Hindawi
Mobile Information Systems
Volume 2022, Article ID 3911615, 11 pages
https://doi.org/10.1155/2022/3911615

Research Article

Performance Prediction of Speed Skaters Based on BP Neural Network

Di Peng[1,2] and Hongye Lian[1,2]

[1]*Ice and Snow Sports Department, Hebei Sport University, Shijiazhuang, Hebei 050000, China*
[2]*Department of Physical Education, Qiqihar University Physical Education, Qiqihar, Heilongjiang 161006, China*

Correspondence should be addressed to Hongye Lian; lianhongye@hepec.edu.cn

Received 23 February 2022; Revised 11 March 2022; Accepted 29 March 2022; Published 6 May 2022

Academic Editor: Chia-Huei Wu

To better predict the performance of skaters, a BP neural network-based approach is proposed. With the help of the main component factor analysis method, the performance sample of the athletes was reduced, the traditional high-dimensional data set was changed to the new low-dimensional data set, the size of the model input variables was reduced, and the analysis efficiency was increased and improved. Experimental results show that the larger the iteration step, the lower the prediction error, because more a priori information of sports performance is used through multiple iterations, which improves the prediction accuracy. The error of sports performance prediction using this model is less than that of traditional methods, and the maximum difference is 35.98%. It is proved that this method uses factor analysis and neural network training to cluster and fuse the data information of sports performance, improves the prediction accuracy, and has a good performance in convergence and robustness.

1. Introduction

Speed skating is one of the top ten key sports and the first winter competitive sports to reach the world level. In recent years, the outstanding performance of Chinese Speed Skaters in international competitions has made great progress compared with the past. How to consolidate the projects with advantages and improving the competitiveness of speed skating in international competitions have always been the focus of sports scientific research. The prediction of athletes' performance in major competitions can not only be used as an important basis for analyzing the difference between China's speed skating and the world's advanced level but also reveal the systematic law of sports performance, promote the scientization of athletes' training, and improve the training effect [1]. The prediction of sports performance has been paid more and more attention by sports scientific research. China's speed skating has high sports performance in women's events, but it also has great ups and downs, in order to guide sports training and catch up with and surpass the world advanced level of women's speed skating. There are many prediction methods, such as gray dynamic model, trend extrapolation of time series, and least square regression model. Then, there are prediction methods based on mathematical statistics, such as least square regression and gray model. This kind of method uses mathematical modeling to predict athletes' sports performance. However, this kind of method has weak prediction ability for nonlinear data and can not accurately describe the change characteristics of sports performance. In recent years, predictive analytical methods based on artificial neural networks (Bayesian networks, support vector machines, neural networks, etc.) have been developing rapidly. This method has a strong effect on optimal control modeling. As shown in Figure 1 below, the reverse distribution (BP) neural network is a two-layer presupplied network prepared on an algorithm for optimizing reverse distribution [2]. Physical performance is an important indicator of the level of physical fitness. By accurately predicting physical activity, it is possible to dig into the constant factors and features of human fitness and thus to improve sports training and fitness. Therefore, it is important to study the model of sports performance

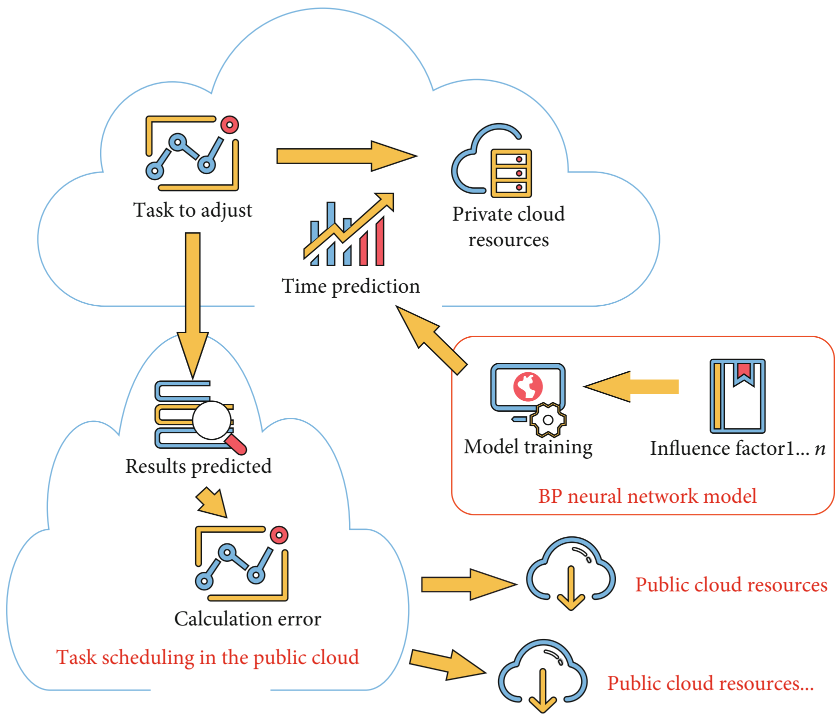

Figure 1: BP neural network prediction model.

