study is the base scientific and rational index system, and the construction of this system is what makes the credit assessment effective.

Therefore, the design of an enterprise credit evaluation index system must be guided by the idea of system science according to the background environment in which the enterprise is currently located and the characteristics of its industry to set up a scientific index system in a targeted manner. Credit assessment is ranked according to the overall attributes and utility of the system worthy of comparison, and the stronger the comparability, the greater the credibility of the evaluation effect. Therefore, 100 companies engaged in international trade were selected for analysis in this study, and 100 questionnaires were distributed through the expert survey method, of which one questionnaire was not returned. The questionnaires were mainly filled in by interviewing several e-commerce experts in different positions. After processing the initial questionnaire data, this study uses the basic principles of the method to quantify the importance of each index. The experimental results are analyzed by training the collected dataset using evaluation metrics.

5. Analysis of Results

5.1. Efficiency Analysis of Fuzzy Hierarchy Analysis. The index system for the evaluation of international import and export trade credit services has been constructed in the previous study. For the convenience of calculation, this study chose a 5-point scale to assign values to the evaluation levels. To evaluate the situation of each indicator regarding

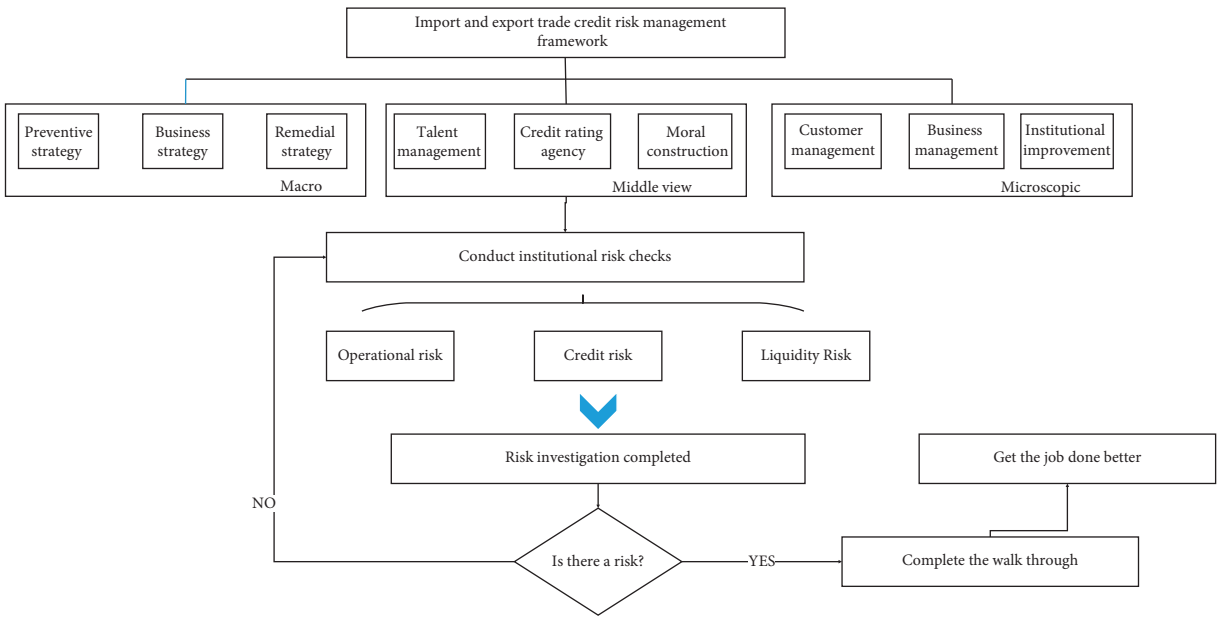

Figure 3: Credit risk management structure for import and export trade.

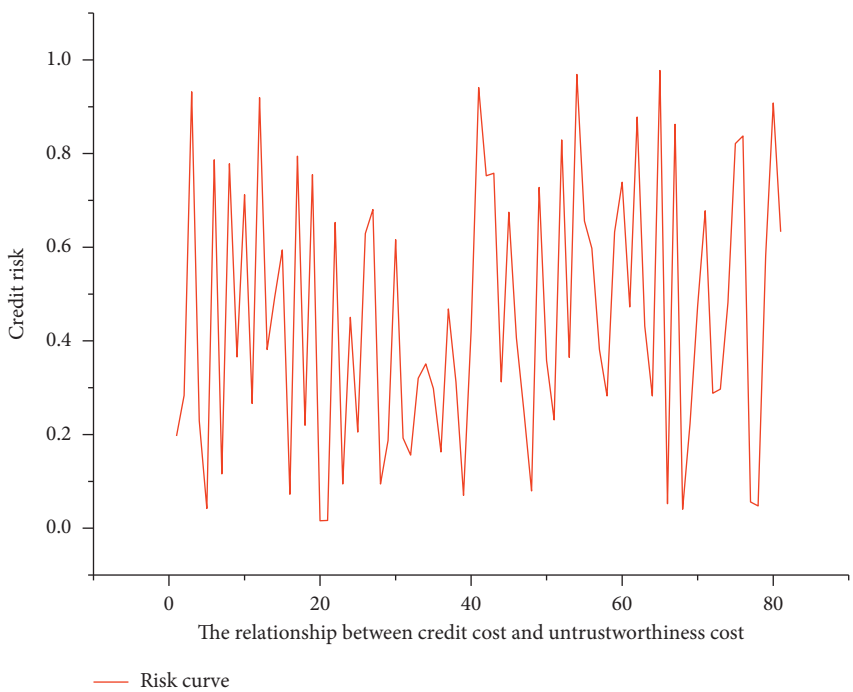

Figure 4: Relationship between credit risk and cost of failure to trust.

international import and export, the study invited a total of ten experts and scholars, including relevant researchers, and asked them to score the indicators of the Institute of Credit Assessment Development according to the current situation of the development of information services and their personal experience, and the scores of their relevant companies are shown in Figure 5.

The single-factor fuzzy judgment matrix is established based on the affiliation degree of the index layer (i.e., the affiliation degree of the secondary index) of the credit service quality of international import and export trading companies obtained in the previous section. The vectors are then calculated based on the established single-factor fuzzy judgment matrix, and the specific process is defined as follows:

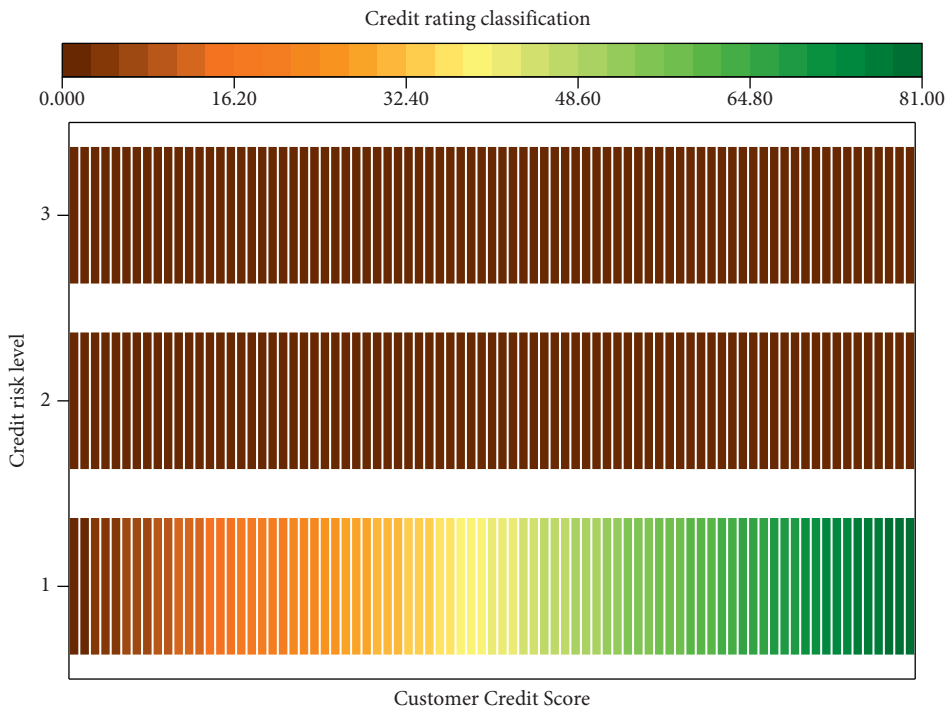

Figure 5: International import and export trading companies score.

$$X = \begin{pmatrix} a_1 & 1 & 0 \\ 2 & \ddots & 8 \\ 0 & 7 & a3 \end{pmatrix}. \tag{2}$$

From this, the evaluation vector of service resources can be calculated.

$$U = \frac{\Delta y}{\Delta x} \cdot \frac{\partial^2 \Omega}{\partial u^2}. \tag{3}$$

The overall evaluation vector of Soochow Development Research Institute was compared with the evaluation set, and the maximum value of the overall evaluation vector B was 0.39777 according to the principle of the maximum affiliation method, then the value corresponds to "excellent" in the evaluation set. The comparison of its efficiency with the hierarchical analysis method is shown in Figure 6.

Agencies should use various web service platforms to disseminate their research results, and at the same time, to make the research results better known to the general public, they can use popular language to "transform" the results to enhance the effectiveness of information services. In the context of new media, credit assessment agencies can enhance their social influence by disseminating their results on these electronic network service platforms through social media or by choosing some mainstream media for their speed in the population. Agencies can hire relevant staff for the task of publishing research results, policy evaluations, etc. on such online platforms. Disseminating relevant think tank products online not only saves publicity costs for university think tanks but also makes the speed of dissemination a qualitative improvement.

5.2. Credit Assessment Model Efficiency Improvement Analysis. The more traditional credit assessment methods are subject to many errors, and inaccurate assessment results occur from time to time, which may bring hidden risks for enterprises. After comparing various credit assessment methods, this study chooses to conduct credit assessment for international import and export trade, using fuzzy hierarchical analysis for credit assessment not only has a higher accuracy rate and is easily convincing but also avoids the influence of staff's subjective consciousness on the assessment results.

In this study, the fuzzy hierarchical analysis neural network method is applied to the credit assessment of cross-border e-commerce enterprises. First, the specific hierarchical institutions of the fuzzy hierarchical analysis method neural network are determined. Second, the sample data are determined, and the sample data are collected from export cross-border e-commerce enterprises according to the index system mentioned above, and the raw data are standardized. Then, make the fuzzy hierarchical analysis method neural network model for training and learning, and the efficiency of its model construction after comparing it with the models constructed by the two algorithms of standard analyze the algorithm structure of Fuzzy AHP and AHP; the obtained figure is shown in Figure 7.

10,000 samples were taken from the dataset in proportion to the positive and negative samples, and after preprocessing the data, the same two sets of models were trained on the training and test sets. The error convergence plots of the algorithms for the four sets were obtained by taking the average of ten experiments as shown in Figure 7. It cannot jump out of the local optimal solution quickly even

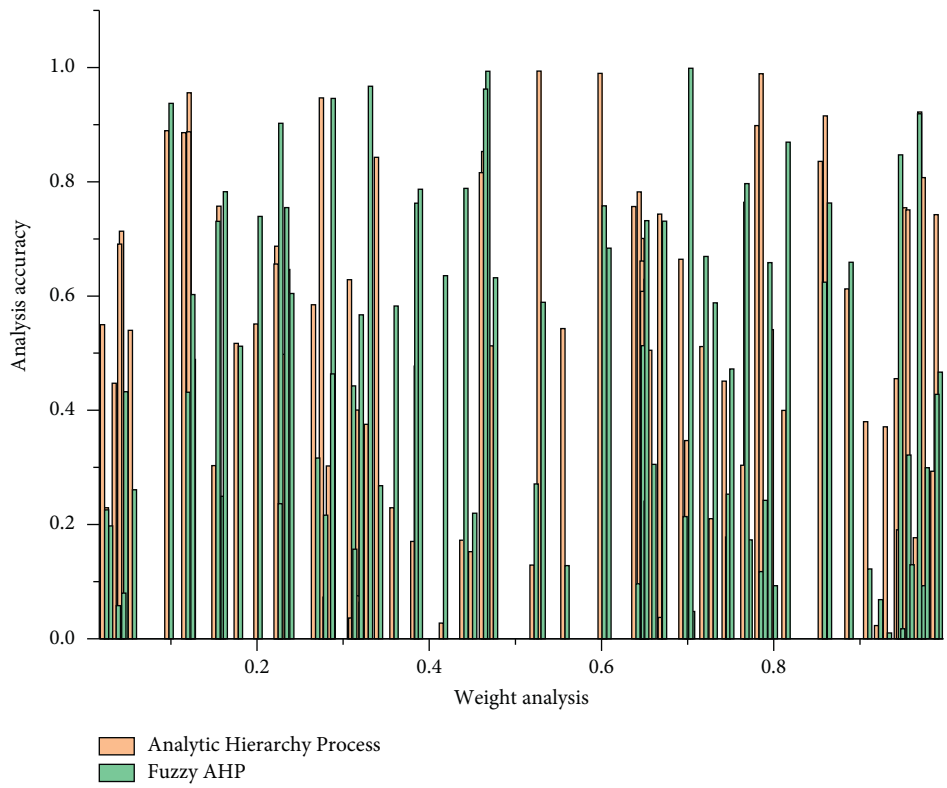

Figure 6: Efficiency of fuzzy hierarchical analysis vs. Hierarchical analysis.

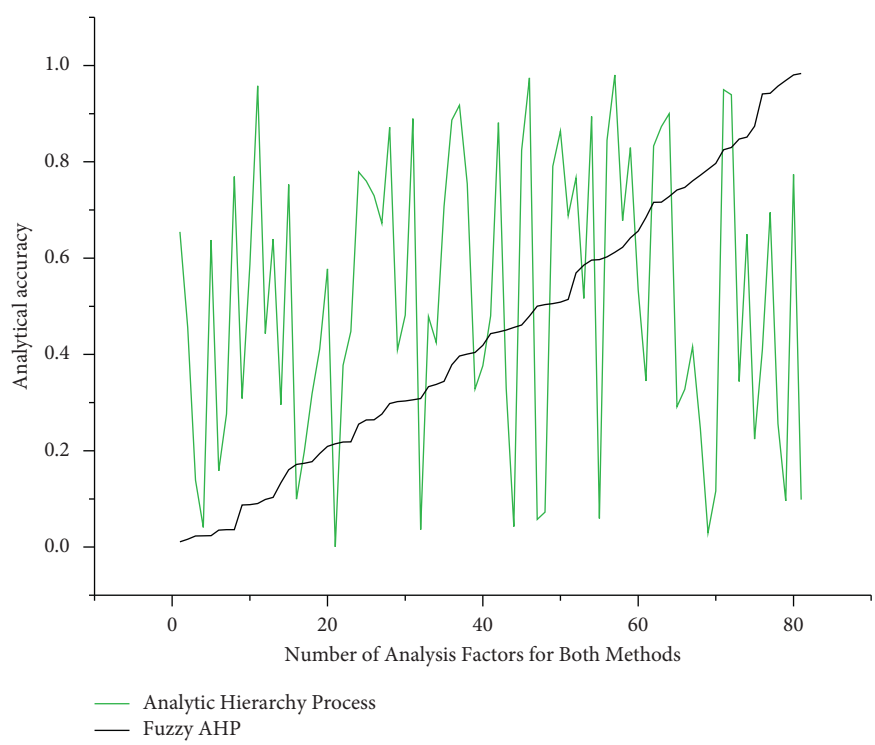

Figure 7: The efficiency of credit model construction by fuzzy hierarchical analysis compared with other approaches.

after falling into it, and finally, it also converges to the local optimal solution. The efficiency of the fuzzy hierarchical analysis method has the fastest improvement and is most capable of making the credit evaluation model more efficient. The prediction correctness of the improved hierarchical analysis evaluation model increases with the number

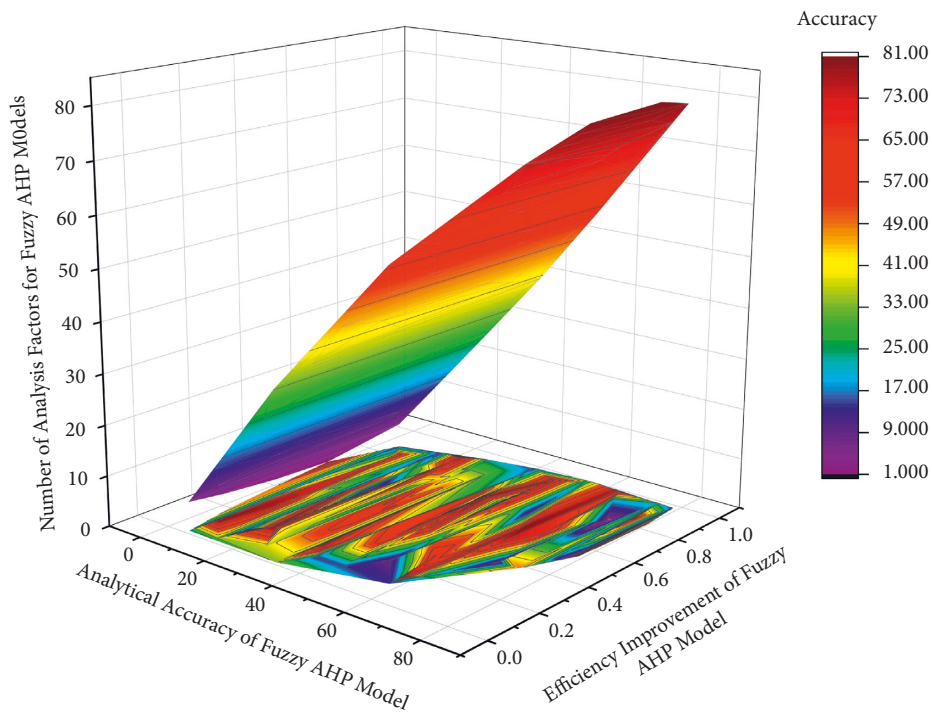

Figure 8: The superiority of the fuzzy hierarchical analysis model.

of iterations of about 4000 iterations; the algorithm enters the convergence state and the accuracy rate no longer increases. The accuracy of the model began to stabilize after the first 3,000 iterations and gradually converged in the next 1,000 iterations, with no significant increase in accuracy.

The improved fuzzy hierarchical analysis model proposed in this study is significantly superior to the traditional hierarchical analysis model in all four indicators, indicating that the improved algorithm has better global search capability and better performance of the model obtained through training than the traditional gradient descent optimization algorithm. The algorithm used in this study has better prediction accuracy compared with the logistic regression algorithm, which is commonly used by financial institutions to model personal credit evaluation. The performance is outstanding in various indicators. In the performance of recall rate, which is very important in the credit business, the model in this study performs more outstandingly, and its performance results are shown in Figure 8.

The experimental results show that modeling data from many financial institutions together through a federated learning architecture can effectively improve the accuracy of the model. For the four financial institutions in the experiment, the prediction ability of the model can be effectively improved by increasing the amount of data for the training model.

The models can still maintain a high correctness rate, and machine learning modeling can be performed for those special operations with small amounts of data.

It shows that the personal credit assessment model proposed in this study is more suitable for the credit business and can help the credit market to operate more stably and healthily to a certain extent.

6. Conclusion

This study focuses on the study of credit risk assessment models for international import and export trade. As more and more people use credit consumption, credit consumption products are widely promoted. There is no complete and unified evaluation index for credit risk assessment research status. And most of the methods applied in credit risk assessment of international import and export trade are black-box models, which makes it impossible to interpret the evaluation results reasonably.

To be able to enhance the interpretability of the model, this study completes the application of the fused fuzzy hierarchical analysis model in international import and export trade risk assessment. The fused fuzzy hierarchical analysis model first uses the scoring criteria of experts to assess the company's credit and then uses fuzzy hierarchical analysis to optimize the parameters of the assessment, to obtain the final fuzzy hierarchical analysis model. Through the experimental results, it can be found that the fused fuzzy hierarchical analysis model obtains a high classification accuracy, the model can filter out the important input variables in the data through the flexible neural tree, and the fuzzy hierarchical analysis further optimizes the parameters of the flexible neural tree to improve the classification accuracy of the

model. So the fuzzy hierarchical analysis method model for international import and export trade credit assessment is an important method to better assess the credibility of institutions and promote trade development. The evaluation model constructed in this study is more efficient, can evaluate risks well, avoid certain risks for international trade activities, and has certain use value.

Data Availability

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

Conflicts of Interest

The author declares that there are no conflicts of interest.

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Research Article

Research on the Impact of Optimal Configuration of University Library Layout on Students' Academic Literacy Development Based on 5G

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This paper provides an in-depth study and analysis of the relevance of adopting the idea of 5G for the optimal configuration of university library layout to the development of students' academic literacy. It also analyzes the benefits of 5G on the digital governance of libraries together with the convenience that the application of 5G can provide to smart libraries and helps to realize the research on the service innovation model of smart libraries under 5G. The survey mainly focuses on four indicators: the development of physical space services in university libraries; facilities and equipment for physical space services; the content and form of physical space services; and it presents the current problems of physical space services, including the overall convergence of physical space services in university libraries. When different libraries are co-constructed and shared, there will be incompatibility problems, and if the library is required to develop its own management system, it will waste resources. The library space layout is arranged by highlighting the elements of the cognitive map to improve the lending efficiency; using a more continuous and transparent interface in terms of color and material to increase the experience of spaciousness; using more wood elements and green to add a natural atmosphere to achieve the purpose of relaxing the readers' heart; and finally increasing the light source in the reading area to complement the illumination in the shaping of the light environment. In terms of spatial functions, more attention is paid to the design of public interaction and leisure spaces so that readers can rejuvenate themselves and devote themselves to the next learning tasks. The interior design is considered in terms of the relationship between arousal theory and task performance, and a moderately complex interface is designed to improve readers' efficiency in the space. Finally, the paper concludes with a summary of what has not been thoroughly researched and an outlook on the future of university library interior design.

1. Introduction

With the development of the information age, the functional change of university library space service in the digital environment is based on the humanistic concept of freedom and equality, and the transformation of multifunctional space service to integrate knowledge service, learning support, and recreation [1]. The multifunctional space includes not only paper books but also the spiritual lives of readers, and it is a comprehensive space for learning, communication, and thinking activities. In addition, the resources of the university library collection, the use of space, and various services are a trinity. The physical space provides services in reading, exhibition, seminar, and communication; the library provides virtual space services through the digital platform; the readers form the corresponding spiritual space in the process of obtaining information and services and interacting with the librarians. Different colors give people different psychological feelings, so the reasonable use of colors in the indoor environment can affect the psychological state of users. The space service in this paper mainly deals with the physical space service. Due to the development of information technology and the diversification of readers' needs, the physical space service of traditional university libraries can no longer meet the diversified needs of readers, so the optimization of library physical space

service has become one of the important works of libraries [2]. Readers can not only read and study in the library but also enjoy digital information and physical space services with various characteristics such as academic seminars, education and training, and creative displays.