forecasting to promote scientific training and improve sports success. The accuracy of predicting sports performance has many limitations, including changes in human characteristics, gender, age, weather, sports field, and various environmental factors. The model for predicting sports performance is a multivariable, multiparameter statistical analysis process involving statistics, data processing, and modern mathematics. Traditional methods of sports performance prediction include sports performance prediction algorithms based on AR model calculations, specific spatial decomposition methods, empirical mode decomposition methods, and wave analysis sports performance time series prediction methods. The feature of linear adjustment of sports performance is used to define the space and to create a predictive model of the method of restoring the limitations of many parameters, which has a good predictive effect. However, these methods are less accurate due to their high computational costs and poor adaptability to the parameters in the prediction process.

2. Literature Review

In Ma et al.'s study, the use of neural network modeling in dynamic modeling opens a wide range of possibilities for this scientific research market. As an example of filming, they use a neural network to technically create a model of the transition between a feature and the original information. The inverse of the information-theoretical mechanics of kinematic structures is considered. Editing the first post works well. In essence, the neural network can be used to create a more complex model of physical and motor logical communication, as it acquires professional knowledge through learning [3]. Chang et al. modeled the level of technical training and quality training from 1996 to 2001, analyzed the relationship between the value of the athlete's technical qualification and the training quality index, and developed a unique hypothesis model for athletes. Based on this hypothesis model, the forecast analyzes the specific performance of 2002 and 2003. The results show that the enterprise model is free from many linear regression unit models and gray model defects [4]. Ji et al. focused on elite athletes nationwide, analyzed the relationship between the value of the athlete's isotype and the literacy practice index, and developed a unique hypothesis model for athletes. The enterprise model should be free of multiple linear regression unit models and gray model defects, and more accurately visualize the functional relationship between the athlete's literacy practice and the exercise index value, and then accurately predict and analyze the athlete's concentration in shooting blow [5]. Lee et al. won the women's hammer throw champion of the 12th Asian track and field championship and entered the top 10 in the world in one fell swoop. Four groups of historical data corresponding to four quality training indexes and special achievements are used as the training samples of neural network. Using the powerful function mapping ability of artificial neural network, a neural network model reflecting the relationship between hammer thrower's physical quality and special performance is proposed [6]. Xing et al. based on relevant data from the 2002-2003 research institute performed an analysis of the relationship between the value of eight literacy training indicators and the technical profession of athletes. We choose from 4 measures of training quality and the athlete's unique neural network. The results show that the enterprise model more realistically reflects the functional relationship between the level of altitude literacy training and key points and thus achieves higher linear alignment accuracy. Using this type of neural network enterprise model, coaches and athletes can better understand the development trends of athletes' unique expressions and develop more scientific training programs [7]. Zhang uses neural networks and obtained the structural properties of molecular structural analogs, selected genetic associations and groups as identification factors, and created a data drainage matrix of molecular structural properties [8]. In Wu et al.'s study, according to the BP network algorithm and the basic theory of gray system, based on the existing gray neural network model theory, a third-order gray neural network model GNNM (3,1) based on time response function is established, the accuracy of gray neural network model used to simulate complex nonlinear dynamic process is improved [9]. Li and Ning take the attribute value of the basic index describing the economic benefits of the enterprise as the input vector of ANN and take the result representing the comprehensive evaluation goal as the output of ANN. Then, we train the network with enough sample vectors to make different input vectors get different output values. In this way, the set of weight coefficient values possessed by ANN is the correct internal representation of the network after adaptive learning. Trained ANN can be used as an effective tool combining qualitative and quantitative methods to comprehensively evaluate different enterprises [10]. Na et al. expounds how to apply the neural network method to the prediction in the field of market evaluation [11]. Le and Zhao train the neural network through the on-site historical data, stores the expert experience that is difficult to formalize in the form of nonlinear mapping on the nodes of each layer of the neural network and the coordination organization diagnoses the system fault with rules and neural network according to different situations, and obtains the corresponding diagnosis results. After completing a diagnosis example, the neural network can remember the diagnosis process and results, summarize new diagnosis rules, continuously expand the content of the knowledge base, and make the knowledge base have self-learning, self-adaptive, and other functions [12]. Tseng and Luo aimed at the complexity of teaching quality evaluation process; using the structural characteristics of neural network, this paper puts forward a teaching quality evaluation system based on neural network algorithm and determines the mathematical model of the system. Each evaluation index is used as the input and the evaluation target is used as the output. Through the training of the model, the simulation calculation shows that the mathematical model has good identification accuracy [13].

Current scientific research clearly suggests a neural network-based approach to BP. Enterprise design and high efficiency were analyzed. This process solves the problem of moving back and forth between model data messages. Using an evolutionary algorithm to improve the basic parameters of the BP neural network flow board can improve the Internet worldwide.

3. Establishment of BP Neural Network Performance Prediction Model

The artificial neural network (ANN) is an information processing system with distributed storage, parallel processing, and adaptive learning, which is abstracted, simplified, and simulated from the structure, function, and some basic characteristics of real human brain neural network in physiology. The trained neural network model can quickly reflect new knowledge and information by learning new samples. In particular, the feedforward network can approach all nonlinear mappings, which makes it a potential and effective modeling tool for nonlinear images in competitive sports. The multilayer feedforward network can approach any continuous function. The two-tier transmission control internet is used to create a player-specific prediction model that can mimic all functional relationships between unique and qualitative exercise index values. There are many reasons why competition can be harmful to fitness. Motion imaging is highly dynamic and variable, but it can only be considered a black box system if the results of observational and predictive analysis are considered. Neural network discrimination is not limited to optimal management models. Based on the defined input/output data-information pairs of the system, training and instruction determine the optimal vision of the system's input/output communication management. Inputs are provided to get the output when it is not clear how the input and output are connected. The neural network is suitable for multivariable and highly nonlinear problems, with self-organization and learnability. It can learn knowledge from samples, and the learned information is distributed in many connection weights [14]. In this paper, the neural network model is used for prediction, and the results of the top three women's speed skating in 500 m, 1000 m, 1500 m, 3000 m, and 5000 m in previous winter Olympics are modeled as follows:

$$y = f(x_1, x_2, x_3), \tag{1}$$

where y is the first predicted result and x_1, x_2, x_3 is the top three competition results.

The network structure is designed as follows: the number of hidden layers is 1, and the number of hidden layer neurons is 7. Its structure is shown in Figure 2.

The network structure according to the BP algorithm is shown in Figure 3 below.

3.1. Statistical Parameter Analysis of Sports Performance. Sports performance data can be regarded as a set of nonlinear time series. The trend of sports performance is analyzed by nonlinear time series method, and the sports performance is statistically analyzed, which is as follows:

$$\begin{pmatrix} X \\ P(X) \end{pmatrix} = \begin{pmatrix} a_1, a_2, \cdots, a_m \\ p(a_1), p(a_2), \cdots, p(a_m) \end{pmatrix}. \tag{2}$$

For a set of multivariate sports performance statistical series $x(n)$, the fractional generalized integral-differential

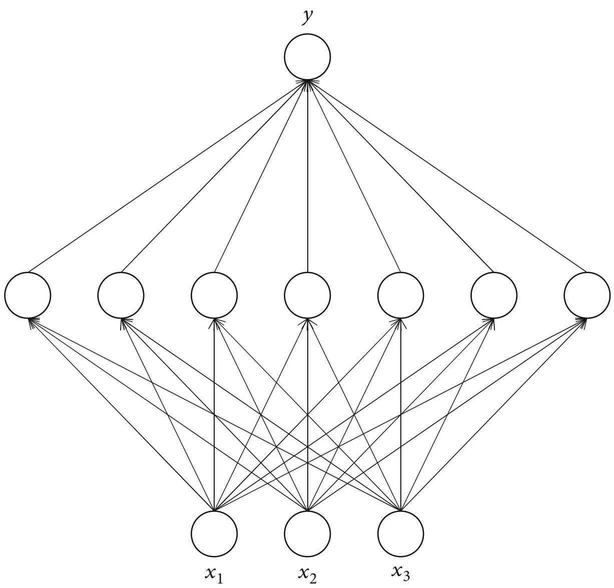

FIGURE 2: Neural network structure of prediction model.