The development of 5G is now in full swing, and many countries around the world are accelerating the application and innovation of 5G, and the industries combined with 5G are also emerging. 5G is slowly integrating into our lives, gradually improving our lives, promoting the consumption of information, and providing a solid foundation for the realization of a digital economy and society in smart cities. This technology has the characteristics of ultra-high network speed and low delay, will realize the interconnection between people, between people and things, between things and things [3]. The 5G, new technology and standard, will bring great changes and impacts to the organization and delivery of information in libraries. It will further bring about changes in the organization and content of library information, and ultimately in the behavior of library users using terminals. Based on 5G, the services provided by smart libraries will be better and more innovative. In terms of the amount of information to be undertaken at the terminal, due to the large capacity and low latency of 5G, it will realize the rapid docking of information to the server terminal and the real-time circulation between data, realizing the value of data and greatly improving the quality of the past [4].

It will improve the education mode and learning mode of academic master of education students, enhance the comprehensive quality of academic master of education students and the cultivation quality of talents, show the character and ability that a professional in education should have, form the characteristic core literacy of academic master of education students, improve the system of core literacy of students in different stages, different disciplines, and different majors in China, and provide lay a good foundation for the reform of education teaching under the new situation. The main task of pedagogy is to study education and help the reform and development of China's education. When the greenness of nature reaches 25% in people's field of vision, people's spirits are particularly comfortable, and their mental activities will be in the best state. As an important part of the discipline of pedagogy, pedagogical professionals should not only show the knowledge and ability they should have professionally but also take up the heavy responsibility of the development of pedagogical disciplines, and the study of core literacy puts forward new ideas and new ways for the cultivation of pedagogical professionals. The study of core literacy of academic master students in pedagogy, the establishment of the corresponding core literacy system, the cultivation of students' ability to adapt to personal development and contribute to social development, and the formation of the characteristic core literacy of master students in pedagogy are the way to build a first-class pedagogy discipline, to realize the take-off of Chinese pedagogy, and to improve the quality of high-level and high-level personnel training.

2. Related Works

Tong proposes that learning shared spaces integrate libraries, information technology, and other supportive services from a functional and spatial perspective, integrating librarians' knowledge and skills with experts' references, and are dynamic spaces that encourage learning problem solving through consultation, collaboration, and discussion [5]. Numerous university libraries are also fleshing out their understanding of learning in shared spaces in practice. For example, the Stover Library at Queen's University in Canada has added more areas, facilities, and staff to support learning activities based on information-shared spaces as collaborative learning environments [6]. The Library and Student Affairs Centre at the University of Guelph in Canada have jointly established learning shared spaces [7]. The learning commons model is defined as a "one-stop shop" for intellectual learning, writing, science research, and technical support. The University of Cincinnati's Library learning commons is a seamless learning environment defined by the university library in collaboration with the campus student support center as a student-centered, engaged learning environment. Scholars' research on the elements of creating urban spatial vitality has mostly focused on urban public spaces at the most-micro level [8]. For example, Petscher et al. analyzed two case studies of spatial creation in urban centers and summarized that urban public space vitality is related to accessibility, environmental quality, and public facilities elements [9]. Starting from the nature of the city and the purpose of urban research, Smith proposed the principles of functional mixing, scale creation, transportation system organization, individualization, and driving elements as the principles for the creation of urban public space vitality [10]. Increased students, who apply for postgraduate studies in education, enter the field of education, but their self-awareness ability in this field has not increased proportionally. Although many design theories aiming to create urban space vitality have been proposed, they all rely too much on designers' intuition and experience and need further empirical evidence and generalization, so increased number of scholars have started to verify and evaluate the principles of creating urban space vitality [11].

Dai et al. first published an article on smart libraries, and they first proposed that smart libraries are mobile libraries that are not limited by space or time like traditional libraries, and can help readers find the books and materials they need by providing personalized services to different readers' needs and fully implementing mobile networks and wireless services [12]. Allam et al. argue that a smart library should be treated as a social learning place and its service model should be informal and cooperative from the perspective of library users [13]. It not only has the service functions of a traditional library, but it needs to fully exploit the creativity and logic of users while presenting a collective and interactive form to users, and the library needs an online knowledge learning system to increase the number of users.

The questionnaire method was used to obtain users' satisfaction evaluation of the maker space service, and SPSS software was used to analyze the reliability of the scale data and rank the satisfaction evaluation of each service item, analyze the reasons for the low satisfaction level, and propose strategies to optimize the lack of service, to provide a new perspective for the study of maker space service in university libraries. The author conceptualizes the propaganda path, constructs models such as space alliance, virtual space, and evaluation system, and proposes countermeasures under public health events for creator spaces in the light of the current situation of normalization of epidemic prevention and control, which will provide reference significance for other libraries. Meanwhile, the all-around development of human beings also includes the development of human talents, aspirations, and moral qualities in many aspects. In short, the all-around development of human being includes both the all-around development of material level and the all-around development of spiritual level. Therefore, Marx's doctrine of comprehensive human development requires that in cultivating the core qualities of academic master students in education, it is necessary to think clearly about what core qualities educators should have and what core qualities are necessary for academic master students in education to achieve their development and promote professional development.

3. 5G's University Library Layout Optimization Configuration Design

Libraries put space services and their innovation in an extremely important position in library work. Library space service is the service of providing targeted knowledge products for the acquisition, sharing, and innovation of readers' explicit knowledge and tacit knowledge. In other words, libraries rely on different types of spaces to carry out document services, information services, knowledge services, and contextual services, and librarians apply cognitive, technical, and experiential tacit knowledge to process information at different levels according to readers' needs, to continuously improve the level of services and the quality of knowledge products and promote readers' better construction of knowledge. As a high-level skill, knowledge transfer mainly trains students to integrate knowledge and skills in other disciplines and related fields, and give full play to their thinking; information technology enables ubiquitous learning to be realized. This paper focuses on the physical space service of university libraries.

The physical space of the library mainly includes the physical building architecture, facilities, equipment, physical collection, decoration style, and space layout. The physical space is the physical place where the university library provides services and carries out readers' learning and communication activities. Some scholars also refer to the physical space of libraries as architectural space and building space [14]. Under the concept of resource sharing, scholars define university library space serves as a service that ultimately improves readers' cognitive level and comprehensive ability by providing suitable places, resources, and activities for teachers and readers. In summary, the author defines the physical space service in this paper as the service aimed at improving the comprehensive ability of readers based on the physical space and various facilities and equipment of university libraries.

From the perspective of service composition and configuration, the physical space service of the college library includes not only the appropriate reading space, i.e., books, databases, and other literary resources in the collection but also facilities and equipment such as computers, tablets, interactive multifunctional electronic screens, miniature book readers and other professional reading tools, as well as the corresponding technical and business support librarians. From the readers' point of view, the most well-equipped facilities within the research space service of university libraries, readers can immediately carry out corresponding reading activities and research activities in this space without bringing their equipment, while the reading space service is the most typical service among the physical space services of university libraries. Promoting the realization of professional value and promoting social development and progress are the value pursuit and significance of academic postgraduates in education. College libraries provide a variety of physical space services for readers by creating a comfortable atmosphere for their reading space, from infrastructure equipment such as tables, chairs, lighting, and air conditioning to reading objects and reading tools such as books and computers.

Before the advent of the information age, old libraries often used paper tools such as library cards, loan information cards, and catalog cards to keep records of books checked out and returned, which was very inconvenient as it consumed a lot of work for the librarians and took up a lot of space for the library. Now, these operation processes have been digitized, and since most of the library management systems now use bar codes to identify books, only a reader's card, a scanner, and a computer are needed to quickly record the borrowing and returning information into the library management system, which greatly accelerates the speed of borrowing and returning books, and users can also do self-service borrowing and returning. But this does not solve the problem completely. Whether self-service or manual borrowing and returning, the shelves of literature resources still need to spend a lot of effort to complete, including the entire shelf, off the shelves, inventory, and other work that requires a lot of workforces. The intelligent library in this regard can use intelligent equipment to complete these tasks, through RFID, sensor networks, M2M, and other Internet of Things technology to achieve the application of intelligent shelves and purpose of automatic organization of literature resources and fast search.

Since the 5G network is not a complete replacement of the previous network, there are various wireless network standards for network devices that access the base station, and most of the 5G is used in scenarios that require high transmission speed, so its network bands will mainly focus on the high-frequency band, which in turn will increase the access of many different network devices and require many micro base stations to receive processing. In this case, only a

superdense heterogeneous network can meet the abovementioned requirements and at the same time not lose the characteristics of fast speed, low latency, traffic density, and high capacity of 5G, so the key technology of superdense heterogeneous network technology cannot be missing in 5G, as shown in Figure 1.

Because of this, the resources in the library cannot be connected to other management systems outside the library more openly. When the library needs to provide resources to users, it is very inconvenient to provide services if the resources are under the authority of different library management systems [15]. The number of students, who go to the reading library for self-study, is as high as 60%. Furthermore, libraries do not store their metadata information locally in terms of electronic resources, which makes it difficult to perform value-added services such as knowledge mining. Finally, the traditional library management system is designed differently from the smart library, so the overall architecture must have its shortcomings for handling these new types of resources, and it is difficult to improve this problem even if it is constantly updated and optimized. The library management system in a smart library must consider the integrated management of many different types of resources, and it must be unified not only in terms of library management but also in terms of user needs so that it feels unified when users find and use it.

In the past, library management systems were generally outsourced to companies specializing in this area, and the companies must have several sets of templates for libraries to choose from to save R&D costs, and then make some technical adjustments according to the actual situation of the library. So on the one hand, because the architecture of the management system is determined, unless the library chooses to change the system, it can only be left to the staff of the outsourcing company to carry out some minor updates and optimization, which cannot fundamentally change certain problems; on the other hand, the library management systems of different companies may have different interface specifications and standards, and incompatible problems will occur when shared between different libraries [16]. On the other hand, if libraries develop their management system, it will be a waste of resources, and outsourcing can be mutually beneficial for libraries and companies. The best way is for the library consortium or library association to develop standards so that there will be no problems due to incompatible interfaces when sharing knowledge.

Services in library learning spaces include lending services, training services, and consulting services, with lending services concentrated in traditional reading spaces and electronic and audio-visual reading spaces. Training services are concentrated in the training space, and some of the libraries in the study also directly use electronic or multimedia reading rooms for training. On the other hand, consultation services are mainly provided in three types of learning spaces. Third, the processing and creation spaces of each library are also equipped with professional librarians to provide consultation services because they support students' practice and creation, as shown in Figure 2.

Documentary information resources are mainly concentrated in the traditional reading space and the electronic audio-visual reading space, in which the traditional reading space is classified according to the type of publications and provides resources corresponding to the type of publications, and users can borrow printed publications in the traditional reading room [17]. This is an important factor that distinguishes the campus library from the social library. The electronic audio-visual reading space mainly provides the borrowing of physical audio-visual materials and the reading of resources such as databases, electronic journals, electronic books, and network information.

Color is the design element with the strongest emotion, and the visual experience and visual stimulation will stimulate internal emotional changes after people receive color visually, and the psychological feelings of people vary greatly with different colors. The main activity of the library is reading, and the university library also assumes the function of providing space for students to study when they study their homework. Reading and self-study activities are influenced by reading materials, study contents, and students' psychology. The reasonable color scheme of the reading room can improve students' motivation to read and study, and ensure that students can study in a bright and comfortable environment.

In addition, the use of a more complex color design in the rest space and corridor can also activate the readers' thinking and make them more energetic when they return to the reading environment. Environmental psychology points out that people love natural elements, and any color and element that can awaken people's association with nature can increase people's comfort. Psychologists believe that green is the most calming color, which can bring the benefits of tranquility to exhausted people, and when the green color of nature reaches 25% of people's vision, people's spirit is especially comfortable and their mental activities will be in the best state.

4. Impact of Students' Academic Literacy Development

After systematically analyzing the relationship between core categories and primary and secondary categories, the study found that self-cognition, learning strategies, scientific thinking, humanistic cultivation, and innovative practical ability become the constituents of core literacy of academic master students in education. Among them, self-cognition and humanistic cultivation are the twin foundations of core literacy of academic master's degree students in education, and they are interrelated and promote each other, which are the foundation of core literacy development [18]. The top level is the ability of innovation and practice, and the ability of practice is the highest manifestation of learning strategies and scientific thinking. According to the abovementioned analysis, the model of core literacy of academic master students in education is established as shown in Figure 3. Therefore, the combination of seats in the reading room should be increased to obtain more space.

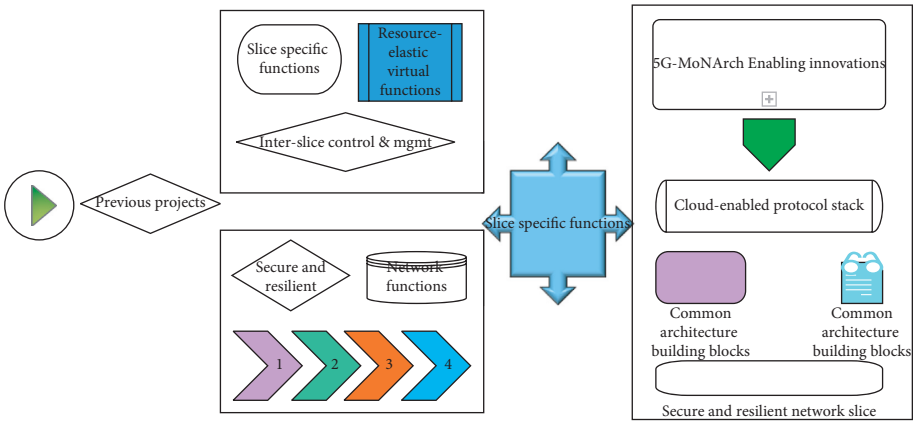

Figure 1: Layout framework of the university library for 5G.

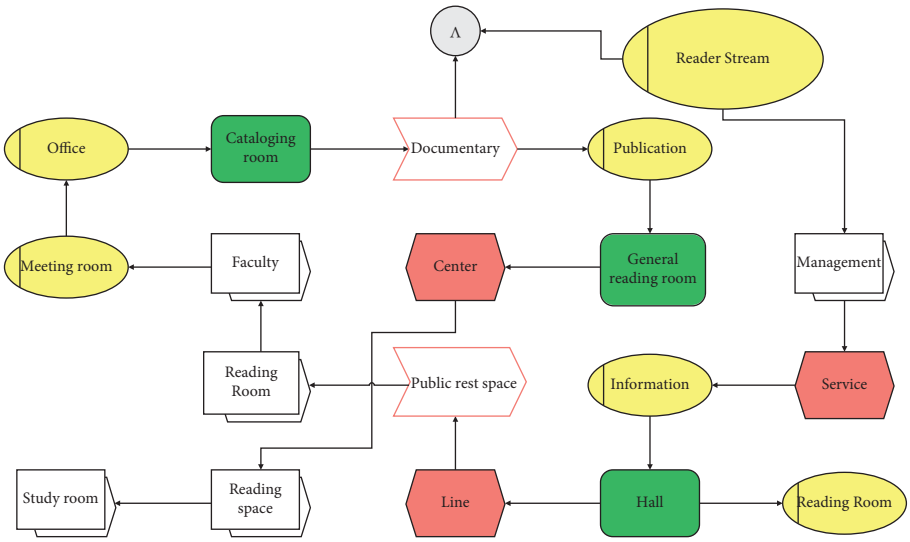

Figure 2: Library flow design.

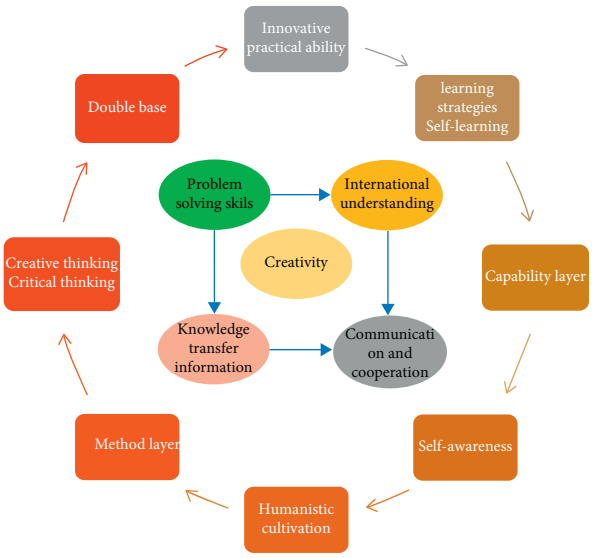

Figure 3: Model construction of core literacy.

Secondly, the two foundations that constitute the core literacy of academic master of education students are self-cognition and humanistic cultivation. Without these two elements as the foundation, it is impossible to develop upward. According to the interview data, with the increase of the craze and the number of examinations, more and more students applying for master's degree in education enter the field of education, but their self-cognitive ability for entering this field does not increase proportionally, and they do not have a correct understanding of the profession, which in turn leads to the inability to get their studies on the right track and the inability to drive their emotional cognition, and eventually makes their development concept contrary to that of the initial entrance stage.

Academic master's degree students in education are exposed to the relationship between education and people, which naturally involves whether pedagogues can hold a benevolent heart, whether they can put themselves in the position of contributing to the cause of education, and whether they can shoulder the important responsibility of

raising the country through education; at the same time, pedagogical research is a long and arduous process, and students have a persevering will and can abide by academic ethics for it is the foundation of research [19]. Formative evaluation and summative evaluation have not really started effectively, and the feedback received lacks normative requirements. The continuous improvement of self-cognition makes personal humanistic cultivation stronger; the strengthening of humanistic cultivation promotes self-cognition in the field of pedagogy, and the two are closely related and mutually reinforcing. Accordingly, it is the right thing to take self-cognition and humanistic cultivation as the "double foundations" of the core quality system of an academic master's degree in education.

It emphasizes the ability of independent learning, which is a high stage, manifested in the planning and arrangement before learning, the monitoring and evaluation, and feedback during learning, and the adjustment and control after learning; communication and cooperation is a skill that runs through the activities of graduate students, including the communication between supervisors and students during daily learning and the cooperation between students and students among research team members; knowledge transfer as a high stage. The main skill is to cultivate students to integrate knowledge and skills from other disciplines and related fields to give full play to their thinking; information technology enables ubiquitous learning, which is the process of quantitative to qualitative change after the development of digital learning and mobile learning to a certain stage, as shown in Table 1.

Finally, the uppermost element that constitutes the core quality of academic master's degree students in education is the ability to innovate and practice [20]. The formation of educational theory is based on educational problems, while the discovery of educational problems depends more on educational practice. As a public cause of human beings, education is related to the interests of the public and society in many aspects. It is the value pursuit and meaningful embodiment of academic master's degree students in education to enhance the ability of educational practice, promote the realization of professional value and advance the development of society. The innovative practical ability of academic master students in education includes problem-solving ability, international understanding ability, and integration ability, which are based on learning strategies and scientific thinking. Most students only complete practice reports for credits, which do not meet the real training requirements for innovative practical ability. A good learning style and reasonable use of scientific thinking are the keys to solving practical problems, which are directly related to whether graduate students can use the knowledge and skills they have acquired to solve practical problems arising from social life.

First, in terms of teaching content, the observation of teaching content mainly focused on the teachers' choice of reading materials [21]. In terms of content selection, the four teachers would independently choose the reading materials to be taught before the class, which were usually texts to be taught in the textbook or the reading training exercises. The reading materials were generally determined by the teachers and were usually texts that contained knowledge points or expanded on the content of the text. Moreover, the teacher did not pay much attention to students' interests when selecting the materials but rather chose reading materials that were related to the topic of the unit and contained relatively more knowledge points.

Table 1: Statistics of basic information.

Variable	Category item	Sample size	Percentage
Grade	Kenichi	32	50
	Kenji	50	54
	Kenzo	24	34
Gender	Male	60	38
	Female	49	49
Is it interprofessional	Do you love education	48	42
	Easy to postgraduate	45	41
Reason for study	Adjust	53	34
	Employment difficulties	59	20
Plan after graduation	Other	38	42
	Read a Ph.D.	49	32
	Employment	35	48

5. Analysis of the Results

5.1. The Results of 5G's College Library Layout Optimization. Slightly more respondents use the Humanities and Social Sciences Chinese book library, the Foreign Language book library, and the Natural Sciences Chinese book library in the basic library. Meanwhile, the utilization rate of the periodicals reading room, the tools reading room, and the newspapers reading room is not high. Only 5 of the respondents in the library regularly use the specialized current periodicals reading room and the tools reading room, respectively, accounting for 5.10% of the number of respondents on the premises.

Among the traditional reading spaces built in the library building, they can be divided into 12 categories. The most built traditional reading spaces are humanities and social science reading rooms and Chinese science and technology reading rooms. The next most common ones are foreign language books reading room, periodicals reading room, back issues reading room, and newspaper reading room. The coverage rate of tool book reading rooms, preservation book reading rooms, antique book reading rooms, and dissertation reading rooms is significantly lower compared to the former. In addition, literature/art/history leisure books, and teaching reference books, are not separate publication types, but some of the premises in the statistical survey also have separate reading rooms for these materials.

Regarding the floor distribution of each learning space, traditional reading space and seminar space are relatively evenly distributed on the low, middle, and high floors, with traditional reading space slightly more distributed on the

middle floors and seminar space slightly more distributed on the low and middle floors, while there is an inverse relationship between the floor setting of seminar space and the scale of the space, with the larger the scale the lower the floor it is located. Libraries provide virtual space services through digital platforms; readers form a corresponding spiritual space in the process of obtaining information and services and interacting with librarians. The electronic audio-visual reading space and training space are mainly distributed on the lower floors of floors, while the public self-study space and processing and creation space are concentrated on the lower and middle floors, and the single-learning space is shown to be concentrated on the upper floors.

As shown in Figure 4, among the 250 questionnaires from readers, only 105 of them could find the books they needed in time, and 145 could not find the location of the books in time. Among the 30 staff questionnaires, 19 people could find the books in time and 11 people could not find them in time. This shows that it is very important for both readers and staff to find the location of books in time. For readers, not being able to find the books they need in time is very delaying and affects readers' mood, which brings bad service feeling. The 5G is slowly integrating into our lives, gradually improving our lives, promoting everyone's consumption of information, and laying a solid foundation for us to realize the digital economy and society of smart cities. This library will not be visited again. For the staff, the inability to find books in time affects the efficiency of the staff, when the intelligent library can realize the automatic search and borrowing of books, it will be a good experience for both readers and staff.

Through this issue, we can see that most people choose to prefer paper books, the least number is the library service is very good, so in the minds of most people, the reason that attracts them to the library is that although the electronic channel e-books are now very advanced and developed, many people still like to read paper books, and as for the library service is ignored by many people. The library service is not enough to be recognized by the public, and the intelligent library needs to improve the service and meet the needs of the readers. Based on 5G, the services provided by smart libraries will have better innovation.

The whole library space is divided into main function space and auxiliary function space, and the auxiliary function space is used to connect the main space. The original layout of the first floor is that the lending and returning office, the new book depository, and the first reading room are arranged on the left after entering the foyer, and each space is closed independently. In terms of the amount of information received by the terminal, due to the large capacity and low latency of 5G, information will be quickly connected to the server terminal. On the right side, the exchange book bar, machine room, and literature office are arranged, and in the middle is the rectangular atrium, as shown in Figure 5.

The borrowing and returning offices are separate rooms on the left side of the whole space, and such a layout is very inconspicuous. Readers cannot easily find the borrowing and returning office after entering the library without signs, which affects the efficiency of borrowing and returning

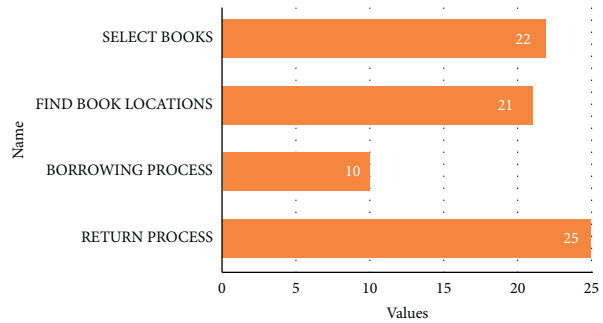

Figure 4: The most time-consuming steps.

books. The information retrieval equipment is placed on the right side of the entrance, directly opposite the original lending and returning office. Readers need to search for book information before borrowing books, and sometimes they need to ask the staff if they cannot solve the problem completely by themselves.

The original design separates the information self-help retrieval area from the lending and returning office. Since people will try to minimize contact and dialogue with people, such an arrangement will make readers more inclined to avoid problems when they encounter problems in the process of borrowing books without a specific purpose. It enables people to find the lending and returning office the first time they enter the library and facilitates readers to check out and return books more efficiently. Therefore, the information retrieval equipment and the circulation desk are combined in the middle of the whole first floor so that readers can find the circulation desk and the retrieval area the first time after entering the library, and improve the efficiency of consultation and circulation while saving the space of the original circulation desk. The original satellite aerial view of Shenyang city covers a large area and is generally beautiful, so it was removed during the renovation and replaced with the preferred indoor water feature, which can also play a role in purifying the environment.

In a previous survey, it was learned that up to 60% of students go to the reading room for self-study, which is an important factor that distinguishes campus libraries from social libraries, so the combination of seating formats in the reading room should be increased to gain more space. According to the needs of readers, librarians use tacit knowledge such as cognition, technology, and experience to process information at different levels, and continuously improve the level of service and the quality of knowledge products. At the end of the period, 40% of the students encountered a situation where there was no study space in the library and they needed to take a seat in advance. Therefore, the allocation of study space in the library should be adjusted and subdivided into open-shelf reading rooms and collection rooms according to the usage rates of different major categories of books, and some less frequently used and more outdated books should be managed by closed-shelf management and called when readers inquire about borrowing, to improve the efficiency of space utilization and alleviate the problem of insufficient study space for students at the end of the period.

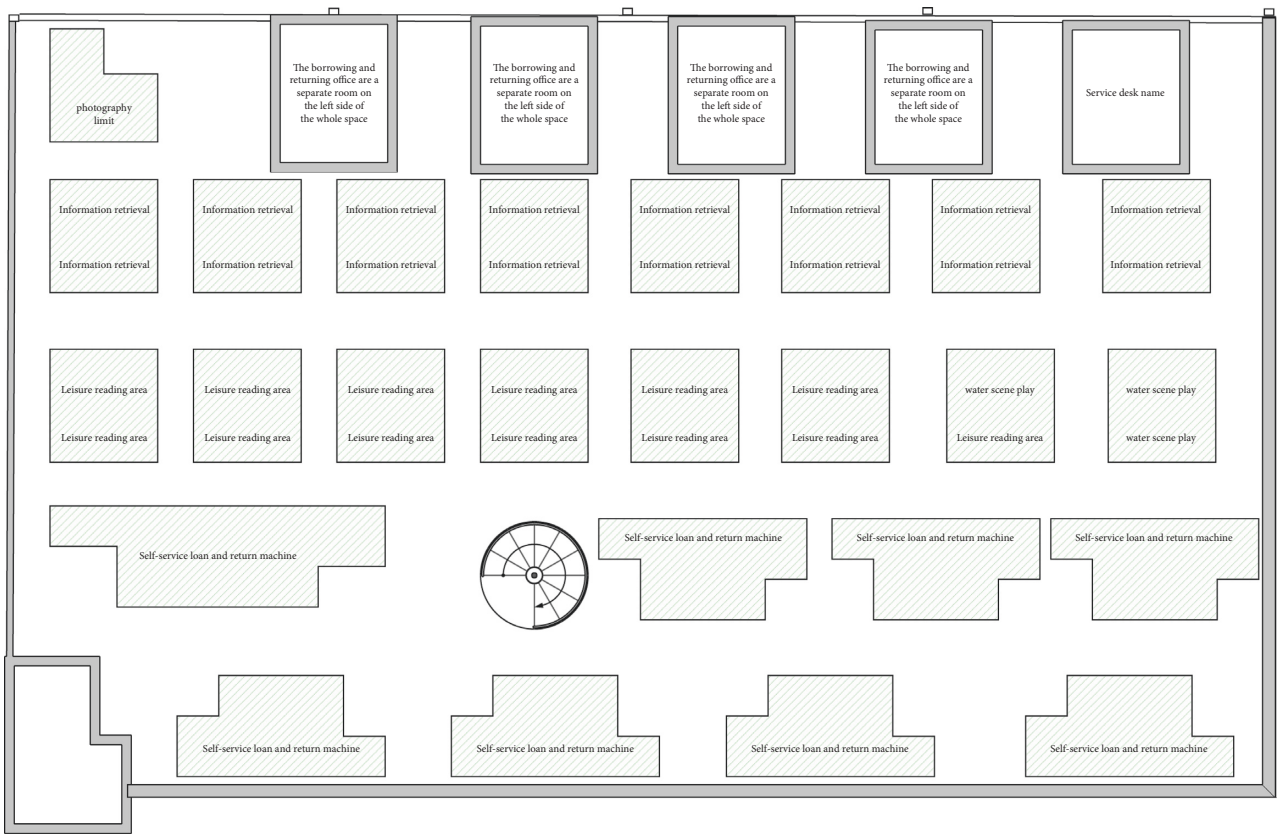

Figure 5: Layout of the university library of 5G.

5.2. Analysis of the Results of Students' Academic Literacy Development. For the cognitive element of learning, most students reflect that the current professional courses they study are conservative and old-fashioned in terms of course content, structure, organization, assessment methods, etc. It is difficult for students to exercise their autonomy to learn, and they do not know which appropriate learning method to adopt to meet their learning needs at this stage. They feel that they are constrained and suppressed in their professional learning, and it is difficult for them to take the initiative and be active in learning. At the same time, more than half of the students think that it is difficult to serve theoretical learning in practice, and there is a lack of discussion and research on educational problems, which makes it difficult to solve the practical problems in education, resulting in students' failure to achieve a satisfactory level of learning cognition.

For the element of emotional cognition, only a quarter of the students can identify with the philosophy and value of the subject of education emotionally, and more than a third of the students do not hold any emotion at all. Through the questionnaire survey, we found that some students have a complicated purpose of studying for the entrance examination, believing that it is easy to study for the education major, the review difficulty is relatively small, and it is easy to achieve self-satisfaction by passing the examination. Ultimately improving the reader's cognitive level and comprehensive ability of the service. The students, who succeeded in the examination, because they did not understand the major of education, found that the cognition of the major before the examination was inconsistent with the cognition produced after the actual contact after the examination, and even deviated very far, and the students' study aspirations decreased, which led to the low emotional cognitive element of the students and the difficulty in finding a sense of belonging emotionally, as shown in Figure 6.

For the developmental cognitive element, the questionnaire survey found that less than one-third of the students thought they had better development by studying in education. The reasons for students' low developmental perception of themselves exist in three aspects. First, the employment channels of education majors are narrow, and the employment positions provided by society are related to teachers, which cannot meet the intrinsic needs of different students. Secondly, an academic master's degree cannot do as strong practice as a professional master's degree, nor can it do a deep research as a doctoral degree, and hovering between the two makes academic master's degree in education students confused about self-development. Thirdly, most of the graduates say that their employment pressure is too great, and only very few of them can find satisfactory jobs. This reality of difficulty in being accepted and recognized by society also leads to students' low awareness of self-development.

At present, more educational practices are carried out for professional master's degree students in education, while the educational practices established for academic master's degree students in education are not perfect. First, there are fewer educational practice platforms or bases provided to

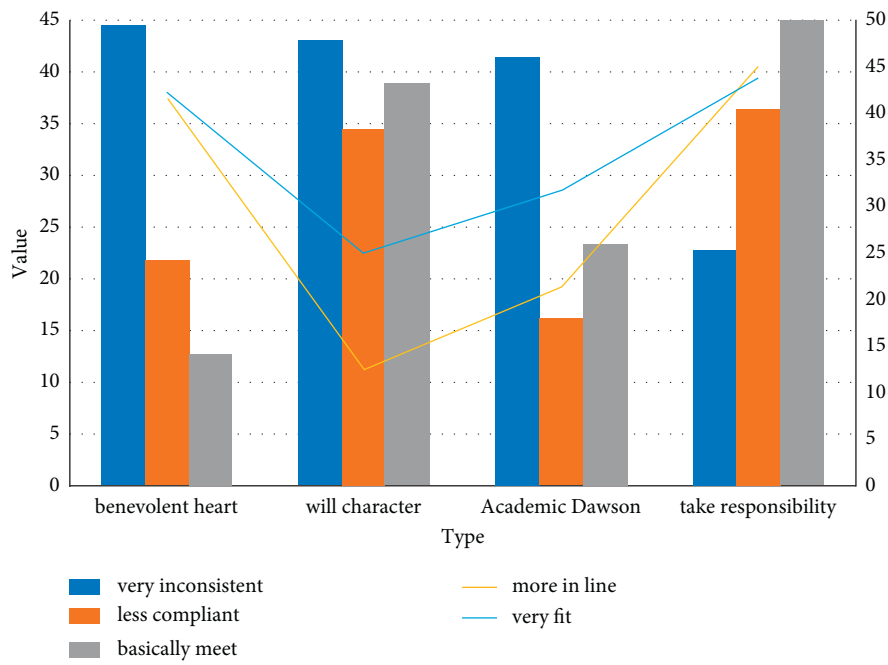

Figure 6: Histogram of the survey of cultivation elements.

students, and students have few opportunities to exercise their practical skills. To sum up, the author defines the physical space service in this article as a service based on the physical space and various facilities and equipment of the university library to improve the comprehensive ability of readers. The lack of students' practical experience and the single interpersonal relationship of social interaction makes them not have many channels and opportunities for social practice, and the forms of practice activities thus lack diversity, while the enthusiasm, attitude, and motivation of graduate students to participate in practice are not high, and the final feedback of practice is not done properly, and it is difficult to cultivate innovative practice ability, as shown in Figure 7.

Secondly, in the process of academic master's students in education participating in practice, the evaluation of formative and summative evaluation does not start effectively, the feedback received lacks normative requirements, and most students just complete practice reports for the sake of getting credits, which does not meet the requirements for the cultivation of real innovative practice ability. Corresponding reading activities and research activities can be carried out in this space immediately, and the reading space service is the most typical service in the physical space service of the university library.

In terms of the cultivation of multiple thinking, in daily English reading teaching, teachers give students less time to think about problems when discussing them; they lack hierarchy in the setting of questions and the exploration of the meaning of topics, which all lead to certain problems in reasoning, analysis, association, and induction. Secondly, in terms of developing reading fluency, teachers should pay more attention to students' reading aloud in daily teaching and arrange for students to

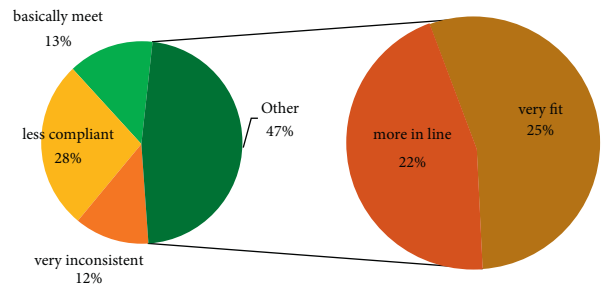

Figure 7: Elements of learning strategies.

read aloud in class, but they simply let students read aloud without teaching strategies and skills and evaluating students after reading aloud.

6. Conclusion

Although the development of 5G smart libraries has just begun, it is a qualitative leap for the development of smart libraries, and there are already 5G combined smart libraries in operation in China, and the number of readers' visits is increasing, and readers' demand for smart library services is also increasing. As 5G continues to expand research continues to be applied and integrated into all occupations in society, and how to provide better quality services will be the topic forever. A perfect service management system of creative space should include four aspects: its daily management system, creative team management system, funding management system, and creative project management system. It is proposed that the learning space of a college library mainly consists of seven types of spaces: traditional reading space, electronic and audio-visual reading space,

public study space, seminar space, single-learning space and processing and creation space, and the learning space of college library are the integration of space and services and resources within the space. There is also a lot of workforces required for the whole rack, take off the rack, and inventory. College libraries are generally concerned about the construction of learning space on the premises, and at the same time the library is also the most important after-school learning place for students, but there are still some problems in the specific use of library learning space by students, and there is room for optimization of learning space in the premises.

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

Mathematical Control of Space-Based Kinetic Energy Weapons Based on Partial Differential Equations and Evaluation of Their Destructive Effects

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This paper presents an in-depth study and analysis of the mathematical control of space-based kinetic energy weapons and the evaluation of the damaging effect by partial differential equations. The spectral element discrete format of the optimal control problem is constructed, the a priori error estimate of the control problem solution is proved theoretically, the posteriori error estimator is constructed, and the adaptive solution algorithm is designed. The posteriori error estimator is used as the encryption criterion to guide the local encryption of the grid so that the distribution of the dissection nodes is denser where the function regularity is poor. In the case of a compartment subjected to a shell attack, the effect of different factors on the structural damage of a single compartment under two explosions is investigated by varying the explosive mass, the location of the blast point, and the interval between the two explosions. In this paper, the problem of implosion in the cabin is studied, and the main factors affecting the response of the implosion structure are analyzed using dimensionality. The data of various simulation conditions are counted, and the dimensionless damage number is fitted with the deformation results of the bulkhead under each damage mode. It is still difficult to obtain the acceleration information of the target. Experimental studies were conducted on the composite honeycomb sandwich structure penetrated by fragmentation at different velocities and angles, and the accuracy of the theoretical model and the fragmentation residual formula was verified based on the test results. The analysis found that the antidamage performance of the composite honeycomb sandwich structure is better than the existing honeycomb sandwich body structure, and the energy absorption per unit volume of the structure is 27.2%–84.2% higher than that of the existing structure in the range of different penetration velocities. The average error between the theoretical calculation results and experimental results of the remaining velocity of the broken piece is within 6%, the error with the numerical simulation is about 8%, and the composite honeycomb sandwich structure with the best energy absorption characteristics and structural parameters is obtained.

1. Introduction

After having a high-power laser and a stable and reliable follow-up system, the high-energy laser reaches the target through atmospheric transmission, and its physical and chemical properties are changed by irradiating it for a certain period to finally complete the damage to the target structure or function. In this process, the influence of the atmospheric environment on the high-energy laser transmission cannot be ignored, and the atmospheric transmission characteristics are an important factor influencing the application effect of high-energy laser weapon systems and an important basis for their system testing and evaluation. In addition to the attenuation effect and turbulence effect of the atmosphere on the laser, the atmospheric transmission characteristics must also consider the effect of the thermal corona effect for high-energy lasers [1]. The attenuation effect makes the laser energy decay after transmission, the turbulence effect makes the laser transmission time intensity or phase undulation, beam drift or expansion, the thermal corona effect makes the beam further distorted and quality degradation, and the combined effect

of turbulence and thermal corona will have further impact. The fly-net bomb ultra-close range active protection interception system is a new concept of ultra-close range active protection system, which detects the incoming munitions into a certain range in real time, solves the ballistic trajectory of the target munitions, and launches the fly-net bomb with the action. The fly-net projectile captures and induces detonation of the target munition outside a certain range from the protection target so that the protection fortification is changed from possible penetration damage to fragmentation and shock wave damage, thus increasing its survival probability [2]. However, the maneuvering acceleration of the target plays a key role in the terminal interception of the interceptor, so this chapter also designs a disturbance observer based on high-order sliding mode for the terminal guidance stage. Underwater explosion load is very powerful, whether shock wave load or bubble pulsation and bubble jet can cause devastating damage to the ship, especially the ship's structure in the whole process of near-field explosion in different stages of the combined effect of different forms of load, and it is very easy to lead to the complete loss of life, so in the field of ship impact resistance and underwater attack weapons, research and development are required to carry out in-depth research on this. US Navy combat ships are required to undergo underwater blast impact tests before they are commissioned.

The study of inverse problems and mathematical control of stochastic partial differential equations is still in a very preliminary stage. The main difficulties in the theoretical analysis of stochastic equations are that the solutions of differential equations are affected by random noise, the classical derivatives concerning time t no longer exist, some tight embedding theorems for the deterministic case no longer hold in the stochastic case, and the immovable point method for nonlinear partial differential equations is not always feasible for stochastic nonlinear partial differential equations [3]. In general, it is difficult to find the exact solution to these control problems; therefore, it is important to study the efficient numerical solution algorithm to check the correctness of the mathematical model and the successful application of the optimal control problem. At present, the most important numerical method for solving optimal control problems with restricted partial differential equations is the finite element method [4]. In some extreme conditions, the air defense interceptor position may be destroyed by the attacking bomb before it is fully operational. Second, the higher flight speed possessed by hypersonic weapons as the attacker poses a great threat to the interception capability of interceptor bombs. The model based on the target motion equation is used to filter the system state with the augmentation of position parameters, which is equivalent to the identification of the parameters of the motion model. Traditional interceptor systems in the interception of cruise missiles, aircraft and other typical targets, the use of their speed advantage, etc., can more easily achieve interception. However, in the face of hypersonic targets, the speed advantage no longer exists, the inescapable area for interception of hypersonic weapons by interceptors is significantly compressed, and the interceptor's operational effectiveness is severely challenged.

The study of explosions in confined spaces began with the analysis of the factors causing structural damage, and as the research progressed, the study of the destruction of cabin structures by shock wave overpressure, quasi-static overpressure, fragmentation loads, and coupling effects between them attracted extensive attention from scholars. In this paper, we focus on the effects when a hull hits a ship and explodes in the compartment and the change law of compartment wall response when multiple weapons explode in the compartment. This has some application value for the design of ship protection structures and various damage assessment techniques that are compatible with intelligent combat. The main forms of implosion loads are high-speed fragmentation, shock wave overpressure, and quasi-static overpressure. High-speed fragmentation duration is the shortest, mainly resulting in localized damage, and cabin equipment and other obstacles can have a dampening effect on the high-speed fragmentation load. Shock wave overpressure peak is a large, wide range of action, reflected and superimposed at the bulkhead many times, and the load form is complex and related to the specific structure of the cabin. Quasi-static overpressure peak is smaller, the longest duration, the scope of action in the chamber where the explosion occurred, and the adjacent chamber that caused the breach, and the cabin equipment will enhance the destruction of quasi-static overpressure loads. The shock wave overpressure and quasi-static overpressure can be collectively referred to as the "pressure load."

2. Related Works

Goldberg pilots did not have any feedback on the damage of the target, and decision-makers needed to know the damaging effect of the target being struck to reasonably allocate combat resources and develop the next battle plan, so the Air Force pilots started to take pictures of the target during the strike and write postbattle reports [5]. Iohara et al. elaborated on the main differences between system targets and typical targets, gave the basic principles and general steps for the assessment of the damaging effect of system targets according to their characteristics, and discussed the effect decay model and the selection of indicators for the damaging effect accordingly [6]. Boukera et al. proposed the module composition, overall structure, and evaluation process of the general target destruction effect evaluation simulation system, and wrote the program to give the relevant calculation examples [7]. The research on the inverse problem of the stochastic partial differential equation and the problem of mathematical control is still in a very preliminary stage [8]. The main difficulties in the theoretical analysis of stochastic equations are that the solutions of differential equations are affected by random noise, the classical derivatives concerning time t no longer exist, some tight embedding theorems of the deterministic case no longer hold in the stochastic case, and the immovable point method for nonlinear partial differential equations is not always feasible for stochastic nonlinear partial differential equations [9]. These difficulties lead to the fact that many method dealings with the controllability and inverse problems of deterministic equations cannot be applied directly to the stochastic case.

Harfash considers a system of stochastic second-order and fourth-order parabolic equations [10]. The authors establish Carleman estimates for the stochastic heat equation and the fourth-order operator, respectively, and sum up to obtain the Carleman estimates for the coupled system of equations. Based on this Carleman estimate, the zero controllability of the coupled system is obtained [11]. Gupta proves the zero controllability of the coupled inverse stochastic heat equation system [12]. Because of the transient occurrence, this process can usually be regarded as a linear problem, so the shock wave load can be accurately calculated by empirical formula, then the energy carried by the shock wave can be obtained by integrating the relationship between the wave energy and the shock wave pressure, and then the energy carried by the shock wave can be obtained. There is no study related to the Carleman estimation of the system of stochastic degenerate equations and its application. The structure was tested for intrusion using a falling hammer experimental machine, the intrusion energy was relatively low compared to Wang's study, and the main energy dissipation of the structure was still dominated by the fiber tensile fracture of the composite skin [13]. Strength gradient and precompression experiments were conducted, respectively, and it was found that the tandem structure exhibited better mechanical properties, while no peak force appeared in the subsequent deformation phase of the structure under precompression, the transverse resistance had a significant effect on the deformation mode, and filling the honeycomb tube with tandem honeycomb could significantly improve the mechanical properties of such structures [14]. For honeycomb structures, the three commonly used analysis methods are static compression, ballistic damage, and blast impact. Under static compression, the compressive strength is much smaller than that under dynamic loading, and the plastic deformation region of the honeycomb structure is near the region where the sandwich structure is in contact with the intruder, while its damage is mainly concentrated inside the specimen, and the structure is more easily damaged during the intrusion process, which leads to fiber fracture, debonding delamination, or even perforation.