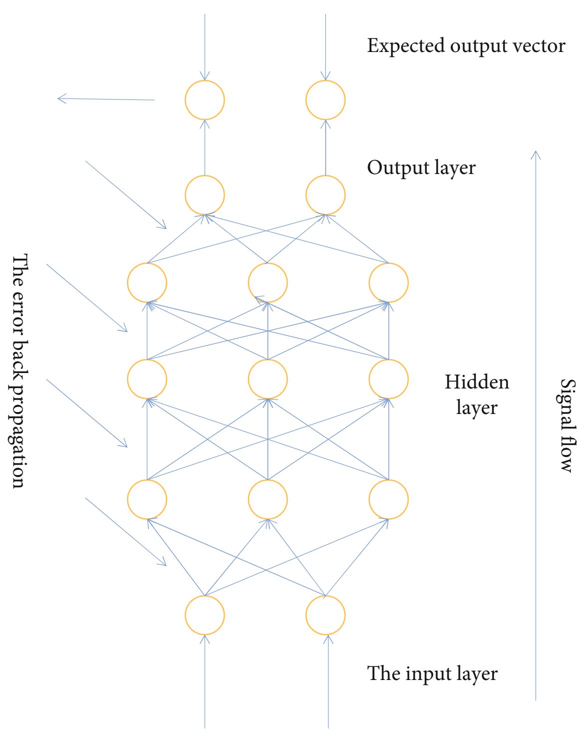

FIGURE 3: Structure of neural network based on BP algorithm.

equation is used to express the statistical characteristic quantity of sports performance as follows:

$$\begin{aligned} c_{1x}(\tau) &= E(x(n)) = 0, \\ c_{2x}(\tau) &= E(x(n)x(n+\tau)) = r(\tau), \\ c_{xk}(\tau_1, \tau_2, \cdots, \tau_{k-1}) &= 0, k \geq 3, \end{aligned} \tag{3}$$

When $q = 2$, the constraint function of sports performance information vector on differential equation satisfies the continuous functional condition of $(2 + 1)$ dimension in Bernoulli space, and the constraint condition is

$$\psi_x(\omega) = \ln \varphi_x(\omega) = -\frac{1}{2}\omega^2\sigma^2. \tag{4}$$

Through the global asymptotic stability characteristic decomposition, the factors in sports performance are analyzed, and the factor principal component probability density confidence region of sports performance time series is obtained as follows:

$$g\left(x_i, y_i \middle| \mu_k, \sigma_k^2\right) = \prod_{k=1}^{K} a_k \frac{1}{\sqrt{2\pi\sigma_k^2}} \exp\left\{-\frac{(x_i - \mu_k)^2}{2\sigma_k^2}\right\}, \tag{5}$$

where a_k is the vector field of sports achievement time series in the state of global gradual stability and μ_k is the statistic of nonlinear components.

In the process of creating a motion model that considers the hazards of the natural environment, temperature, and other factors in predicting motion, a first-order general integrated-differential equation system with a time lag can be obtained, Fourier equation [15]. An analytical internal spatial model is shown to show the hypothesis of exercise performance. The set of environmental features arguments are as follows:

$$c_k = \frac{1}{j^k}\left[\frac{d^k}{\omega^k} \ln \varphi_x(\omega)\right]_{\omega=0} = (-j)^k \left[\frac{d^k}{\omega^k}\psi_x(\omega)\right]_{\omega=0} = (-j)^k \psi_x^k(0). \tag{6}$$

According to the a priori criterion, $c_1 = 0$; $c_2 = \sigma^2$; $c_k = 0 (k \geq 3)$ can be obtained.

In order to maintain the nonlinear characteristics of the original sports performance time series data, the fractional generalized integrodifferential equation is defined to reconstruct the statistical model of sports performance. The fractional order generalized integrodifferential equation is

$$\begin{cases} u_u - \Delta u + |u|^4 u = 0, \\ (u, \partial_t u)\big|_{t=0} = (u_0, u_1) \in \dot{H}_x^{s_c} \times \dot{H}_x^{s_c - 1}, \end{cases} \tag{7}$$

where u_u is the process function of sports performance prediction and u_0 is a homogeneous linear subspace.

3.2. Self-Similar Regression Model. The self-similar regression model is constructed for the prior information of statistical sports performance. The statistical prior information characteristic state equation of sports performance obtained by generalized least squares estimation (GLS) is as follows:

$$E(u(t), u_t(t)) = \int_{IR^d} \frac{1}{2}\left(|\nabla u(t)|^2 + |u_t(t)|^2\right) + \frac{1}{6}|u(t)|^6 dx. \tag{8}$$

Among them, $u_t(t)$ represents the characteristic coefficient, and the least square estimation (GLS) of sports performance is the mean square consistent estimation. When $s_c > 1$ (i.e., $d \geq 4$), the regression model of sports performance prediction restricts the variable s_c is a sub square matrix of any order. The control objective function of sports performance prediction is

$$\max_{x_{a,b,d,p}} \sum_{a\in A}\sum_{b\in B}\sum_{d\in D}\sum_{p\in P} x_{a,b,d,p} V_p, \quad \sum_{a\in A}\sum_{d\in D}\sum_{p\in P} x_{a,b,d,p} R_p^{bw} \leq K_b^{bw}(S), b \in B, \tag{9}$$

where $x_{a,b,d,p}$ represents the predicted calibration value of sports performance, R_P represents the prediction factor of sports performance, K_b represents the prediction load of sports performance, and bw represents the predictive parameter value of intended performance.