However, the propagation of pressure load inside the compartment and the effect law of multi-shot explosives on the destructive effect of the compartment wall when multi-shot explosives explode inside the compartment have not been fully studied. In the actual battle, the ship is likely to be attacked by multiple weapons, so this paper studies the damaging effect of multi-shot explosives on the cabin structure. The main purpose of this paper is to provide a quick prediction of the damage range of the compartment when it is subjected to multiple explosive attacks and to provide a reference for the damage assessment of multiple weapons. In this paper, we use the method of dimensional analysis to clarify the main factors affecting the structural response of the internal explosion and derive the dimensionless damage number of the internal explosion when the explosive charge and the blast distance change, the data of the simulation conditions are counted, and the dimensionless damage number is fitted with the deformation results of the bulkhead in each damage mode.

3. Analysis of Mathematical Control Partial Differential Equations for Space-Based Kinetic Energy Weapons

The optimality condition is given, the discrete format of spectral element approximation is constructed, the a priori error estimate of the optimal control problem is proved, the posteriori error estimator is constructed, and the adaptive solution algorithm is designed. Finally, the discrete system is solved using the gradient projection algorithm, and the efficiency of the adaptive solution algorithm is verified by extensive numerical experiments on the indication of the error by the posteriori error estimator. In this section, we discuss the integral control-constrained optimal control problem and consider the following model problem. Define the local velocities of the body as specified, including coupled translational and rotational motions.

$$\max_{u\in F_{ad}} J(u) = \left\{\frac{1}{2}\int_{\Omega}(y-y_c)^2 - \frac{1}{2}\int_{\Omega} u\right\}. \tag{1}$$

The basic idea of the Eulerian finite element method is to separate the transport term from the Eulerian equation, thus splitting it into two equations, solving them separately, and then combining the results of the two parts to obtain an approximate solution of the original equation. The method has a clear physical meaning: the equation without the transport term can be considered as fluid motion from the Lagrangian point of view; i.e., the grid follows the fluid mass under the action of the pressure gradient [15]. Since there is no transport term in this phase, it can be solved directly by the explicit finite element method without the need to construct the windward format; the second equation, which contains only the transport term, indicates that at the end of the time step, the fluid mass is kept still and the deformed mesh is moved back to its original position.

In this process, there is a relative motion between the cell and the fluid, and the transport of matter between the cells needs to be considered, a phase called the Eulerian phase. Through the combination of the two phases, the fluid matter keeps moving forward with time, while the mesh is fixed to maintain the original mesh mass. The method uses the proven techniques of the finite element method and the finite volume method, which makes the method highly robust and stable, especially for violent bubble motions with relatively high density at the interface. This kind of mesh control is almost exclusively used to solve problems involving rigid body motion, and it is necessary to define the mesh deformation range, the physical parameters of the rigid body, and the force and motion constraints on the rigid body in the dynamic mesh file Dynamometric.

$$a_i^L = \frac{1}{V-\Delta V}\left(a_i V + \frac{\bar{K}}{K_i}\Delta V^2\right). \tag{2}$$

In the Lagrangian step, the mesh and the fluid physical quantities are moved forward first, but in large deformation problems, the movement of the mesh can produce distortions and other factors that are detrimental to computational accuracy and stability. Therefore, it is also necessary to move the mesh back to its original position by a Eulerian step after each Lagrangian step. In the Eulerian step, the fluid mass is fixed, the mesh is moved backward to its initial position to eliminate the cell deformation according to the velocity calculated in the Lagrangian step, and the relative motion between the fluid and the mesh occurs.

$$G = A_c \sum_{j=1}^{38} R_j a_j^2. \tag{3}$$

With the rapid development of software and hardware technologies, numerical computation methods have become a common means for people. Therefore, an effective mathematical model can simplify the complex problems caused by numerical simulation and other methods. Compared with analytical methods, numerical computation methods lack certain rigor, but they are extremely adaptable and have outstanding advantages when dealing with practical problems. The core of numerical computational methods is discretization, and in general, the discretization in time and space is significantly different, while the discretization in space is relatively complex and has a great impact on the computational results [16]. Another focus of numerical computation method is the discrete format, which is the embodiment of its mathematical ideas and according to which different methods are divided accordingly, and the most common ones are finite difference method, finite volume method, and finite element method.

$$\begin{gathered}[C]\left\{\dot{T}\right\} - [K]\left\{\dot{T}\right\} = \{P\}, \\ \left(\frac{\partial T}{\partial t}\right)^{I+\Delta t} = \frac{1}{\nabla t}\left(T^{t+\Delta t} + T^{t}\right) - O(\nabla t).\end{gathered} \tag{4}$$

The motion law of the vehicle is determined by the external load acting on the vehicle, and the trajectory and motion state of the object can be determined by solving the six-degree-of-freedom motion control equations. The independent part is updated by numerical integration, the nonindependent part is updated by iteratively solving a nonlinear system of equations, and after one step of integration, error checking and integration step size selection are performed. If the tolerance error is satisfied, the state variables are updated and the simulation results are output to the simulation result file at the specified time interval before the next integration step.

$$P_w = 2\gamma p\left(S_{ij} + wS_{nm}\delta_{nm}\right)S_{ij}. \tag{5}$$

Although it is possible to simulate most of the penetration process and the breakage of the target plate with the help of finite element simulation, the results are always poor compared to experiments. Therefore, an effective mathematical model can simplify the complexity of the problem brought about by numerical simulations, etc. By simplifying the problem, the elements of the material can follow simple stress-strain laws, thus making the main features of the intrusion process obvious.

The elastic energy absorption of the underlying structure fills the problem of the lowering of the energy absorption curve caused by the stress drop of the upper core layer during the softening stage, resulting in the phenomenon that the structural energy absorption does not change significantly when the softening stage transitions to the crushing stage. Predictive corrected guidance is a common algorithm for ballistic planning of re-entry vehicles, but the prediction process of predictive corrected guidance is complex and is generally obtained by integrating differential equations, which is computationally intensive and has poor real-time performance. As the target model in this paper, the accuracy requirement for ballistic planning is not the primary consideration, so an energy-based analytical predictive guidance algorithm is used to perform ballistic simulation for the boosted glide hypersonic vehicle, as shown in Figure 1.

When making predictions, future ballistic predictions can be made based on the lift-to-resistance ratio at the current moment [17]. Between 3.41 ms and 6.21 ms, it can be observed that the deflection value of measuring point 6 continues to increase, and the increasing trend of deflection value of measuring point 7 is obviously slowed down, which indicates that the deformation of the bulkhead at this stage is mainly concentrated in the area near the center of the bulkhead; after 6.52 ms, the deflection value of each place no longer increases substantially and begins to converge to a certain fixed value. Although the lift-to-resistance ratio changes throughout the ballistic process, this error is acceptable when the distance is far, the range of error in the lift-to-resistance ratio becomes smaller and smaller during the approach to the target point, and the prediction accuracy becomes higher and higher. Although this analytical method has limited accuracy compared with the traditional prediction method, the computing efficiency is greatly improved, which is very suitable for the research object of this paper.

In addition, in the end-guidance phase, the general infrared detectors can only obtain the relative angular information of the target, and it is still difficult to obtain the acceleration information of the target even when supplemented with the distance and velocity information from external detection systems. However, the maneuvering acceleration of the target plays a critical role in the implementation of terminal interception by the interceptor. Therefore, in this chapter, a perturbation observer based on a high-order sliding mode is also designed for the terminal guidance phase, and the unknown acceleration information of the target is observed and estimated as a random perturbation. Regarding the convergence of the sliding mode observer, the detailed proof is given in this paper to ensure that it can achieve accurate estimation in finite time while satisfying the assumptions. From the overload characteristics, the relative change in the target's overload has a large magnitude and a long change duration, and although the absolute value of the overload change is not large in a short

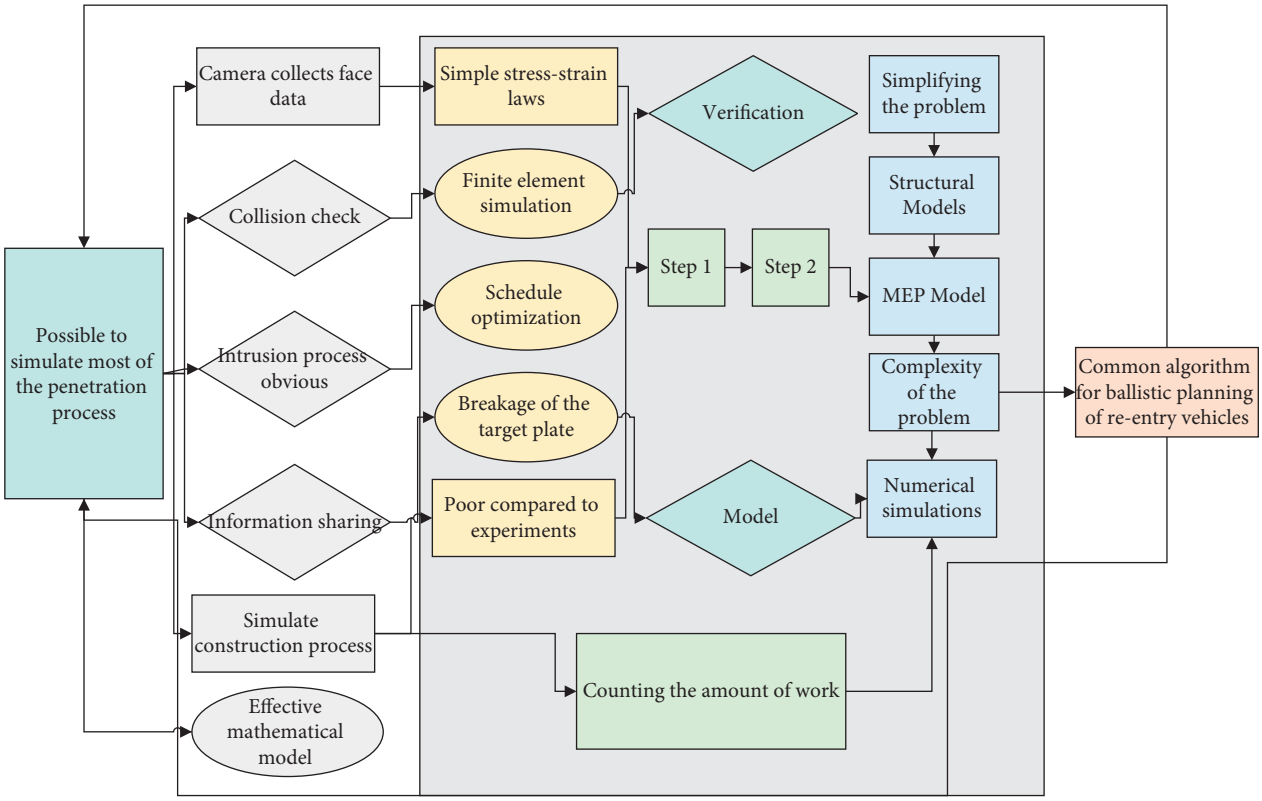

Figure 1: Mathematical control of partial differential equation steps.

period, more accurate modeling of the target's motion must also be performed to perform a 50–100 s ballistic forecast, as shown in Figure 2. With the continuous action of the pressure load in the cabin, the units in the direction of the final explosive connection line are also all separated from the bulkhead.

However, in this paper, in addition to the target tracking, it is also necessary to predict the future motion of the target for 50–100 seconds to give the predicted collision point [18]. To solve this problem, a model based on the equation of motion of the target, supplemented with position parameter augmentation, is used to filter the system state, which is equivalent to the identification of the parameters of the motion model. However, when using this type of motion model, many unknown parameters cannot be obtained directly, they need to be assumed using a stochastic process and augmented to the state of the original equation of the target, and the specific process of this method is described below.

When performing such state augmentation and filtering, we must admit that the final obtained parameter identification results do not necessarily achieve high accuracy due to the noise of the observations, the degree of approximation of the augmented state model, and other factors, but this part of the study is mainly to make a general forecast of the future state of the target vehicle and does not require a very accurate prediction. Moreover, as the prediction time is shortened, the prediction error will be reduced continuously.

4. Design for Mathematically Controlled Destruction Effects of Space-Based Kinetic Energy Weapons

As mentioned earlier, the underwater explosion process includes shock wave and bubble stages, both of which account for an important proportion of the total energy. In the shock wave phase, the blasted product generates a strong intermittent shock wave by compressing the surrounding aqueous medium, which carries the shock wave energy consisting of kinetic and internal energy to propagate outward and eventually dissipate in the distant flow field. Because of the transient occurrence, this process can usually be considered a linear problem, so the shock wave load can be calculated accurately by empirical formulas, and then the energy carried by the shock wave is obtained by integrating the relationship between the wave energy and the shock wave pressure, and then obtains an empirical formula that can meet the engineering needs [19]. Therefore, although the underwater explosion shock wave and bubble two-stage full process numerical simulation method established in this paper can simulate the shock wave stage well, this section does not focus on the energy dissipation in the shock wave stage as the research focus.

In the bubble phase, when the underwater explosion bubble moves in the free field, the internal gaseous explosion products and the external flow field constitute a dynamical system, and under the balance of pressure and inertial forces,

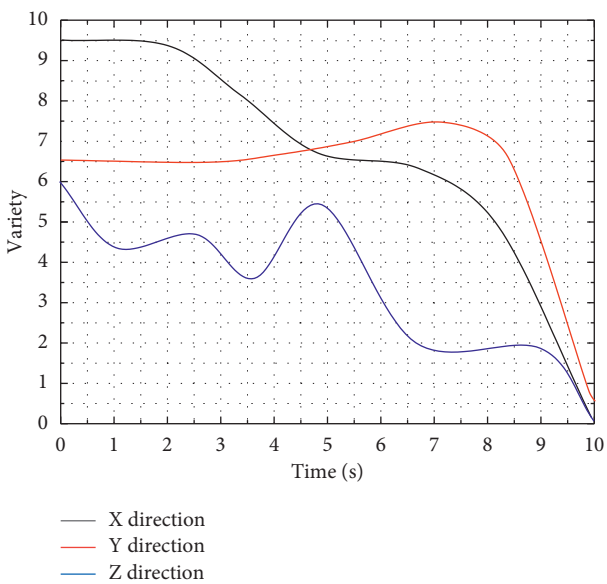

Figure 2: Variation of center-of-mass position.

the bubble generates multiple pulsations and radiates the bubble pulsation load outward. Experimental studies have found that the maximum radius of multiple bubble pulsations decreases one by one, which indicates that the energy of the whole system is continuously dissipated. This energy dissipation is essential for the accurate prediction of bubble pulsation loads. However, bubble motion is a typical nonlinear large deformation process, which is usually accompanied by complex processes such as nonspherical motion, jet development, and tearing and fusion, while the complete compressibility of the flow field needs to be accounted for, which poses great difficulties for accurate calculation of energy dissipation in this phase, as shown in Figure 3. The attenuation effect makes the energy attenuate after laser transmission, the turbulence effect makes the light intensity or phase fluctuate, the beam drifts or expands, and the thermal halo effect further distorts the beam and reduces its quality. The combined effect of turbulence and thermal halo will have further influence.

The angle selected in Figure 3 can observe the propagation pattern of the shock wave in the center of the chamber and the area near the bulkhead. The phase represented by 0.7~0.8 ms indicates that the shock wave propagates along the bulkhead boundary to the corner of the chamber and converges at the corner; the phase represented by 1.1~1.6 ms indicates that the shock wave converges at the corner and then reflects along the diagonal of the chamber and bulkhead toward the center of the chamber and bulkhead, and the high-pressure area is formed again at the center of the chamber with the highest pressure inside the chamber [20]. From the center of the chamber, the shock wave starts to propagate to the bulkhead once again. The difference with the first incident phase is that before the subsequent shock wave reaches the other areas of the chamber, there is already a certain value of overpressure, and the shock wave propagation path is more "dispersed" and no longer concentrated at the boundary of the bulkhead. By simplifying the problem, the elements of the material can follow a simple stress-strain law, so that the main characteristics of the penetration process become obvious.

The mesh motion is calculated based on the pressure on these boundaries, and in turn, the solver provides feedback to the fluid simulation. It changes the velocity boundary conditions on the included boundaries to specify the local velocity of the defined body, including coupled translational and rotational motions. This mesh control is used almost exclusively to solve problems involving rigid body motion and requires information on the extent of mesh deformation, physical parameters of the rigid body, and force and motion constraints on the rigid body to be defined in the dynamic mesh file DynamicMeshDict. In particular, under the combined action of different forms of loads at different stages in the entire near-field explosion process, the ship structure can easily lead to the complete loss of vitality.

The density, pressure, and velocity values of the gas change drastically under the interference of the excitation waves, and the pressure at the excitation wave action increases significantly [21]. Then, during 0.0002 s~0.0015 s, due to the blockage of the sub-bullet body, the excitation waves are repeatedly superimposed, causing multiple reflections of excitation waves and mutual intervention, resulting in the gas pressure in this region which has been increasing; due to the blockage of the support body surface, a stronger beam of excitation waves is reflected toward the bullet, and the range of the low-pressure region formed in the lower side of the bullet increases significantly; the tail of the bullet is complicated by the excitation wave disturbance. The complex structure of the flow field at the tail of the projectile due to the complex surge disturbance and the obstruction at the bottom of the support body is shown in Figure 4.

The two sets of numerical simulations start to have errors with the experimental data at a later stage, and this error accumulates with time. The distance between the same node of the experiment and the simulation is getting larger at the same moment. Therefore, it is necessary to carry out in-depth research in the field of ship shock resistance and the research and development of underwater attack weapons. The above set of experiments and two sets of simulations are briefly analyzed and evaluated, and the following conclusions are drawn: both sets of simulation models can simulate the motion attitude of the bead chain in the experiment to some extent, the simulation effect is good in the early stage, and the error gradually increases in the later stage.

After this, the upper layer of the composite honeycomb sandwich structure is in the softening stage, while the deformation of the middle skin is gradually increasing the load applied to the lower honeycomb core layer. Due to the inertia effect, the deformation trend of the upper layer structure is larger than that of the lower layer structure, the upper layer structure is the first to enter the compacting stage, and the energy absorption curve of the structure can

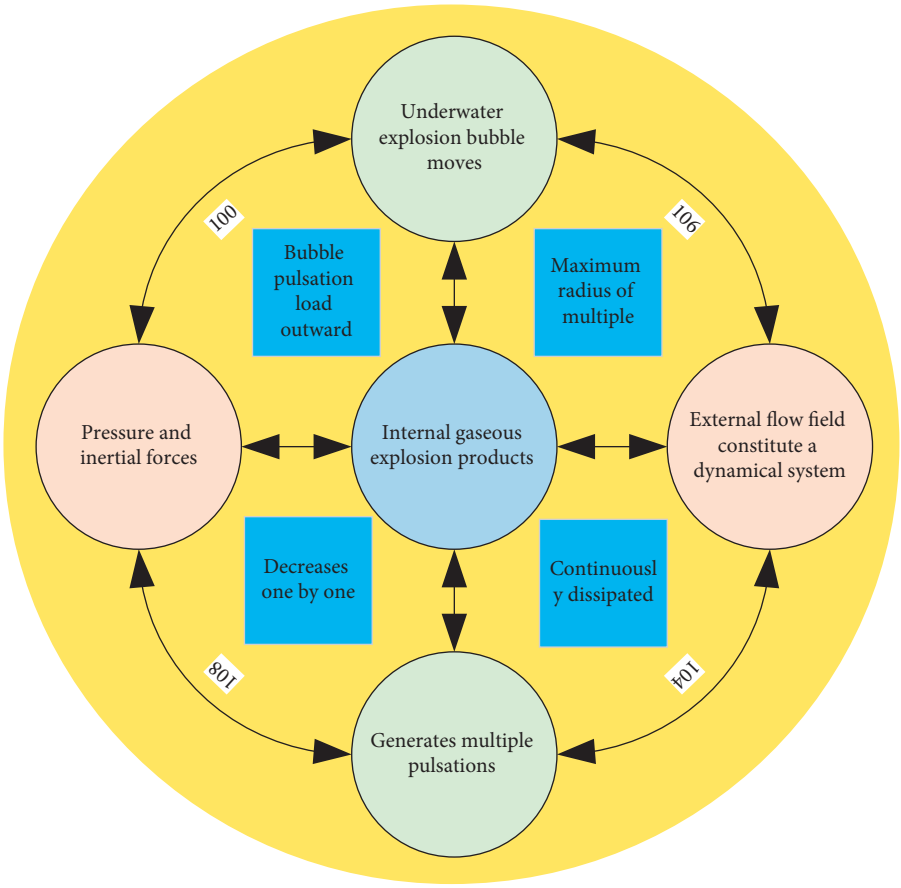

Figure 3: Mathematical control model for space-based kinetic weapons.

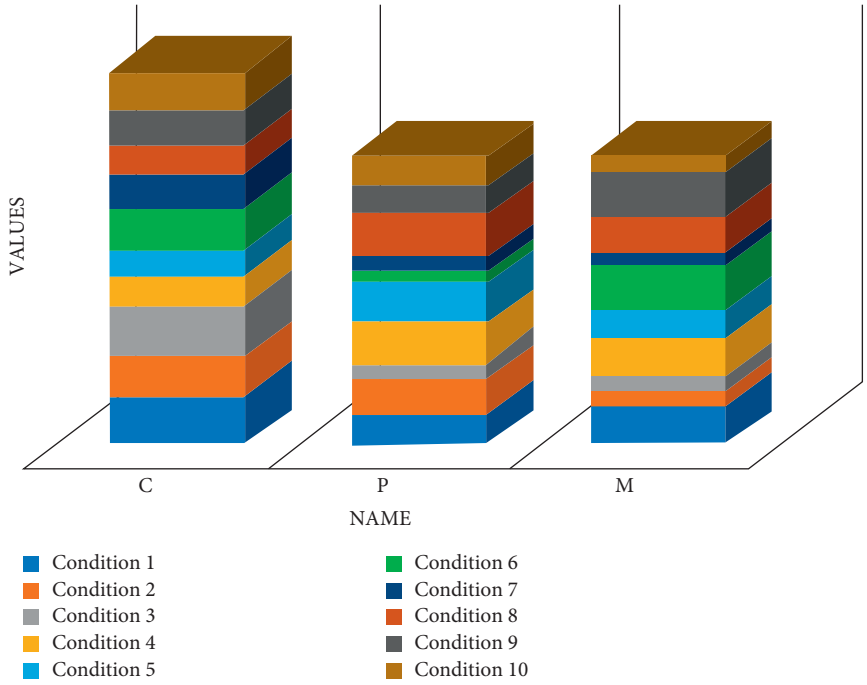

Figure 4: Dimensionless parameters at different sound velocity working conditions.

be seen to increase significantly. After 150 μs, the bottom skin is penetrated completely and the energy absorption curve reaches the limit value.

5. Analysis of Results

5.1. Analysis of Algorithm Performance Results. The consistent and adaptive grids are used to compute Example 2, and the control, state, and conjugate state variables are approximated by the piecewise higher-order elements. In Table 1, two different sets of results are presented, where M in the consistent and adaptive grids denotes the overall number of cells dissected, except that the consistent grid is uniformly dissected each time, while the adaptive grid is more densely dissected at each cell to be encrypted and the rest of the cells are sparsely dissected. CS denotes the number of encryptions of the cells to be encrypted in the adaptive grid, and N denotes the polynomial number.