Feature compression is applied to the sub eigenvector with distributed time delay in the formula. When the initial value of disturbance characteristic is certain, the probability density functional coefficient of sports performance prediction is obtained as follows:

$$K = \left[\left(4\beta\tau P\ell^{-a}\right)^{1/a} \cdot \left(2^{-a/2}P\ell^{-a} - \beta N_0\right)^{-1/a} + 1 + \sqrt{2}\right]. \tag{10}$$

The confidence degree of sports performance prediction accuracy is only $c_1 e^{\lambda_1 t} + c_2 e^{\lambda_2 t}(\lambda_1 \neq \lambda_2)$ or $(c_1 + c_2 t)e^{\lambda t}(\lambda_1 = \lambda_2 = \lambda)$.

The characteristic decomposition value of the self-similar regression model meets the following requirements:

$$\begin{aligned} &f(x_1, x_2, i) - g(y_1, y_2, i) + \int (h(x_1, x_2, i) - g(y_1, y_2, i))xdu \\ &\quad < x\left(|x-y|^2 + x|x-y|^2\right), \end{aligned} \tag{11}$$

where $\forall x_1, x_2, y_1, y_2 \in R$.

Let x^* be a weight contribution point in the vector solution set $\{x_k\}$ of the sports performance prediction model and make factor analysis of the second-order moments $f(x_1, x_2)$ and $g(x_1, x_2)$ of linear transformation at point $P_0(x_1^0, x_2^0)$. If $C_0(x^*) = 0$, the self-similar regression model of sports performance is

$$Y(P, Q, \beta) = Y[\text{red}(P, Q, \beta), Q, \beta]. \tag{12}$$

By constructing the self-similar regression model of sports performance, the empirical mode decomposition and factor analysis of the time series of sports performance are carried out, and the BP neural network classification model is used to cluster and fuse the characteristic information of sports performance, to optimize the prediction model [16].

3.3. Model Design and Implementation. According to the Lyapunov-Krasovskii functional theory, for a continuous sports achievement time series, the recursive calculation expression of empirical mode decomposition is

$$\begin{aligned} &P\left(y_{w_3}|x_{w_3}, \theta, \beta\right) \infty \left(y_{w_3}|x_{w_3}, \theta\right)\left(y_{w_3}|\beta_i\right) \\ &\infty \prod_{k=1}^{K} a_k \frac{1}{\sqrt{2\pi\sigma_k^2}} \exp\left\{-\frac{(x_i - \mu_k)^2}{2\sigma_k^2}\right\} \cdot \frac{1}{Z(\beta_i)} \exp\left(-\sum_{c\subset C} V_c(Y, \beta_i)\right) \\ &\infty \prod_{k=1}^{K} \frac{a_k}{Z(\beta_i)\sqrt{2\pi\sigma_k^2}} \cdot \exp\left\{-\left[\sum_{k=1}^{K} \frac{(x_i - \mu_k)^2}{2\sigma_k^2} + \sum_{c\subset C} V_c(Y, \beta_i)\right]\right\}. \end{aligned} \tag{13}$$

By constructing the covariance matrix of sports performance data, a proper dimension matrix is obtained. The high-order moment of sports performance prediction characteristic points meets $X = X^T \geq 0$, $Y = Y^T \geq 0$; then, the following equation is true:

$$\begin{aligned} 0 &= \int_{t-\tau}^{t} \eta_1^T(t)X\eta_1(t)ds - \int_{t-\tau}^{t} \eta_1^T(t)X\eta_1(t)ds \\ &= \tau\eta_1^T(t)X\eta_1(t) - \int_{t-\tau}^{t} \eta_1^T(t)X\eta_1(t)ds, \\ 0 &= \int_{t-\sigma}^{t} \eta_2^T(t)Y\eta_2(t)ds - \int_{t-\sigma}^{t} \eta_2^T(t)Y\eta_2(t)ds \\ &= \sigma\eta_2^T(t)Y\eta_2(t) - \int_{t-\sigma}^{t} \eta_2^T(t)Y\eta_2(t)ds. \end{aligned} \tag{14}$$

The BP neural network structure model is shown in Figure 4.