Numerical results are given for each cell with seven and eight polynomial approximations. The results show that for the same number of cells, the adaptive grid converges significantly faster than the consistent grid, greatly reduces the number of heavy operations, the errors are within the desired range of controllability, and the computational efficiency is significantly improved.

Theoretical proofs of the a priori and a posteriori error estimates of the numerical solutions are presented. The hN adaptive spectral element algorithm is designed, and two numerical examples are used to verify the correctness of the theoretical results. In the first example, the solution regularity of the elliptic equation is good, and a consistent grid is used for the calculation. The numerical results show that the adaptive grid converges faster than the consistent grid, which greatly reduces the computational effort and improves the computational efficiency. As an attacker, the higher flight speed of hypersonic weapons poses a huge threat to the interception capability of the interceptor.

The adaptive spectral element method for the control-constrained elliptic optimal control problem is studied. The spectral element discrete format of the optimal control problem is constructed, the a priori error estimate of the solution of the control problem is proved theoretically, the a posteriori error estimator is constructed, the adaptive solution algorithm is designed, and the discrete system is solved by combining the gradient projection algorithm and finally verified using numerical experiments. The solution regularity of the first example is good, the computation is performed using a consistent grid, and the numerical results show that the indicator is efficient; the solution regularity of the second example is not good, the computation is performed using a consistent grid and an adaptive grid, the numerical results again show that the adaptive grid converges faster than the consistent grid, and the singularity of the solution can be captured quickly, which greatly reduces the number of heavy operations and the error. The error is also within the ideal range of controllability, as shown in Figure 5. Results are always far from satisfactory when compared to experiments.

Table 1: Numerical calculation results for $N = 7$.

Type	CS			N	
1	49.3	23.5	77.2	71.2	79
2	15.1	24.5	56.9	34.6	22.9
3	57.8	80.7	13.7	74.2	34.3
4	80.6	14.9	50.5	52.2	62.8
5	54.4	14	87.4	55.2	52.4

It can be seen from Figure 5 that the deformation trend of the three measurement points at the boundary is the same before 1.35 ms, and the deflection value increases simultaneously in the region inside the bulkhead boundary and at the boundary when the bulkhead boundary starts to deform and the middle region of the bulkhead deforms together with the boundary. After 1.35 ms to 3.41 ms, the slope of measurement points 7 and 8 changed less, and the slope of measurement point 8 decreased significantly, indicating that the deflection value at the boundary increased at a significantly slower rate, and the deflection value in the middle region of the bulkhead continued to increase at a higher rate synchronously with the center of the bulkhead. The deformation in the bulkhead boundary region is significantly reduced because of the applied solid support boundary condition. Between 3.41 ms and 6.21 ms, it can be observed that the deflection value of measurement point 6 continues to increase, while the deflection value of measurement point 7 tends to slow down significantly, which indicates that the deformation of the bulkhead is mainly concentrated in the area near the bulkhead center during this period, and the deflection value of each area stops increasing significantly after 6.52 ms and starts to converge to a fixed value.

All other boundaries are assumed to be far enough away from the bubble except for the horizontal wall located near the bubble. Due to the pressure difference between the bubble interfaces, an initial Riemann problem is formed. Then, the excitation waves propagate outward in the surrounding water, while the rarefaction waves propagate inward in the inner gas. The main forms of implosion loads are high-speed fragmentation, shock wave overpressure, and quasi-static overpressure. At the same time, the bubble interface expands with the intermittent motion of the contact. If the effects of rigid walls and buoyancy are not considered, the bubble will oscillate in a spherical shape until all the energy is dissipated by the emitted pressure waves. If the direction normal to the wall is parallel to the direction of gravity, the problem can be considered axisymmetric.

However, one significant drawback of strategy iteration is that the strategy must be evaluated in each iteration, and strategy evaluation requires traversing each state, which is itself a computationally intensive step. To reduce the computational time consumption of strategy iteration, it is not necessary to use a fully convergent value function for strategy evaluation. In many cases, too many iterations of the value function do not affect the strategy update, so a simplification of the strategy evaluation can be considered, and a more effective simplification method is to perform only one

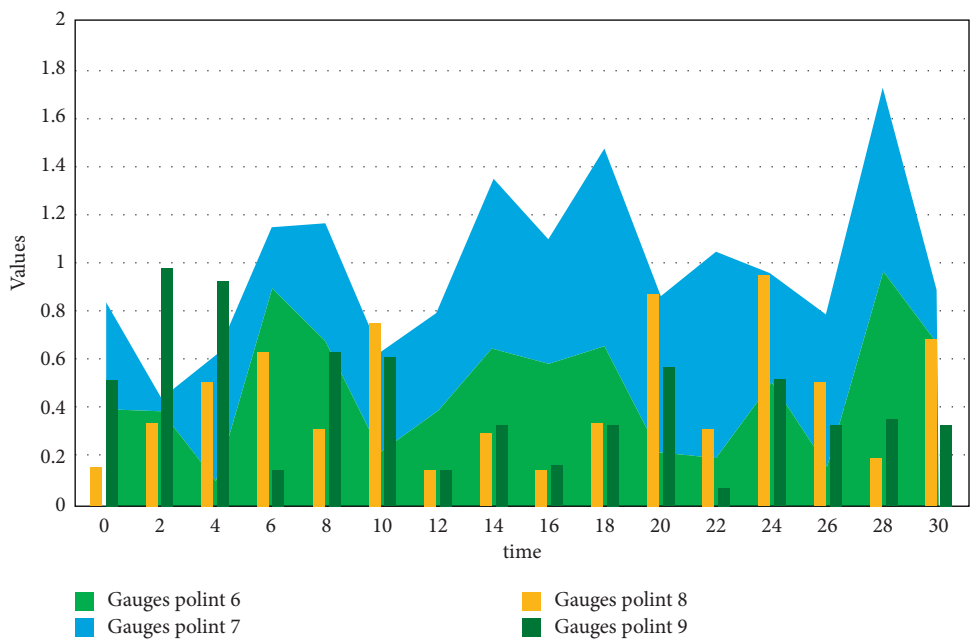

Figure 5: Location of measurement points and the corresponding deflection time course curves.

round of iterations of the strategy evaluation and then go directly to the strategy update.

5.2. Space-Based Kinetic Weapon Mathematical Control Destruction Effect Assessment Design. In the case of interception using the extended proportional guidance law, the initial overload of the interceptor is higher than that of the proportional guidance law; i.e., the target is intercepted with a more advanced posture, so the overload command of the interceptor does not increase rapidly and saturates quickly compared with that of the proportional guidance law. However, as the target with differential countermeasure guidance law performed a reverse maneuver at 3.5 seconds, the interceptor overload demand changed rapidly. During the final seconds of the interceptor maneuver, the interceptor continues to approach the target with the maximum saturation maneuver, but it is still not enough to achieve the interception of the target.

Target vulnerability refers to the ease with which a target can be damaged by enemy fire. In an operational scenario, a weapon system killing a target is a complex random event that can be viewed as two mutually independent events in sequence. The equation without the transport term can be regarded as the fluid motion in the Lagrangian view; that is, the grid moves along with the fluid particles under the action of the pressure gradient. The first random event is the probability of the combat section hitting the target, a process that affects many factors and is usually described in terms of tactical vulnerability; the second random event is the probability of causing corresponding damage to the target after the combat section successfully hits the target, which is a conditional probability and is usually described in terms of structural vulnerability. Therefore, to cause a certain degree of damage to the target, two independent events must be guaranteed to occur simultaneously; i.e., the final kill probability is the product of the probability of hitting the target and the probability of damage to the target after the hit. In this study, considering the specific research focus and concern, the analysis of the structural vulnerability, i.e., the probability of the target being damaged under the hit condition, is mainly carried out for the convenience of the study.

The above situation arises because of the convergence of the shock wave loads reflected in the cabin several times, and the form of the shock wave loads in the enclosed space is very complex and difficult to derive directly from the theory. Next, the propagation of shock waves will be illustrated by analyzing the pressure load distribution in some air domains inside the chamber during offset detonation to further explain the above situation where the highest value of deflection of the surrounding bulkhead appears to shift to the left, as shown in Figure 6.

The evaluation process can be divided into two major parts: the first part is the calculation of the thermal ablation effect of the laser on the target in the atmosphere, whose specific mathematical model and numerical calculation methods have been described more completely in the previous section. Discrete in space is relatively complex and has a great influence on the calculation result. The second part is the conversion of the thermal ablation effect to the degree of the target function and combat capability destruction, which is closely related to the target characteristics. Taking the typical target missile of laser weapon as the object of study, the analysis of its target vulnerability is carried out, including the determination of its structural composition and key components, the selection of damage criteria, and the classification of damage level, taking into account the differences in structure and material of different components, their interaction mechanism with laser and damage effect is

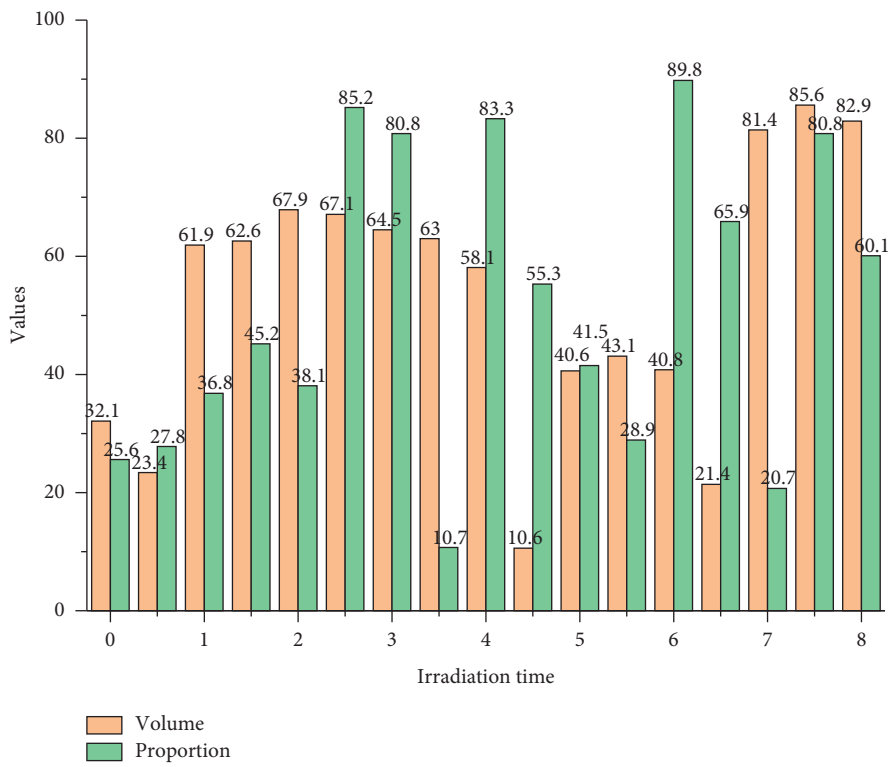

Figure 6: Destruction situation and conditional destruction probability.

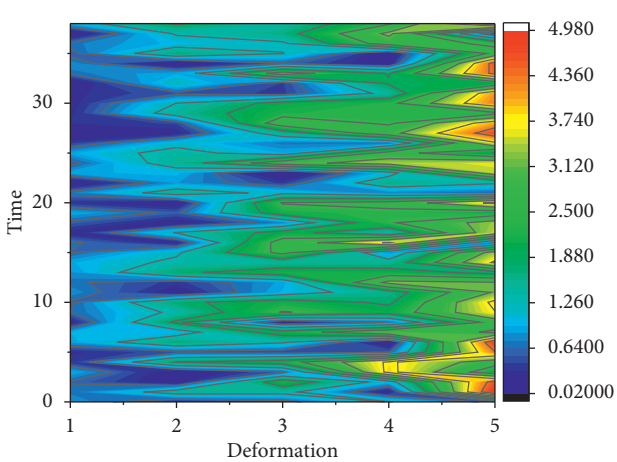

Figure 7: Deformation process of bulkhead.

also different, and the laser-to-target energy density is no longer used as the judgment criterion. Instead of using the laser-to-target energy density as a criterion, the components were subdivided according to their characteristics, and the component temperature, component strength, and component ablation volume were selected as the indicators of the damaging effect for the missile's combat wing, engine, and tail fin, respectively, as shown in Figure 7.

As can be seen from the figure, after the multiple reflection and convergence of the shock wave, the plastic deformation at the center of the bulkhead is the largest, and with the increase of time the center of the bulkhead begins to appear a breach, in which the damage along the direction of the explosive arrangement line is greater than the vertical direction. Another key point of the numerical calculation method is the discrete format. In the breach with the explosives connected to the vertical direction of the unit first all failed to delete, while the unit in the direction of the explosive line did not all fail; with the continued action of the cabin pressure load, the final explosive line of direction of the unit also all separated from the bulkhead. For delayed initiation, because the right side of the explosive is first detonated, the shock wave converges on the left half of the compartment area, resulting in the maximum deflection of the bulkhead to the left and the crack area to the left.

6. Conclusion

In this paper, the adaptive spectral element calculation of elliptic partial differential equations and their optimal control problems are systematically studied. In addition, to accurately describe the dynamics of the target motion and better evaluate the actual operational effectiveness of the interceptor system, a target motion trajectory planning algorithm based on the prediction correction method is also given, which enables the hypersonic boost-glide vehicle to plan the attack trajectory to the landing area according to its lift-to-drag ratio characteristics. The discrete format is the embodiment of its mathematical ideas, and different methods are divided according to its difference. To analyze the antidamage performance of the composite honeycomb sandwich structure, an experimental study was conducted on the fragmentation of the composite honeycomb sandwich structure at different speeds and angles, and the accuracy of

the theoretical model and the fragmentation residual formula was verified. It is found that the accuracy of the residual velocity calculation formula of the fragmentation penetration composite honeycomb sandwich structure is very high, and the theoretical value is always between the numerical simulation and the experimental value with an average error of 6%. The destruction of the circumferential bulkhead was greater than that of both bulkheads under each condition, the destruction of the left bulkhead was greater than that of the right bulkhead during the delayed detonation, and the maximum deflection value of the bulkhead and the area of the breach tended to increase with the increase of the detonation time interval. Comparison of simulation results in the cabin pressure load, velocity curve, the load process, and the classical "three-wave method" is consistent. The difference between different targets also plays a crucial role in the damaging effect. The smaller the target thickness, the lower the thermal conductivity of the material and the lower the curvature of the irradiated surface.

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

Dynamic Scheduling and Optimal Control of Coordination Supply Chain Based on Automatic Allocation of Orders for Multicycle Integrators

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Selecting suppliers and allocating orders scientifically and rationally not only have important theoretical value but also have extremely important practical significance to enterprises. This study proposes an improved multicycle integration method that can effectively determine the optimal number of suppliers under the premise of considering the risk of supply interruption and transaction costs that may be caused by various uncertain factors. The supply interruption risk is divided into two categories: "common risk event" and "individual risk event." On the basis of balancing the transaction cost of the company's choice of suppliers and the financial loss of supply interruption, quantitative analysis methods are used to determine the optimal number of suppliers for the company. The problem is analyzed, the corresponding model is given, and the influence of each parameter on the optimal number of suppliers is analyzed. From the perspective of stochastic uncertainty in both customer demand and supplier supply capacity, this study analyzes the optimization problem of enterprise purchase quantity allocation under the volume discount environment. The relaxation factor is somewhat adaptive because the particle swarm is continuously updated. Aiming at ordering cost, transaction cost, transportation cost, order delay quantity, and product quality, considering random demand constraints, supplier supply capacity constraints, and multisupplier multiproduct situations, we establish supplier selection in an environment of uncertain demand and supply capacity and dynamic relaxation approximation algorithm for order allocation. The research results show that the dynamic relaxation approximation algorithm can not only determine the optimal supplier but also determine the optimal procurement allocation for each supplier.

1. Introduction

The study of traditional optimization problems in multicenter coordination networks aims to minimize the operational costs of coordination networks by optimizing the routes of vehicles in the multicenter [1]. In the context of economic globalization and the rapid development of information technology, there is fierce competition among manufacturing supply chains [2]. Excellent suppliers can play a leading role in downstream companies, integrating manufacturing resources and providing a continuous impetus for downstream manufacturing. At the same time, problems with the supplier's supply capacity not only put pressure on the downstream manufacturer but also lead to a series of chain reactions in the downstream supply chain.

Effective synchronization constraint as a measure to evaluate delivery timeliness can reduce the time interval and waiting time of two-level vehicles in the two-level network serving between facilities through reasonable scheduling of vehicles, thereby reducing fuel consumption and improving the transportation efficiency of the entire network [3]. Therefore, an effective cooperation mechanism and resource sharing mode and synchronization strategy can optimize the distribution services of multicenter and multiperiod networks, improve the efficiency of the transportation system, and realize the rational allocation of resources. The multiperiod distribution network considers the periodic changes in customer demand and facility service quality, as well as the time interval that customers are visited in different service periods, so an effective network design can improve

customer service levels [4]. The establishment of a cooperation mechanism can reduce unreasonable transportation through cooperation between facilities, thereby reducing coordination operation costs; an effective synchronization strategy can reduce the waiting time of vehicle services by optimizing vehicle scheduling, thereby reducing fuel consumption and improving transportation efficiency. The resource sharing mode based on cooperation can realize the rational allocation of resources by sharing customer service and transportation resources, thereby promoting the sustainable development of multicenter and multicycle distribution networks and providing a basis for cooperation among organization enterprises [5].

As suppliers have different production resources and manufacturing capabilities, suppliers will inevitably be late in supplying the manufacturer or fail to meet manufacturing requirements, preventing the manufacturer from producing normally at a given time, causing significant losses to the manufacturer, and seriously affecting the efficiency of the supply chain. Incremental insertion of new orders does not result in a high-quality solution when dealing with real-time order data, and approaches based on neighborhood search and destructive reconstruction require the processing of static DARPA that need to be reoptimized for each response, resulting in high computational costs. The available manufacturers are filtered out. By selecting a manufacturer in each process, the actions required for that order are done at that point. A framework for handling dynamic scenarios with real-time orders is needed that continuously responds to new orders and updates the delivery solution based on the execution status of the UAV, maintaining a high-quality solution throughout the process.

2. Related Work

Artifacts are not delivered as early as possible but on a specific date. If a part is delivered too early, the manufacturer will incur some storage and warehousing costs. If a part is delivered too late, customer satisfaction and the company's reputation suffer. Companies must therefore consider the sequence of parts to reduce the impact of lead times. Lead-time planning models have received considerable attention in recent decades, with most research focusing on determining an appropriate lead time were completing before the lead time incurs penalty costs and after the lead time incurs penalty costs. Li et al. used a fuzzy time window treatment scheme to simplify the impact of time windows in multicenter coordination networks [6]. Zhang et al. introduced the concept of vehicle sharing to network optimization of multiple distribution centers with time window constraints to achieve a balance of decisions between multiple centers [7].

Goli and Davoodi proposed an optimization problem for multiple centers with time constraints based on the flexible selection of vehicle docking points [8]. Liu et al. introduced open vehicle paths in a multicenter distribution network optimization problem to reduce the operational complexity of the coordination network under a soft time window constraint [9]. Yu et al. combined the service concept of dynamic changes in customer demand with effective conservation of coordination resources and proposed a multicenter distribution network path optimization problem with a time window constraint [10]. Gharaei and Jolai analyzed the characteristics of dynamic alliances, discussed the key points and difficulties in developing this model for Chinese enterprises, and designed an agile supply chain architecture based on the principles of intelligent agents and reconfigurability [11]. He et al. explored the characteristics of an agile apparel supply chain and built a virtual organization centered on exporting apparel companies to respond quickly to large-scale changes [12]. Goodarzian et al. constructed an agile supply chain selection model that considered six aspects [13]. Batero Manso and Orjuela Castro developed a hybrid multicriteria decision model, used the triangular fuzzy number method to determine quantitative indicator weights, and finally used the fuzzy topology method to select the best model for the supply chain [14]. After an extensive literature review, they concluded that most of the current research has focused on the technical aspects of managing big data itself, rather than applying it to create strategic value and change for businesses and supply chains. It looks at dynamic alliances from a different perspective, considering the alliance phase, partner selection and reconfiguration phase, operation phase, and dissolution phase in building a flexible supply chain.

The traditional supply chain pursues a stable partnership that tends to produce a static or slowly evolving solid structure, a factory-prepared and driven supply chain, in which there is a mismatch of supply and demand information, a severe bullwhip effect, and low flexibility. Traditional supply chains that produce only one or a few similar products are no longer able to adapt to the changing market demand for diverse and customized products. In this study, we explore an agile e-commerce supply chain based on the C2M model, which focuses on consumer demand, forms short-term organizational alliances, uses smart technology to effectively meet personalized demand, and drives the modernization of manufacturing. Promoting innovation in supply chain models focused on dynamism, intelligence, and efficiency.

3. Multicycle Order Allocation Distribution Design

We will analyze the synchronization problem in the automotive industry, which is one of the main concerns of lean management [15]. The optimization process of two-level multicenter and multiperiod coordination network is to study the service optimization problem between coordination facilities and customer points in discrete space. Therefore, it is a typical combinatorial optimization problem, which aims to study discrete space through certain mathematical methods. The solution of combinatorial optimization problem is mainly divided into two parts: mathematical model establishment and optimal solution search process [16]. The intelligent optimization algorithm is the sum of the theoretical methods to find the optimal solution of the problem under the condition of feasible

solutions and constraints through a certain optimization process based on a certain search mechanism. The main intelligent optimization algorithms are divided into two categories: exact algorithms and heuristic algorithms. For structured combinatorial optimization problems, the size of the solution space can be controlled and is generally small, so such problems are usually solved using exact algorithms. For large-scale combinatorial optimization problems, the process of optimizing through exact algorithms such as enumeration will bring about an explosive combinatorial amount of computation. Therefore, such problems usually use heuristic algorithms to obtain approximate solutions. We are only concerned with cycle time overlap:

$$\begin{aligned} \max F(x) &= [f_1(X), f_2(X), \ldots, f_m(X)] \\ s.t. g_i(x) &\le 0, i = 1, 2, \ldots, p \\ h_j(x) &\le 0, j = 1, 2, \ldots, q \\ X &= [x_1, x_2, \ldots, x_m], \end{aligned} \tag{1}$$

where $f_1(X), f_2(X)$, and $f_m(X)$ are the m objective functions respectively, and under the constraints, they denote the set of feasible solutions that minimize each objective function. Figure 1 Cross transport is also reduced to a large extent.

The trajectory space and MSP values are growing to the extreme case where supply and demand are not correlated. Every deviation between supply and demand is shown in regions A and B, except for perfect synchronization. In the region, demand inventory is higher than supply inventory. Since the manufacturer reliability index of manufacturer 12 is 0.682 and the reliability index of manufacturer 14 is 0.330, manufacturer 14 is selected with the goal of low cost, and then, manufacturer 14 will be selected.

The subject of this study is a coordination company with multiple distribution centers. The operation of a multi-distribution center is shown in Figure 1.

$$\begin{cases} B_0^k = O_k, \\ B_{n_k}^k = \varphi, \\ \left[o_1^2 \notin S_{v_i^k}^k\right] = 1. \end{cases} \tag{2}$$

Unlike traditional coordination networks with collection and distribution, the multicenter multicycle collection and distribution coordination network (MDPLNPD) encompasses both open and closed routes, designed to form effective collaboration and delivery through multiple facilities and service cycles. Figure 1 shows the comparison diagram of the noncooperative network before optimization and the network path comparison after optimization. It is important to use their resources to increase efficiency and deepen cooperation. However, if the assessment finds that the partner is no longer able to meet the requirements of the product order, it can be removed from the partnership and a new partner can be found to continuously improve the efficiency of the agile supply chain. The numbers on each route in the figure represent the transportation time of trucks or cars, respectively. As can be seen from the figure, trucks can realize centralized transportation between cooperative coordination facilities, and the service path from facilities to customer points realized by trolleys has also been optimized, thereby minimizing large-scale long-distance and cross-transportation.

Assigning orders to partners and selecting nodes in an agile supply chain from a pool of companies with the same processing functions is not an easy task. A thorough and dynamic assessment of partners is therefore essential to track their development and help them make the most of it [17].

Each distribution center gives priority to using its vehicles, and in the case of insufficient own capacity, vehicles should only be called to the nearest distribution center with abundant capacity. When vehicles are shared throughout the distribution center, the correct type of vehicle is only hired when there is insufficient capacity.

$$\text{result} = \max \sum_{i=0}^{n} (A_i + B_i)^2 t_{v_i v_{i+1}}. \tag{3}$$

This study focuses on the business of one of the e-commerce company's brands and its operating model. The sub-brand was established in January 2021 and has expanded from 8 categories to the current 25 and is expanding to at least 8,000 products. The company has more than 300 suppliers, of which about a third are large companies. The main customers are mainly financial companies, Internet companies, etc. These companies are mainly staffed by young people in their late 90s, and together with the company's daily tailor-made service, the diversity of products for the company is shown in Figure 2, a process that can lead to poor quality or late delivery.

The law of two-eight is widely used in business, where quality and quantity are satisfied and customer satisfaction is increased. In practice, however, account managers allocate reliable spare parts manufacturers based on the timing of orders [18, 19]. It is helpful to improve several indicators of network optimization and improve the resource allocation efficiency of the coordination system. Orders from priority customers are placed by manufacturers at different levels who cannot provide better service to their customers. E-commerce companies selling their brands often have a rigorous set of procedures to manage, for example, their ability to prioritize orders by ranking customers according to evaluation criteria and creating a reference point for placing future orders.

4. Dynamic Planning Analysis of the Coordination Supply Chain

There are two main channels in this process. Account managers of e-commerce companies' delivery dates. Based on this, which generates almost 80% of all revenue, deepening cooperation with these head customers and orders from head customers requires special attention to improve satisfaction. Determine the order priority according to the order data and the historical performance of the manufacturer, and provide the basis for the order arrangement in the next stage. External facilities

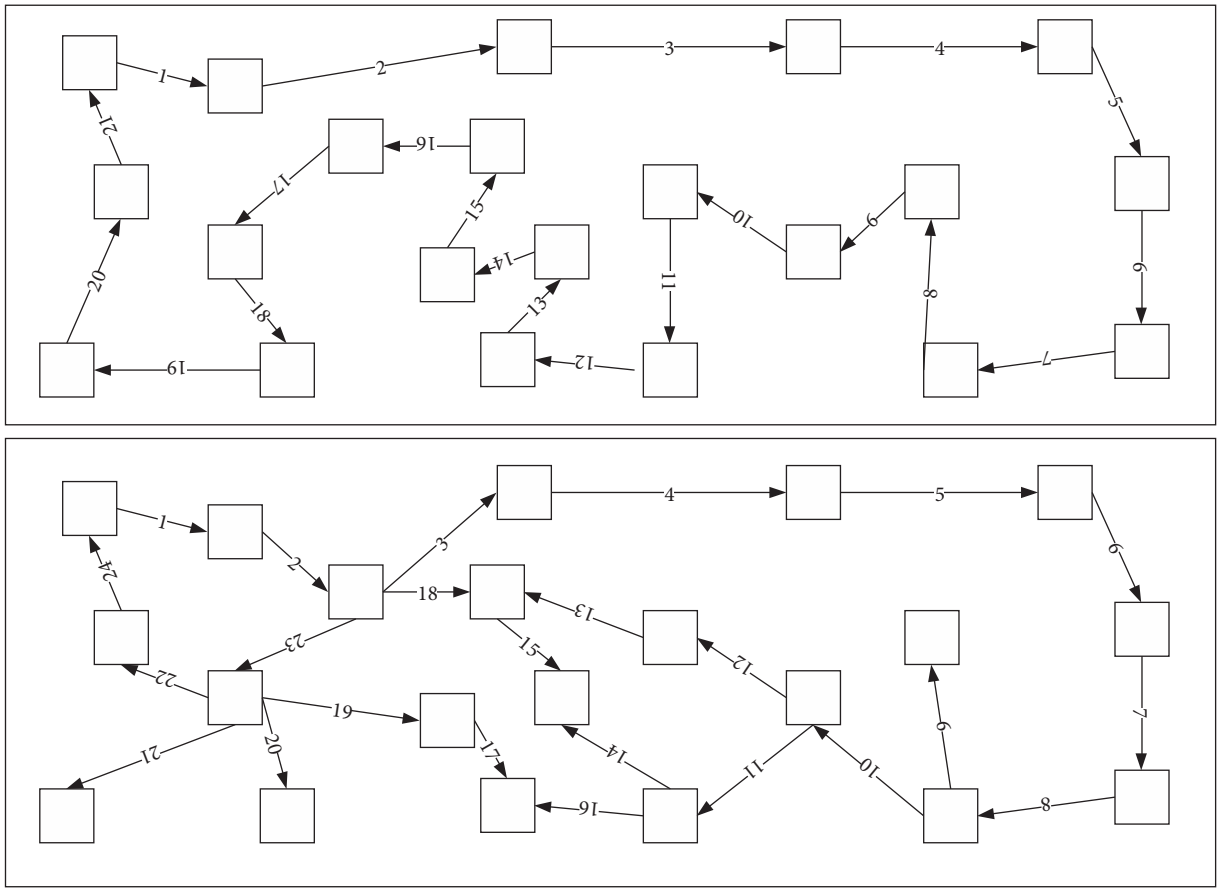


Figure 1: With multiple centers and multiple distribution networks.

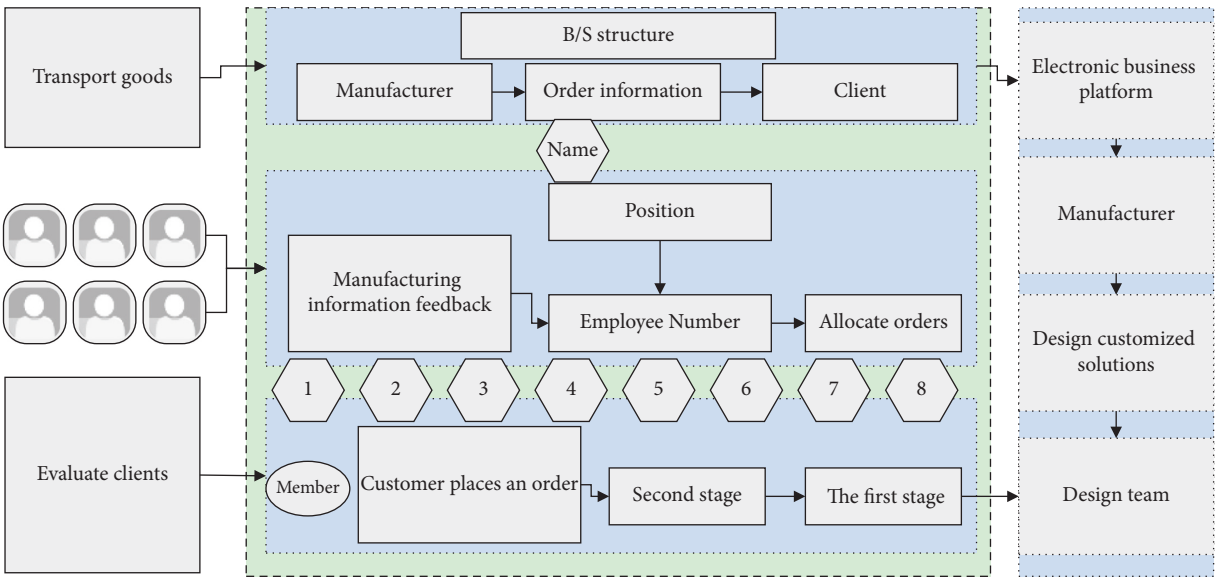


Figure 2: Two-stage business analysis of order scheduling.

such as production sites are visited to examine the production environment and the manufacturer's historical trading performance, whether it can meet expectations in terms of quality and quantity is evaluated, and these data provide the basis for the next stage of order placement [20].

If the order criticality index or customer priority index of the order priority index is greater than or equal to 0.6, this

means that the order priority index is high and is usually characterized by high total order value, high order value, frequent customer contact with the platform, high average order profitability, and purchase loyalty.

As shown in Figure 3, the triangular fuzzy membership function for each index is defined in the interval between 0 and 1, where 0 is defined in the interval between 0 and 1, with 0 being low, 0.5 being medium, and 1 being high. The interval [0–1] is set to match the function of the interval [0–1] of the index previously calculated by TOPSIS. The effective combination of cooperation mechanism and resource sharing strategy promotes the formation of a cooperative coordination network alliance and realizes the maximum cost saving of the network from noncooperative to cooperative coordination facilities. The members of the strategic partnership decide which rules apply and a new reasoning system can always be developed if their preferences change.

To extend the search range of the algorithm and ensure that good genes are not destroyed, this study uses a two-point crossover operation. In addition, the evaluation of manufacturer information is not only to visit external facilities such as production bases, to examine the production environment, but also to include the manufacturer's historical transaction performance, and whether it can achieve the expected goals in terms of quality and quantity. The evaluation of these data is for the next order arrangement of the stage provides the basis. The specific steps are as follows: first, two chromosomes are selected as father 1 and father 2; second, two natural numbers $r1$ and $r2$ of length not exceeding 1 are randomly generated ($r1 < r2$); again, 1 is obtained. The order of all gene segments between gene positions $r1$ and $r2$ is father 2, and this arrangement is to cover the genes between $r1$ and $r2$ in father 1 to become son 1; finally, father 2 and son 2 perform a similar operation.

The qualifications for establishing a sustainable supply network model include preconditions and constraints. Among them, the preconditions are that all customers' orders must be fully satisfied; suppliers have raw material capacity constraints, and production has product capacity constraints; operating costs are fixed during the cycle.

According to the initial position of the individual particle, the function fitness of the individual particle is calculated according to the objective function, which is the total cost value of the supply chain network, the function fitness of the subgroup is calculated, and it compares with the function fitness of all subgroups one by one. If the new fitness is better than the best history record of the current subgroup or the global best history record of the particle swarm, the new best history record or the global best history record of the particle swarm is updated, and the position of the current subgroup is updated. For the new best historical position or the global best historical position, the optimization process of the best particle is shown in Figure 4.

Since the RTC does not know the future requests, schedule generation avoids unnecessary holding costs by proposing an authorized schedule [21]. The typical structure of an authorized schedule contains nonforced idle time slots that minimize the total holding cost. Orders are allocated

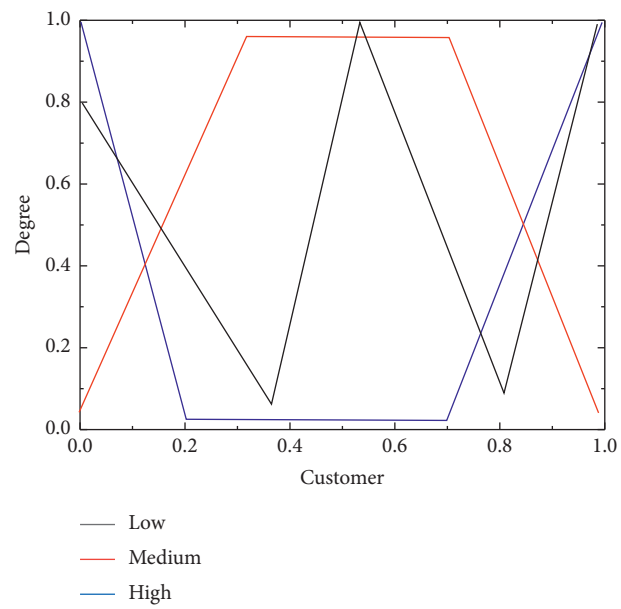


Figure 3: Priority attribution function.

based on the order priority, and the priority orders are assigned to reliable manufacturers, thus avoiding losing big customers and ensuring their maximum satisfaction. Thus, if the current situation does not require the machine to be fully utilized in the next expected range, the proposed associated schedule suggests leaving the machine idle for an extended period. Specifically, the relevant schedule may recommend leaving the machine fully or partially idle, as shown in Figure 4. As the schedule is implemented, the unused machine capacity will be irretrievably lost.

After performing the above steps, the supply chain upstream and downstream, for example, if the sum of the assigned quantities in the single-particle network of supplier 1 is chosen to be zero, while the sum of the assigned quantities in the network of supplier 2 is not zero, this implies a certain degree of adaptivity, as the particle population is constantly updated. In the following study, the effectiveness and solution quality of the dynamic relaxation approximation algorithm are experimentally verified.

With the continuous change of individual particles, the selection of suppliers and producers will also change with the change of the value of each particle. For example, if the current position of individual particles selects supplier 1 The sum of the number of network allocations is 0, and the sum of the network allocation quantities of supplier 2 is not 0, indicating that supplier 1 does not participate in the production plan of the supply chain network at this time, and supplier 2 is in the production plan of the current supply chain network, if after updating the current individual particles. In the update position of individual particles, the sum of the network allocation quantity of supplier 1 is no longer 0, and the sum of the network allocation quantity of supplier 2 is 0. Currently, supplier 1 participates in the new production plan of the supply chain network. Supplier 2 is not in the new production plan of the supply chain network.

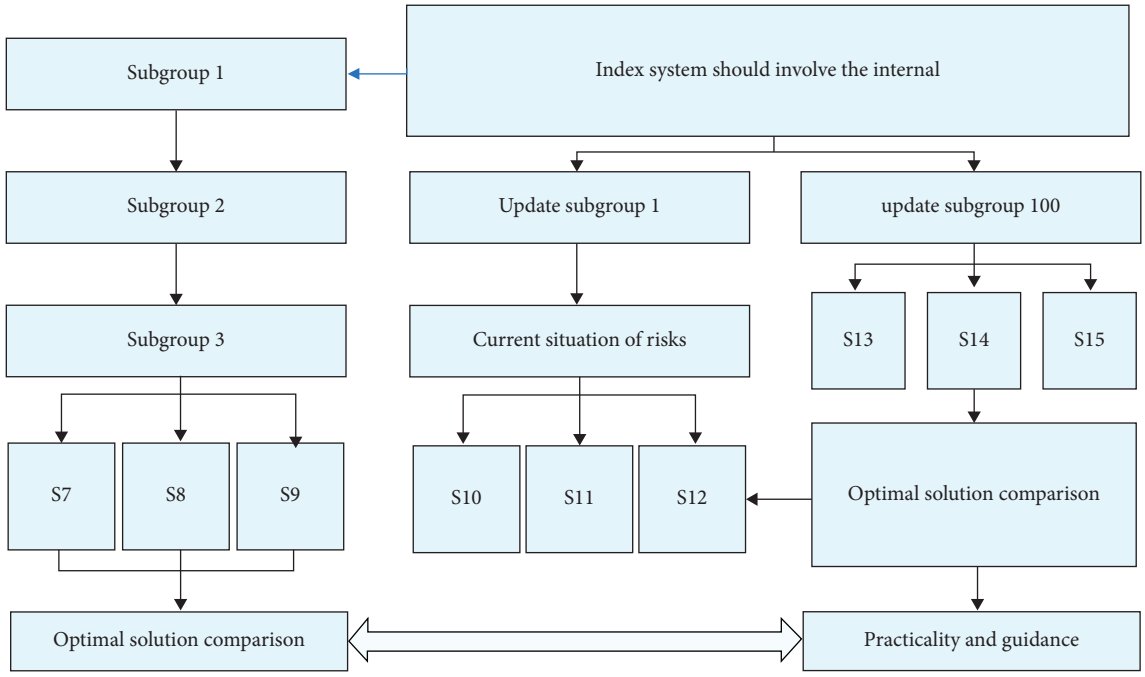


Figure 4: Coordination supply chain optimization process.

In the next section, we use the dynamic relaxation approximation algorithm to iteratively update the allocation number and location decisions of the supply chain network by combining the fitness of the objective function and the dynamic relaxation factor. During the application of SFDDHT-GRASP, the rescheduling process minimizes the loss of scheduling idleness in the scheduling S. This process reschedules jobs without changing the sequence of jobs or the date allocation of the solution and minimizes the total schedule cost within this constraint.

5. Analysis of Results

5.1. Examining the Results of Multicycle Integrator Order Allocation. Due to the sensitivity of customer, order, and manufacturer data on e-commerce platforms, based on practical experience from the internship and with JE-commerce is constantly restructuring and deconstructing its flexible supply chain to respond to new demands for its products from a changing market. With multiple customer-specific orders in the same cycle, multiple manufacturers quickly form a dynamic manufacturing alliance to produce the product the customer wants to be based on the order, as shown in Figure 5.

The operational configuration process for each order is determined by the process operation route, through which the 10 orders pass. For example, order 1 needs to pass through operations 1, 2, 3, and 4 in one go to complete the order, meet the product manufacturing process requirements, and finally ship the goods to customer 3.

In this case, when allocating orders, the platform filters out the available manufacturers based on the availability of each operation. By selecting a manufacturer in each process, the operations required for that order are completed at that time. Moreover, the solution quality of the dynamic relaxation approximation algorithm is better than that of the traditional particle swarm algorithm. The corresponding process operations are carried out according to the order's customized solution and the appropriate production partner is selected in each process to place the order.

The platform evaluates customer, order, and manufacturer data based on data from previous collaborations using the TOPSIS method to obtain a customer priority index, an order criticality index, and a manufacturer reliability index, each of which is shown in Figure 6. The red background represents low priority and low-reliability customers and manufacturers. The green background represents customers and manufacturers with high indices, high priority, and needing priority development. In the integer multiobjective programming function, the manufacturer's reliability index and the order priority index determined in the previous stage are included in the solution to obtain a solution for order allocation. The 0–1 integer programming software is first used to find out which manufacturer the job is assigned to, as shown in the job assignment table, and then which manufacturer should be selected for each job in the single-objective case of maximum reliability, minimum cost, and minimum time, or a combination of all three in the multiobjective case.

The track and trace system that has been implemented generates many status messages throughout the supply process.

For example, in the case of order 10, if manufacturer 12 is selected for process 4 with the objective of maximum reliability, as manufacturer 12 has a manufacturer reliability index of 0.682 and manufacturer 14 has a reliability index of 0.330, but manufacturer 14 is selected with the objective of low cost, then manufacturer 14 will be selected.

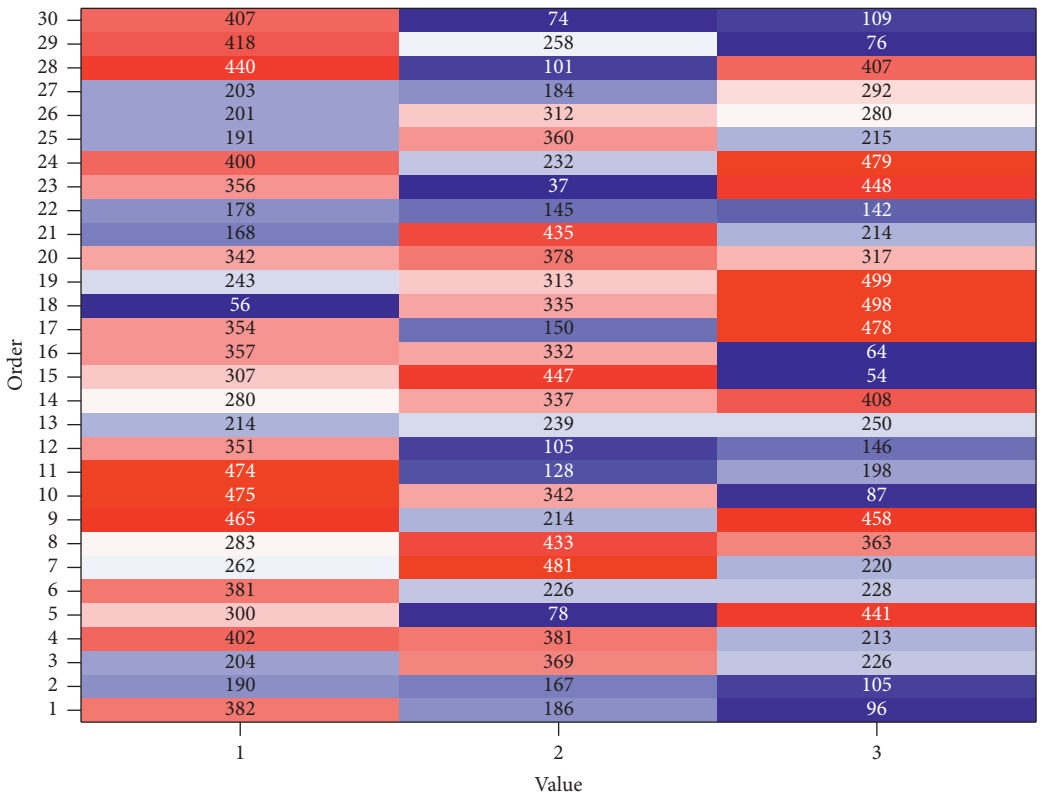


Figure 5: Specific requirements for each order.

Under different goals, the selected manufacturers are different, such as order 10; in the case of operation 4, if the principle of maximum reliability is the goal, manufacturer 12 is selected to carry out the operation of operation 4, because the reliability index of manufacturer 12 is 0.682, while the reliability index of manufacturer 14 is 0.330. However, if the target with low cost is selected, then manufacturer 14 is selected. Currently, the decision-maker needs to weigh the relationship between cost and reliability, between the two substitution relationships. Customers can get service at a specific time according to their needs for the product. Usually, a manufacturer with high reliability means high cost. At this time, the priority of orders can be compared, and orders with high priority can be assigned to reliable manufacturers first.