Sports performance training vector mode input by the BP neural network:

$$x(t) = (x_0(t), x_1(t), \cdots, x_{k-1}(t))^T. \tag{15}$$

The BP neural network is used for information fusion, and a set of new time series y_k instead of sports performance time series is generated from a series of random distribution characteristics $N(m_k, \varepsilon_k^2)$. The output Lyapunov index of sports performance prediction is as follows:

$$\begin{aligned} \text{POF} &= \frac{\sum_{I=1}^{TC} M_o(C_i)}{\sum_{i=1}^{TC}[M_n(C_i) \times DC(C_i)]}, \\ M_d(C_i) &= M_n(C_i) + M_o(C_i). \end{aligned} \tag{16}$$

4. Experimental Results and Analysis

4.1. Application and Evaluation of BP Neural Network Model. The BP neural network hypothesis model simulation test has been completed for the MATLAB mobile software accessory writing function. Out of the 1250 groups of 7-dimensional fitness exercise information data samples obtained after the analysis of the main components, 900 training data sets accounted for about 70% of the total sample, 15 data sets for the validation sample, and 345 data sets for the test sample. For the proportions of all samples, there

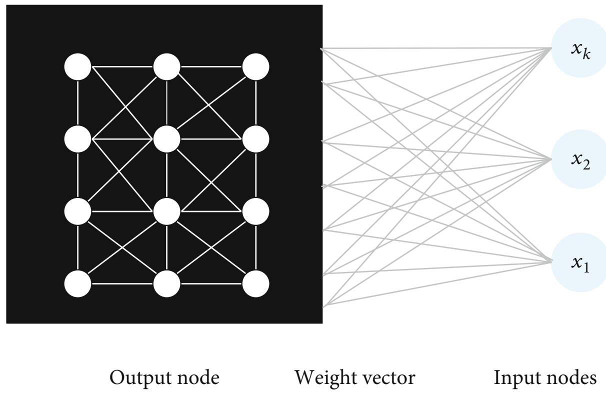

Figure 4: BP neural network structure model.

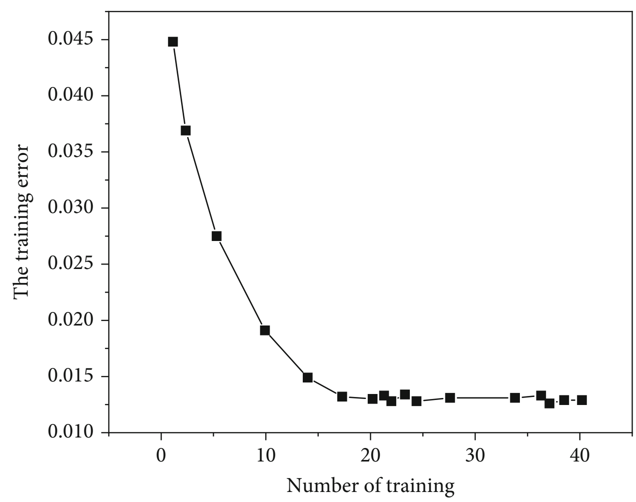

Figure 5: Training results of prediction model.

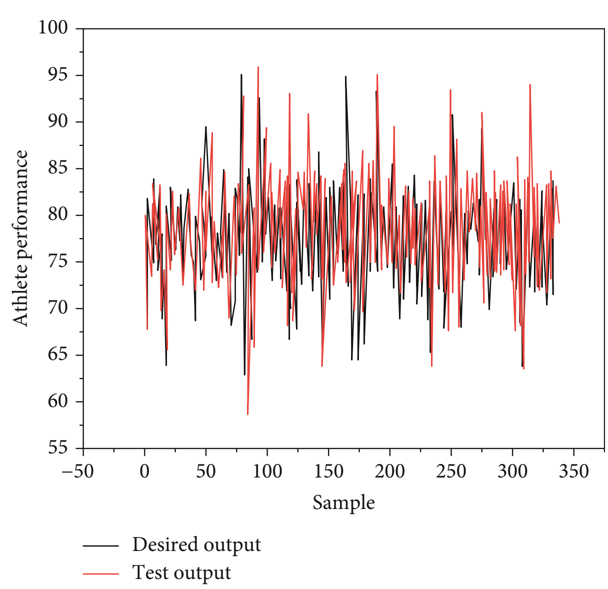

Figure 6: Simulation diagram of test results of the BP neural network prediction model.