In addition, in different weighting schemes, the partner composition of agile supply chain is the same, but the reliability and total cost are different. This is because the manufacturers allocated in the specific operations in the allocation scheme are different, and the partners in the intermediate business are different. Switching varies, but these manufacturers are all in this agile network, which creates a difference in cost and reliability. This sensitivity analysis is important because decision-makers often cannot accurately define the importance of each objective function. Through the comparison of different weights, decision-makers can better understand the robustness of different schemes, which can be directly used in the business network structure. It reflects the priorities of decision-makers, helps decision-makers better understand, and evaluates the impact of subjective judgments on network structure, and is in line with enterprise development strategies.

5.2. Analysis of the Results of Dynamic Supply Chain Adjustment. The maximum cost savings were achieved in terms of quantity, amounting to US$2,824, 75 minutes, and 19 vehicles, respectively. Therefore, the grand alliance {DC1, DC2, DC3, PC1, PC2, PC3} can be selected as the best alliance for a multicenter, multicounty collaborative collection and distribution network. While the optimized vehicle access routes for the cooperating DC1 and PC1 in the grand alliance are shown in Figure 7, the multicenter cooperation achieves vehicle sharing within and across multiple cycles and improves the utilization of transport resources.

In Figure 7, vehicles can share transport resources within and across multiple cycles, reducing the total number of transport vehicles from 30 to 11 and reducing maintenance costs from $450 to $154. Coordinating pick-up and delivery services across multiple service cycles and enabling the sharing of open and closed mixed paths help to improve several indicators of network optimization and increase the efficiency of resource allocation in the coordination system. A planned work cycle is subdivided into a series of service cycles to ensure the delivery of each product, and the customer can be serviced in one or more cycles.

The average and optimal solutions obtained by the improved adaptive genetic algorithm were calculated and simulated to outperform the genetic algorithm for all three algorithms using seven common vehicles to complete 65

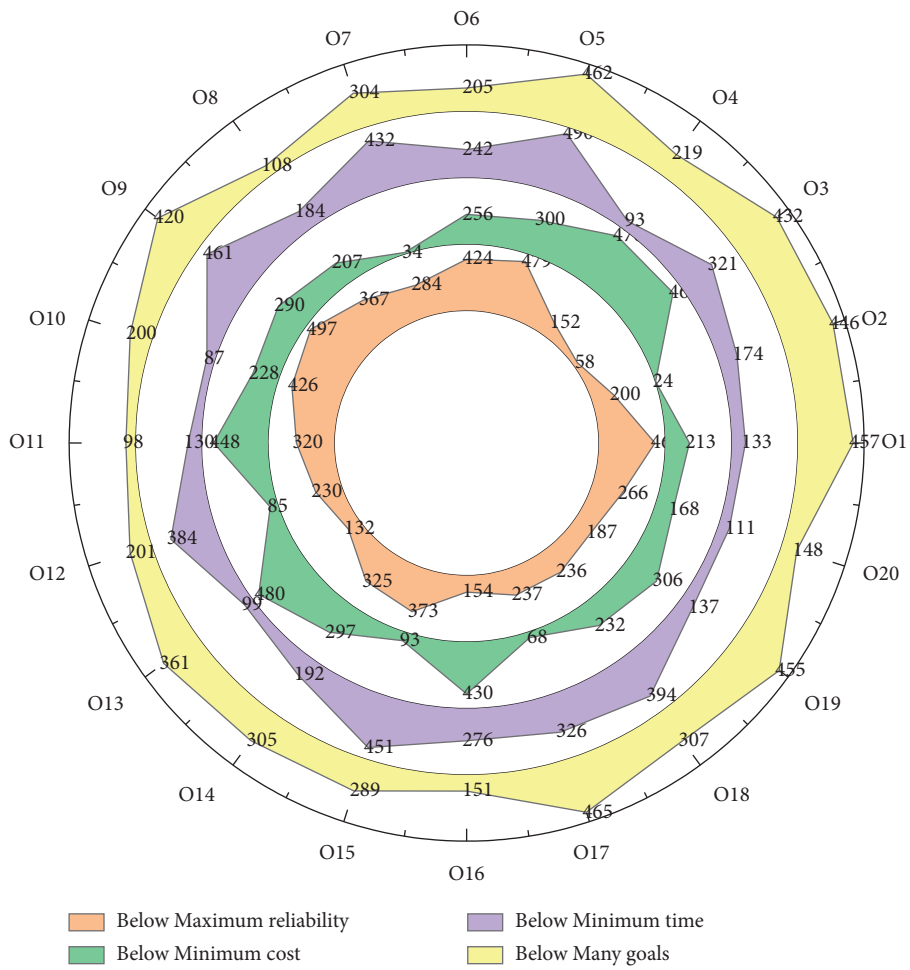
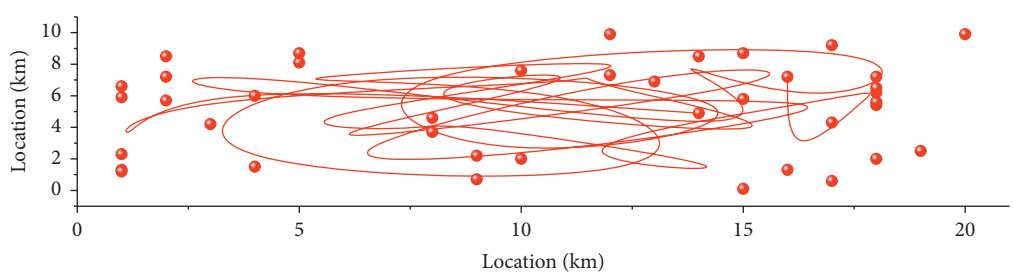
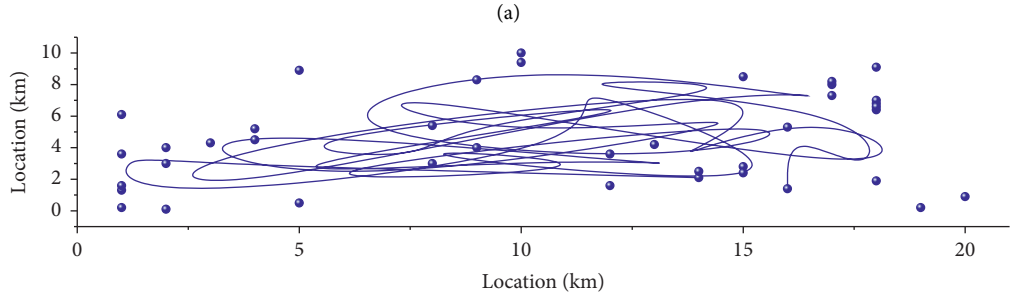


Figure 6: Results of contracting.

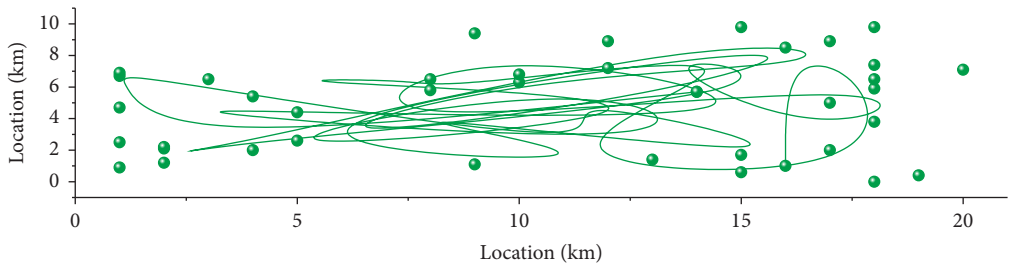


(a)



(b)

Figure 7: Continued.



(c)

Figure 7: Three common paths for DC1 and PC1 in a multicycle collaborative multicenter network.

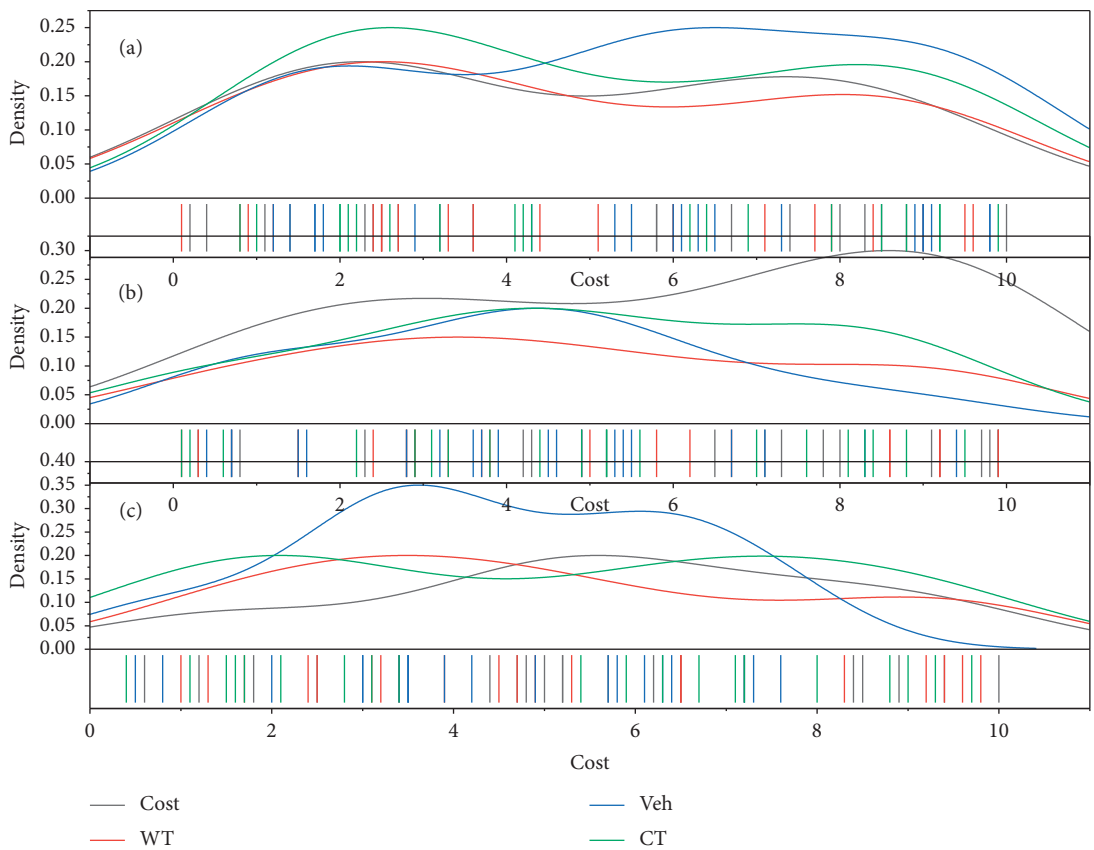


Figure 8: Comparison of the results obtained by the three optimization algorithms.

customer points in the vehicle nonsharing mode. The improved adaptive genetic algorithm obtained an average solution that was 6.73% less costly than the genetic algorithm and 3.73% less costly than the simulated annealing algorithm.

If the integration is successful, the process of implementing the first strategy quickly returns a positive answer to the order request and delegates the final decision to accept or reject the remaining (initially unaccepted) requests to the integration process to be executed within the subsequently expected scope. The default policy of the RTC method is to first apply the integration policy to all incoming requests in order of arrival and then use the optimization policy for all requests where the integration policy fails.

In the vehicle sharing mode, the matching rate for the partner vehicles in the same situation is the same due to the same matching algorithm, and the number of customers completed by the partner vehicles is 65. All three algorithms use seven common vehicles to complete the delivery of the remaining customer orders.

In Figure 8, t-tests and p values show that there are significant differences between the computational results of the three algorithms, so a comparative analysis based on these results is meaningful and reliable. First, IMOPSO is superior in terms of minimizing operating costs, as all IMOPSO calculations yield smaller cost values than those of NSGA-II and MOEA.

The average operating cost calculated by IMOPSO is US$2937, which is significantly lower than the operating costs of US$3616 and US$3779 calculated by the other two methods. In addition, IMOPSO achieves an average

minimum number of vehicles of 13 compared to 16 and 17 for NSGA-II and MOEA, and the computational time required to solve the multiobjective optimization model is also significantly better than the other two methods. The time difference and waiting time for two-level vehicles are reduced in the secondary network to travel between facilities, thereby reducing fuel consumption and improving the transportation efficiency of the entire network.

To calculate the total cost and feasibility of this interim plan, the impact of this new job on the integration of the plan must be considered. This is performed by calculating the completion times of the jobs and recalculating the completion times of the scheduled jobs affected by the job integration, as the local cost optimality of the specification plan is shown, SFDDHT-GRASP calculates the completion times by constructing the specification plan application only in the following way. The reverse calculation of this process starts with the insertion of jobs at the location and continues with the calculation of new completion times for jobs at the previous location of the interim plan.

Compared to the other three cooperative network types, in addition, the total waiting time for the first, second, and third cycle cooperative networks was 47 minutes respectively, significantly higher than the 36 minutes for the optimized cycle cooperative network. When optimizing a network with multiple centers and cycles of collection and distribution, it is, therefore, more beneficial for facilities to cooperate between multiple service cycles than within a single cycle.

6. Conclusion

A collaborative network distribution strategy for vehicle sharing has been proposed to address the lack of dispatching capacity or transport capacity of coordination companies in multiple distribution centers. Based on the comprehensive consideration of multiple distribution centers, multiple models of leased vehicles, load weight, vehicle speed, and fuel consumption, a vehicle energy consumption calculation method is introduced to establish a vehicle sharing network collaborative distribution model based on considering multiple constraints. This study proposes an assignment goal of assigning prioritized orders to reliable manufacturers. Priority orders depend on both customer information and order information. By integrating these information data, it is possible to grasp the historical transaction status of manufacturers and customers, allocate orders according to order priorities, assign priority orders to reliable manufacturers, avoid the loss of large customers, and ensure their maximum satisfaction through the sharing of open and closed hybrid paths. The mechanism optimizes the collection and distribution services within multiple cycles and between multiple centers, and based on the sharing of vehicles within multiple cycles and between multiple centers, it improves the efficiency of the transportation system and maximizes the utilization of coordination resources. A multiobjective optimization model is proposed to minimize the total operating cost, service waiting time, and number of vehicles of the logistics network, and a combined hybrid optimization method is proposed to solve the multiobjective optimization model, finally, through practical example analysis and algorithm. The feasibility and effectiveness of the proposed multiobjective optimization model and optimization algorithm in solving this problem are compared, analyzed, and verified.

Data Availability

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

Conflicts of Interest

The author declares that there are no conflicts of interest.

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Research Article

A Case Retrieval Strategy for Traffic Congestion Based on Cluster Analysis

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In order to improve the retrieval efficiency, this paper uses case-based reasoning (CBR) in the retrieval of traffic congestion cases and tries to adopt the strategy of clustering case databases before retrieval so as to narrow the scope of case retrieval. In terms of case clustering, the *k*-means algorithm, with excellent performance in text clustering, is selected to cluster traffic congestion edge cases. At the same time, considering that there is a certain similarity among the descriptions of traffic congestion, the *K*-means algorithm is optimized to generate an accurate clustering. Those edge cases are clustered into microcase clusters of traffic congestion and then divided into different traffic congestion categories according to the distance of cluster center. Experimental results show that the clustered case base is divided into several microcase bases, which improves the accuracy and shortens the retrieval time in the process of retrieval and provides a new idea for the retrieval method in the process of case-based reasoning.

1. Introduction

A segmentation method for retrieval is proposed in Reference [1]. First, similar case groups of different levels are formed according to the importance of events, and then the degree of similarity is calculated according to the new event levels and related case groups. The method of clustering associated cases is used to improve the success of case retrieval to a certain extent in Reference [2]. An intracase crossover algorithm is proposed to improve the processing effect of parallel data and the efficiency of case retrieval in Reference [3]. A cleaning algorithm for regression filtering is put forward in Reference [4], which shortens the time for case retrieval. In Reference [5], the optimization method of the GRNN neural network is used to improve the efficiency of CBR retrieval, realize the self-learning and self-growth of field problem diagnosis, and effectively avoid the problems of low matching degree and slow convergence speed of traditional CBR algorithms. A sememe-based set similarity matching algorithm (CMSBS) is proposed in Reference [6], which is used to analyze cases with high similarity to the current case. Experiments show that the algorithm has better performance in terms of matching cases and matching accuracy. In Reference [7], the case similarity calculation methods of 5 different attributes are analyzed, and a mode of combining subjective weights and objective weights is put forward. A combination of local and global similarity calculation methods for different types of traffic congestion is adopted in Reference [8]. At the same time, the updating and preserving mode of the traffic congestion case database is proposed. In Reference [9], a traffic emergency decision-making method is designed. At the same time, the case database for traffic-aided decision-making is established, the calculation method of similarity in global-local features is designed, and a case retrieval strategy is given. The weighted information degree to model the traffic route horizontally is used, and a new method for sampling the weighted competition value for a single demand level is proposed in Reference [10]. In Reference [11], a microsimulation to characterize the flow interaction is created by using the toolchain sumo–jade, ensuring that the emergency vehicles arrive as quickly as possible. In Reference [12], a hierarchical

structure for representing historical cases is developed. Reference [13] evaluates the strategy of optimizing the performance of the road network by combining real-time traffic information with predicted traffic information and adopting a heuristic dynamic traffic assignment (DTA) model combined with case-based reasoning technology for instance detection. Reference [14]uses case-based reasoning to calculate the shortest path of traffic and get the optimal solution.

Case-based reasoning, used in traffic safety, has also been widely studied but mainly focused on rail transit or large road networks. Therefore, the combination model of rule-based reasoning and case-based reasoning is mostly used in those research studies for regulation of data analysis. Most of them related to urban road congestion are about congestion prediction, and there are relatively few research studies on the timely dredging of congestion and even fewer on the decision support system of urban road traffic congestion dredging by using case-based reasoning. Especially for the application of case retrieval, the methods are often complicated. In this paper, a retrieval strategy based on text clustering is used to improve the retrieval link of case-based reasoning. Experiments also show that this method has a certain superiority and feasibility.

2. Calculation Method for the Attributes of Traffic Congestion

2.1. Enumeration Property Calculation. Enumeration data are unstructured data and mainly perform Boolean calculations. The value can be 0 or 1, where 1 means being the same and 0 means being different. Let the k attribute of C_i and C_j be an enumeration attribute, so

$$\operatorname{sim}\left(C_{ik}, C_{jk}\right) = \begin{cases} 1, & C_{ik} = C_{jk}, \\ 0, & C_{ik} \neq C_{jk}. \end{cases} \tag{1}$$

2.2. Numerical Attribute Calculation. The distance between two different cases in the traffic congestion database is reflected by the difference of the same numerical attribute in the two cases. The similarity calculation is as follows:

$$\operatorname{sim}\left(C_{ik}, C_{jk}\right) = \frac{\left|C_{ik} - C_{jk}\right|}{\left|\max_k - \min_k\right|}. \tag{2}$$

In the formula, $\max_k$ and $\min_k$ represent k's maximum value and minimum value, respectively, in the case.

2.3. Attribute Calculation of Numerical Interval Type. Numerical interval data could be considered as the fuzzy interval. Suppose G_{ik} as the K attribute of C_i, which is a numerical interval type, then G_{ik} is represented as the number of fuzzy intervals $[G_{ik}^-, G_{ik}^+]$, where G_{ik}^- and G_{ik}^+ are the lower and upper limits of the intervals, respectively. Similarly, if the number of fuzzy intervals of the K attribute G_{jk} of C_j is $[G_{jk}^-, G_{jk}^+]$, then the similarity calculation of the K attribute of C_i and C_j is as follows:

$$\operatorname{sim}\left(C_{ik}, C_{jk}\right) = 1 - D\left(C_{ik} - C_{jk}\right) = 1 - \sqrt{\frac{1}{2}\left[\left(G_{ik}^- - G_{ik}^+\right)^2 + \left(G_{jk}^- - G_{jk}^+\right)^2\right]}. \tag{3}$$

In this formula, $D(C_{ih} - C_{jk})$ expresses the K attribute of C_i and C_j, the average Euclidean distance:, $D(C_{ik} - C_{jk}) \in [0, 1]$.

The similarity calculation has been divided into two steps: when the attributes of different data types are completed, the calculation of similarity among cases is considered the following step. Firstly, the improved algorithm of cluster analysis is used to cluster more than 660 cases in the database. Clustering was carried out according to the traffic congestion cause index of the attribute value.

3. Case Clustering Based on Min-Cluster Distributed Clustering Algorithm

3.1. Selection of Case Library Samples. In a CBR (case-based reasoning) system, the case library, as an important component of the system, is represented in the form of a set. On the assumption that case library $C = (c1, c2, c3, \ldots, cn)$ is a nonempty finite set, which is composed of n cases and $\exists c_i\,(1 \leq i \leq n)$ represents 1 case of the case set. The case library can be classified into m grid units, and $\forall c$ is regarded as 1 grid unit; each grid unit is of the same size, and there is no critical case between grids. But, when starting to classify these grid units, the critical cases within every case are not taken into consideration, and the cases are only classified generally. Thus, inaccuracy is caused by clustering afterwards. Taking this point into account, this paper adopts a new K-means algorithm to cluster, namely, introduce Min-cluster into the critical case and reclassify and cluster for feature value of the critical case, that is, classify the critical case into m grid clustering after the 2nd time clustering, in order to make the target case better find cases that are of more similarity, and perform case treatment to obtain a case optimal solution.

During case retrieval, set the target case, and select the case that is most similar by retrieving the matching degree with elements in Set-C, thus ascertaining the answering case. Meanwhile, store the target case in the case library. The more similarity between ci in case library C and the target case, the better ci answers. Hence, users need to try their best to find among the source cases the most similar case to the target one. A user can calculate the weight of a case in the case library according to the user's feedback on cases and ascertain the best solution based on weight. For selection of the case clustering initial value, on the premise of grid division, put cases of higher weight into the same grid cell pi

($1 \le i \le m$), and perform 2nd time refining and clustering through the improved K-means algorithm, thus obtaining cases of higher weight, and classify pi to obtain pi', then store it in the cases of higher weight after 2nd time clustering.

Definition 1. Some of the source cases in the case library are of higher similarity to the target case, which is > the specified threshold value sim, which means they are the very source cases similar to the target case.

Adopt a quadruple to represent the cases: A = (case, area case, tackle case, sim case).

Here, the case represents any one of the cases in Case-C; the area case is the set of all elements in the cluster which takes case as a sample case. Hence, the case set which is similar to the target case can be regarded as the area, where the distance between the target case ≤ sim case; tackle case is the set of answering cases, and the element in a tackle case is represented through two-tuples, T = (t case, count), among which t case is the answering case, while count is the frequency of t case being answered; sim is the case set which is in conformity with the definition. Since the similar cases whose output needs to meet the definition, the similarity between the target case and the answering case is ensured, and the weight of case ci is represented as follows:

$$W(c_i) = \frac{\text{Count}(\text{case})}{\text{Count}(\text{globalcase})}. \tag{4}$$

Among which, count (case) is the sum-up of the count for all the elements in the tackle case; count (global case) is the sum-up of the frequency in all the answering cases in Set-C. Finally, calculate out the weight value q of ci.

The purpose of case clustering is to divide cases into several grids and store cases of similarity in each grid. When a target case is mapped to a certain area, and its similarity is found to be relatively higher, it is the very case cluster for target case solution generating.

First, calculate the similarity between all elements in case library C, generally using the Euclidean distance formula as follows:

$$D_{(i,j)} = \sqrt{\left(c_{(i,1)} - c_{(j,1)}\right)^2 + \left(c_{(i,2)} - c_{(j,2)}\right)^2 + \cdots + \left(c_{(i,n)} - c_{(j,n)}\right)^2}. \tag{5}$$

Represent the similarity of all elements in C through the following similarity matrix:

$$s = \begin{vmatrix} \text{sim}_{11} & \text{sim}_{12} & \cdots & \text{sim}_{1n} \\ \text{sim}_{21} & \text{sim}_{22} & \cdots & \text{sim}_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \text{sim}_{n1} & \text{sim}_{n2} & \cdots & \text{sim}_{nn} \end{vmatrix}. \tag{6}$$

Among which, $0 \le \text{simij} \le 1$, when $i = j$, simij = 1, and when $i \ne j$, simij < 1. In the matrix, the i th row or i th column is all the similarities between ci and other cases.

If perform retrieval and matching use the target case for each case in case library C, more time will be cost, hence, it needs to be performed that, clustering of similarity for the cases in case library, and classifying cases of more similarity into one grid, with the following rules to be followed.

Rule 1: Combine the two cases, if the similarity between cases is greater than the specified threshold value.

If the two cases sci and scj exceed the specified threshold value sim, the two cases are regarded as the same, and combine sci and scj to be one case.

Rule 2: There is no need to store if the case density in grid unit is greater than the specified threshold value.

Set the density threshold value as P. P is the maximum quantity of the stored cases in the area, namely, the density of the cases in the grid is controlled by P; if the density of the cases in the grid is saturated, newly added cases will not be stored, thus ensuring the case quantity and misrepresentations inside the grid.

Rule 3: If the quantity ratio of the noise case in the case library exceeds S, start clustering; if there is no intersection between cases, stop clustering. The effect of the clustering inside the grid unit is shown in Figure 1.

3.2. Source Case 2nd Time Clustering

3.2.1. Improved K-Means Algorithm. The traditional K-means algorithm can be described as follows: randomly select K elements from the set to be clustered as the initial sample according to the given clustering quantity K, through continuous iteration adjust centroid, thus completing clustering. But, because there are some common features between each case in the case library, namely, the limit between cases is relatively fuzzy, hence, the result of retrieval is strongly dependent on the target case. Therefore, the effect of case clustering in a case library should be inclusive of the elements, which are relevant to the target case as much as possible, so as to improve the success rate of retrieval results.

The K-means algorithm transfers data between each station and occupies abundant network resources, so the limit between data cluster is not clear. Meanwhile, there will still be internal data breach during data transferring. Thus, based on K-means, introducing Min-cluster can not only tremendously improve the efficiency of data clustering but also reduce the possibility of data breach.

The improved algorithm interprets the system framework of the K-means algorithm from another perspective, regards the main station as the central point, and the center points of the k clusters, which have already been classified as margin point, and such system framework is regarded as the center-margin structure. In this system framework, each marginalized node only deals with the partial data near this node and analyzes the data, which has already been treated, and then directly submits the analysis result to the center point, which performs the 2nd time treatment and analysis at the center point, finally, obtaining the result of data clustering. The system framework is shown in Figure 2. Because there is no data interaction between each marginalized node in this system framework, each marginalized node only communicates with the center point. There is no meta data transferring in the whole system. Thus, the tremendous loss of meta data during transferring

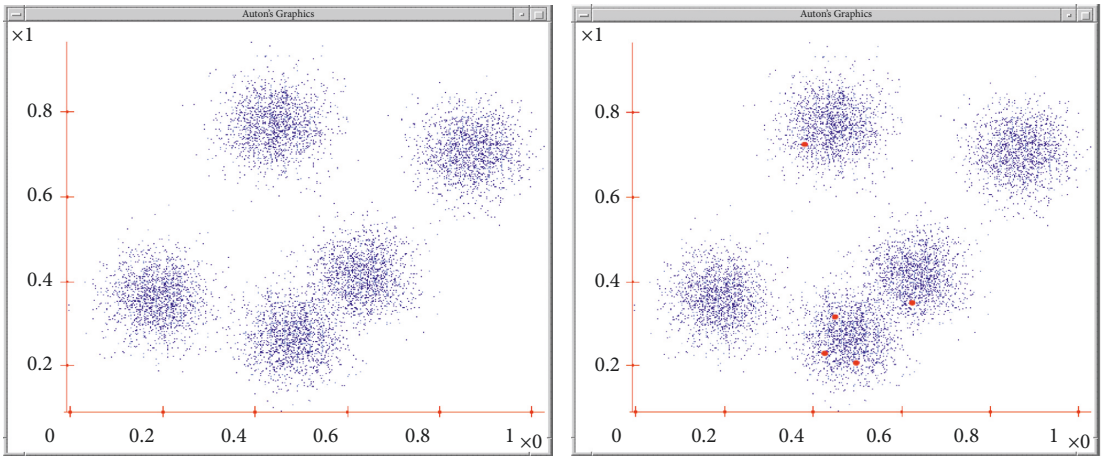

Figure 1: Effect of 1st time grid clustering.

is reduced. Meanwhile, the breach of the meta data during transferring is prevented. Hence, data clustering efficiency is greatly improved.

The case library has already been divided into several grids by the grid clustering at the 1st time in the case library, and cases of more similarity are stored in each grid. But there are still some marginal cases between each grid, which cannot be classified into the corresponding case library. Then, perform 2nd time clustering for the marginal case in grids using the improved K-means algorithm, and again reduce noise of case in grid.

3.2.2. The 2nd Time Clustering Algorithm. In a distributed clustering environment, considering the difference between each node, generally there is a time difference in original data clustering, adopt the K-means algorithm to perform data clustering generally. But, the smaller the quantity of the nodes selected in the K-means algorithm is, the more unstable the result of clustering will be, and the accumulative effect of this clustering instability exists at each marginalized node, finally, it will lead to inaccuracy of data, which is transferred to the center node. Then, to avoid this situation, introduce Min-cluster at the marginalized node and cluster the original data.

Theorem 1. *Min-cluster created from clustering is the subset of the source case.*

Use reduction to absurdity, and assume that there are n cases: $C1$, $C2$, . . ., Cn in 1 grid, this classification is adjacent to the C' case. All the original data points in $C1$, $C2$,. . ., Cn are relatively far away from the C' case. While, the process of clustering of original data in $C1$, $C2$,. . ., Cn meets the definition of Min-cluster; hence, these Min-clusters are relatively far away from the centroid of the C' case, thus, the 2nd time clustering process of Min-cluster will not be taken into the C' case. Under the same principle, the other cases can be proved, the theorem is proved.

Take the marginal case Sn as an example. Assume that the original data set in this case is N.

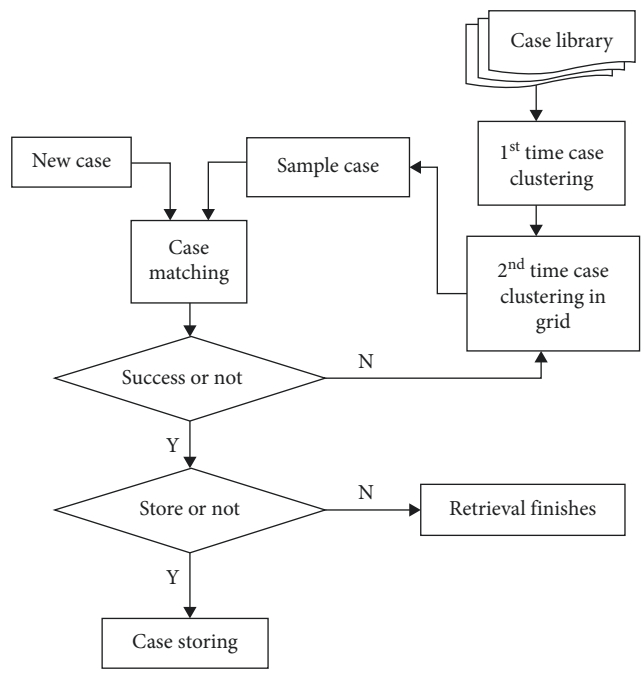

Figure 2: Case retrieval strategy process.

(1) Step 1: Select k random data as the initial center point among N data, and based on the established center point, naturally form k Min-clusters; each Min-cluster is $1d+3$ dimensional vector with the form as ($\overline{CF1^x}$, n, class_id).

(2) Step 2: Calculate the distance of all data points to k center points, select the cluster and add it, which is the shortest distance, thus forming Min-cluster.

(3) Step 3: After all data points are added to the cluster, based on the change in the data set, readjust the center $\overline{CF1^x}$ of Min-cluster and the included node quantity n.

(4) Step 4: When $\overline{CF1^x}$ and n do not change, output all Min-clusters; otherwise, return to Step 2.

The Min-clusters which are formed at marginal cases, will finally be transferred to the case center nodes, which have already been formed for fusion. There are different weight values between Min-clusters, namely, the more nodes included in Min-cluster cases, the higher the weight value, and the bigger the possibility to be a classification center. Furthermore, there may be superposition in Min-cluster cases; hence, each Min-cluster case is not equal, and calculation cannot be performed using a general cluster algorithm. Hence, considering that the data clustering for case center point adopt the K-means clustering algorithm based on weight value, take the centroid of Min-cluster as the data object of center node, and distribute different weights according to the n value of each microcluster. The algorithm steps are as follows:

Input: the Min-cluster set $\{C1, C2, \ldots, Cm\}$ from m cases, among which each Min-cluster set Cj includes k' Min-clusters $\{cj1, cj2, \ldots, cjm\}$ after the clustering of this node.

Output: the result of clustering of the whole case set.

(1) Step 1: make treatment for $m * k'$ Min-cluster, select the Min-clusters, which are equal at center, and adjust the value of n;

(2) Step 2: select k clusters, which are of high weight and of relatively large distance between each other, as the initial clustering center; the distribution of data clustering is not even; if centroids A, B of nodes $C1$, $C2$ do not superpose but are very near, then the weight of $C1$, $C2$ is equivalent. If the selected initial centroid is according to the method of weight sequencing, it will cause a cluster with A and B as centroids, and the result of clustering will not be accurate. Hence, this paper sets threshold value and ensures proper centerfold on the premise of performing weight sequencing.

(3) First, for $m * k'$ Min-clusters, perform weight sequencing; second, calculate the average value of the distance between any of the 2 Min-clusters.

$$\delta = \overline{d} = \frac{\sum \mathrm{d}_{ij}}{C_{mk}^2}. \tag{7}$$

(4) Third, perform sequencing according to weight and take the Min-cluster, which ranks 1 as the 1st initial centroid; then, compare the calculated new Min-cluster with the set threshold value. The selected Min-cluster can only be regarded as the initial centroid when their distance is > threshold value

$$d_{ij} > \delta. \tag{8}$$

(5) Finally, select k clusters, which are of high weight value and with large distance between each other, as the initial clustering center.

(6) Step 3: distribute Min-cluster to the newest cases according to distance, and update the quantity of the original data in case center and case center.

(7) Because Min-cluster itself is a small-scale data set and is different from the data source, which was included in the case previously, gather the Min-cluster as "original data," and calculate its geometric mean to ascertain the center of the classification, instead of only calculating the average value of data points. According to $\overline{CF1^x} * n$, which is Min-cluster center point multiplied by the data quantity included in Min-cluster, record the data quantity, obtain the result, and average it to be the center after case updating. There is

$$\overline{CF1} = \sum_j \frac{n_j}{\sum n_i} \overline{CF1}_j. \tag{9}$$

(8) Step 4: If the final case center does not change, proceed to Step 5; otherwise, return back to Step 3.

(9) Step 5: output clustering results.

After the clustering inside the grid for the 2nd time, the cases in the grid are made accurate further. Compare the similarity between cases by clustering marginal cases, reclassify the cases inside the grid, ascertain the center of cases again, enrich the conditions for case retrieval, and compare the target case better as shown in Figure 3.

From Figure 2, it can be detained that marginal cases after 2nd time clustering reduced tremendously, and source cases which are more complete and independent to each other are formed inside the grid generally.

4. Case Retrieval Strategy

The success rate of case solving of CBR intelligent system depends on the quantity and similarity matching of cases in the case library to a large extent. Based on the clustering for 2 times in the case library (as shown above), map the target case to one of the grid units, then, to the utmost, retrieve the matched case target in the grid, based on the result of the matching of cases in sample set S. The case retrieval process is shown in Figure 3.

The case retrieval process is as follows:

(1) The newly created target case matches with the elements in the sample case set S sequentially, and calculates the similarity between cases $\mathrm{sim}_1, \mathrm{sim}_2, \ldots, \mathrm{sim}_n$.

(2) Compare $\mathrm{sim}_1, \mathrm{sim}_2, \ldots, \mathrm{sim}_n$ with the similar threshold value, extract the set S', which is up to the sample case. If S' is empty, the target case is stored and is marked as noise case; if S' is not empty, extract the sample case s', which is the most similar among $\mathrm{sim}_1, \mathrm{sim}_2, \ldots, \mathrm{sim}_n$.

(3) Store s' to temp list and extract elements of s' to match with the target case, acquire the most similar solution set simcase', and sequence according to degree of similarity, and then output.

(4) Judge and ascertain whether or not the recommendation is successful according to users' feedback information. If successful, judge the selected cases in the

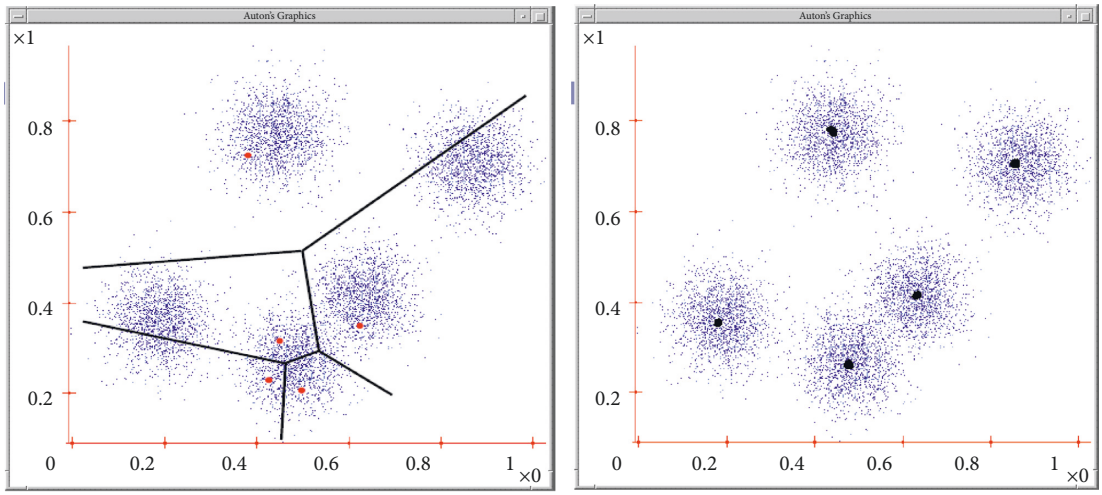

Figure 3: 2nd time clustering inside the grid.

target case and temp list and ascertain whether or not storage conditions are met. If Rule-1 and Rule-2 are met, store the target case; if failed, store the target case on the premise that Rule-1 is met; otherwise, do not store.

(5) If there is no case stored in grid cell after 2nd time clustering, finish retrieval; otherwise, judge whether or not Rule-3 is met, finish if met; otherwise, again cluster, return to 3.

5. Experimental Analysis

The weight calculation of traffic congestion feature attributes can be applied to the retrieval idea of web search engines. The traditional method has been abandoned. This study tried to take text classification as an example, mainly taking the spatial vector model (SVM) as the representation of text.

Firstly, the text is divided into morphemes (word segmentation), and then the selection of eigenvalues and the calculation of the weight of eigenvalues are carried out. Finally, a set of multidimensional traffic congestion feature attribute vectors could be formed.

Second, a table of the attributes of traffic congestion cases is established to integrate the attributes of various traffic congestion cases and is divided into different options. Table 1 is formed by analyzing the traffic congestion text data, which was collected by the research team members from an economic development zone of a city.

All the cases go through data prepossessing from the database, then the indicators are integrated and decomposed. The table of characteristic statistics of traffic congestion cases has been established (shown in Tables 2–4). In this table, attributes are presented as multiple contents, which are diversified (for example, plane intersections show different shapes of intersections) or visibility on hazy days, as shown in Table 5.

There are 70 feature items, which were decomposed from the cases. The computer used in the experiment is configured with a 3.5 GHz Pentium IV CPU, 4 G memory, 250 G and 7200 to IDE hard disk.

According to the attribute content of traffic congestion, these contents can be divided into seven categories, which can be represented as $F = (S_a, S_b, S_c, S_d, S_e, S_f, S_g, S_h)$, where each element represents the following attributes, and the data type of each category is shown in Table 4.

The causes and types of traffic congestion have been expounded in detail. In the database of traffic congestion cases, the causes of traffic congestion can be taken as the focus of the first clustering, and then frequent congestion and occasional congestion are taken as the secondary clustering focus. After the cluster simplification, according to the data types given by attributes, we adopt the method of combining local similarity calculation with global similarity calculation. In the calculation of local similarity, different methods are adopted for different data types, considering different data types.

In the expression of case knowledge, an eigenvector has been established for the eigenvalue attribute of each case, calculating the angle between the two eigenvectors by using the law of cosines. All the weight of the feature value is positive, so the two feature vectors between the cosine values are between 0 and 1. If the cosine value between two feature vectors is close to 1, namely, the two vectors' angle is smaller, the two eigenvectors represented the closer feature value. Conversely, if the cosine value is close to zero, the angle is greater, and the correlation between the two cases is smaller.

Through the previous elaboration, a presentational feature vector has been established for each case, and the angle between the two feature vectors can be calculated by the law of cosines. The formula is as follows:

$$\cos(\theta) = \frac{\sum_{i=1}^{n}(a_i \times b_i)}{\sqrt{\sum_{i=1}^{n}(a_i)^2} \times \sqrt{\sum_{i=1}^{n}(b_i)^2}} = \frac{a^T \bullet b}{\|a\| \times \|b\|}. \quad (10)$$

The experiment compared the cases of unclustered system 1 and clustered system 2. All cases were divided into 8 sets, and each set was clustered according to $K = 4$. Each set was arranged from low to high according to the number of clustered cases. A judgment analysis was made on the

Table 1: Attributes of traffic congestion cases.

No.	Congestion time	Congestion location	Causes of congestion	Congestion type	Congestion range	Weather	Congestion degree
1.	Morning peak	Trunk road	Normal congestion	Initial congestion	Line	Fine day	Serious
2.	Peak peace	*Y*-crossing	Sudden congestion	Subsequent congestion	Plane	Heavy rain	Deadlock
3.	Evening peak	*T*-crossing	Normal congestion	Initial congestion	Point	Fine day	Congestion
.....	.....	.....	.....	.....	.....	.....	.....
n.	Morning peak	Collector road	Special events	Initial congestion	Line	Light rain	Serious

Table 2: System 2 search results.

Test set	Number of cases	Retrieval time (s)	Number of successful cases retrieved	Retrieval success rate (%)
Test 1	148	0.442	144	97.29
Test 2	154	0.480	149	96.75
Test 3	162	0.486	155	95.56
Test 4	175	0.499	166	94.85
Test 5	179	0.501	169	94.44
Test 6	186	0.587	175	94.08
Test 7	189	0.588	177	93.65
Test 8	197	0.597	186	94.41

Table 3: System 1 search results.

Test set	Number of cases	Retrieval time (s)	Number of successful cases retrieved	Retrieval success rate (%)
Test 1	148	0.445	142	95.94
Test 2	154	0.478	148	96.1
Test 3	162	0.479	154	95.06
Test 4	175	0.497	165	94.28
Test 5	179	0.501	167	93.29
Test 6	186	0.588	172	92.47
Test 7	189	0.589	174	92.06
Test 8	197	0.598	181	91.88

Table 4: Case features and values of case library.

Case attributes	Classification of feature attributes	Types of feature attribute
Sa	Congestion time	Enumeration
Sb	Congestion location	Enumeration
Sc	Congestion causes	Enumeration, numerical type
Sd	Congestion types	Enumeration
Se	Congestion range	Enumeration, numerical type
Sf	Weather	Numerical interval type
Sg	Congestion level	Enumeration

Table 5: Characteristic statistics of traffic congestion cases.

No.	Index
1	Sudden congestion
2	Early peak
.....	.....
6	Normal congestion
7	Latte peak
.....	.....
60	Special events
61	Visibility between 100 and 200 m
.....	.....

retrieval time and success rate, respectively. The average retrieval time is taken 10 times for each collection. The retrieval results are shown in Tables 3 and 2.

By comparing the above charts, it can be found that the retrieval test is carried out on the 8 cases to be tested and is only selected from the test case base. The case from system 2 (clustered) shows a linear and slow increase in the retrieval time as the number of retrieved cases increases. In addition, the retrieval time of system 1 (unclustered) is almost the same as that of the system with clustering, and the success rate of the system with clustering has always been higher and more stable. The retrieval success rate of system 1 is not only lower than system 2 but also less stable than System_2.

6. Conclusion

This paper proposes a traffic congestion case retrieval strategy based on cluster analysis. Through the research on the relevant algorithms of clustering analysis, the shortcomings of the *K*-means algorithm in clustering are improved. Then introduce the concept of Min-cluster, and regard marginal cases as Min-cluster, perform clustering at the margin, select neighboring cases based on the clustering effect, take cases with more matching similarity as the new center point, directly transfer data to the new case, and then adjust the centerfold of the new case. Thus, the quantity of cases at case margins inside the grid is tremendously reduced, so the chances of success in the target case retrieval are greatly improved, and it has been proved through a test that the success rate of the case library retrieval after 2nd time clustering is also greatly improved. It improves the success rate of target case retrieval, expands the scope of case solutions in the decision-making system, and enhances the reliability and flexibility of decision-making selection. The next step is to further optimize the case set structure and the relevant parameters and to improve the learning ability of the system.

Colleagues and authors try to apply the optimized algorithm to the daily management of traffic congestion relief. Experiments show that the clustering traffic congestion case set has improved the retrieval accuracy and time.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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