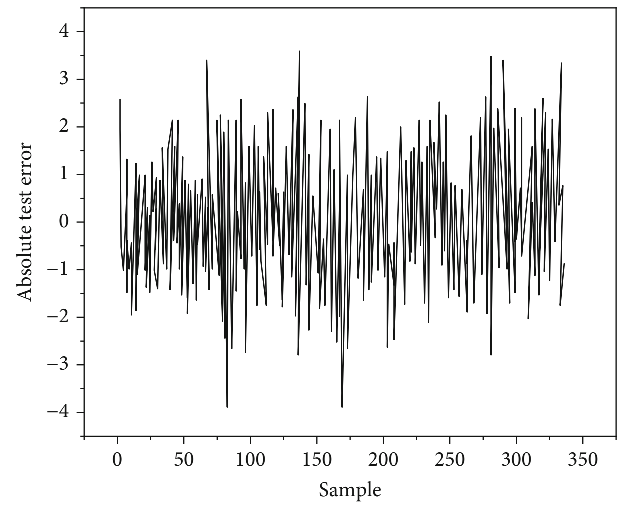

Figure 7: Absolute error of test results of the BP neural network prediction model.

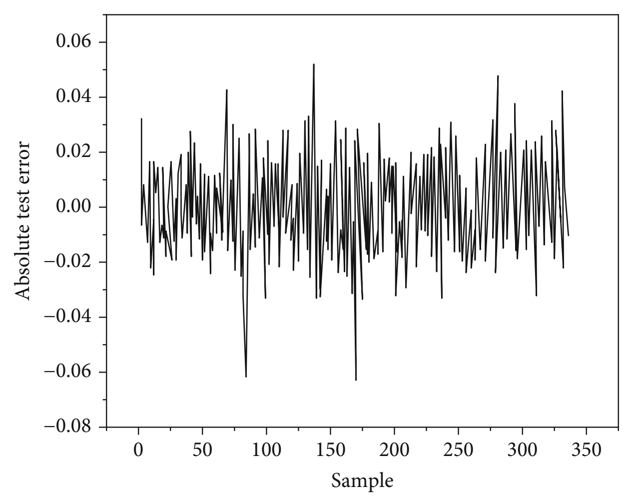

Figure 8: Relative error of test results of the BP neural network prediction model.

Table 1: The BP training fitting error and prediction error of the neural network prediction model.

Standard	Training sample fitting	Test sample prediction
Mean square error	2.1568	2.3084
Average relative error	0.0124	0.0162

were accounts for about 30 percent of the total sample. Initially, 900 training and training samples were used to implement the learning process in the predictive model, and then, 15 sets of validation samples were used to clarify the structural characteristics and variables of the unit model in order to validate the model. Finally, the exercise hypothesis model was used to predict and analyze the fitness expression of 345 sets of experimental samples.

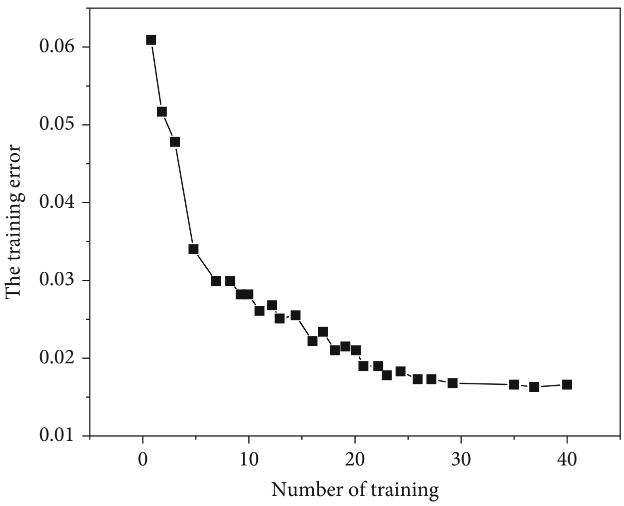

FIGURE 9: Training results of the ANFIS prediction model.

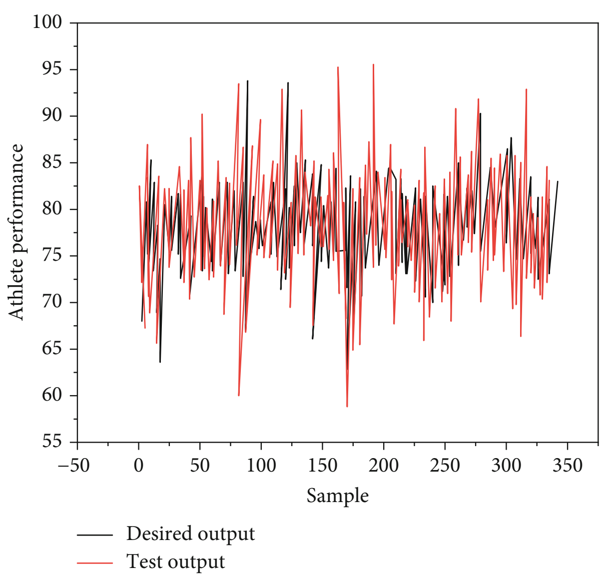

FIGURE 10: Simulation diagram of test results of the traditional prediction model.

As shown in Figure 5, the average error in model training is stable after 20 training sessions. After the 40th repetition, the average relative error in model training is 0.0128. We examine the predictive model using 15 sets of validation samples and validate the model after training. The results show that the mean relative error of the model agrees and the model does not agree.

4.2. Test Results of Prediction Model. 345 groups of test samples are used to study the prediction model of athletes' sports performance after training. The prediction results of the model are as follows.

Figures 6–8 are the simulation diagram, absolute error diagram, and relative error diagram during the prediction model test, respectively. It can be seen intuitively that the two curves of the predicted value and the actual value in Figure 6 are basically consistent, which shows that the prediction model can accurately predict the athletes' sports performance. In the latter two figures, it can also be seen that the prediction error of the prediction model is relatively small, which also verifies that the model has good prediction effect.

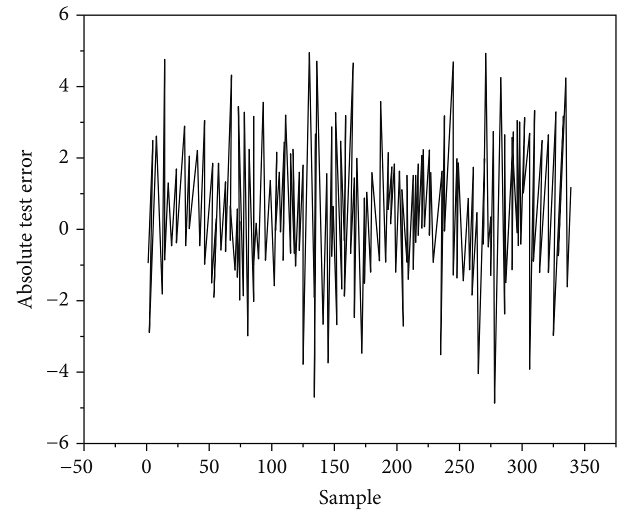

FIGURE 11: Absolute error of test results of the traditional prediction model.

It can be seen from Table 1 that the mean square error and average relative error of the model training fitting are 2.1568 and 0.0124, respectively; The mean square deviation and average relative error of prediction are 2.3084 and 0.0162, respectively. From the above data analysis, the fitting of the prediction model is very good in the training process. In the prediction process, its accuracy of performance prediction is relatively high, and its prediction value is very close to the expected value of the test sample. This shows that the prediction model is suitable for the prediction of athletes' sports performance.

4.3. Comparative Study of This Prediction Model and Traditional Prediction Model

(1) Experimental analysis of traditional prediction model

In this paper, the current prediction model is modeled using the MATLAB mobile application tool. Without analyzing the above basic characteristics, 900 data sets from the first 1250 12-dimensional fitness exercise 3D visual information data samples are special samples, 15 data set that account for about 70% of the total sample are validation samples, and 345 data sets are data information. The data are experimental samples and account for about 70% of the sample. For the 30% of all samples, initially, the current predictive models were scientifically studied in 900 training and training samples, and then, 15 structural samples were used to identify the structural types and individual variables of the corporate enterprise model [17]. Finally, fitness statements were predicted in 345 test samples using a fitness exercise prediction model. 900 sets of training samples are

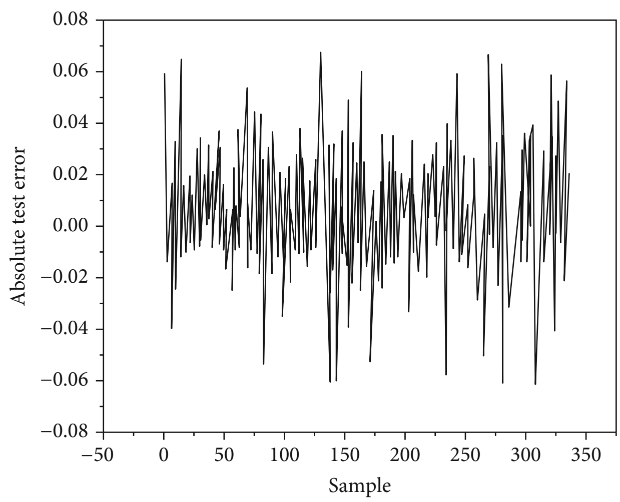

Figure 12: Relative error of test results of the traditional prediction model.

Table 2: ANFIS prediction model training fitting error and test error.

Standard	Training sample fitting	Test sample prediction
Mean square error	3.7841	4.1784
Average relative error	0.0190	0.0194

Table 3: Comparison of prediction results between this prediction model and traditional prediction model.

Standard	Paper model	Traditional model
Mean square deviation	2.6547	4.3215
Average relative error	0.0164	0.0197

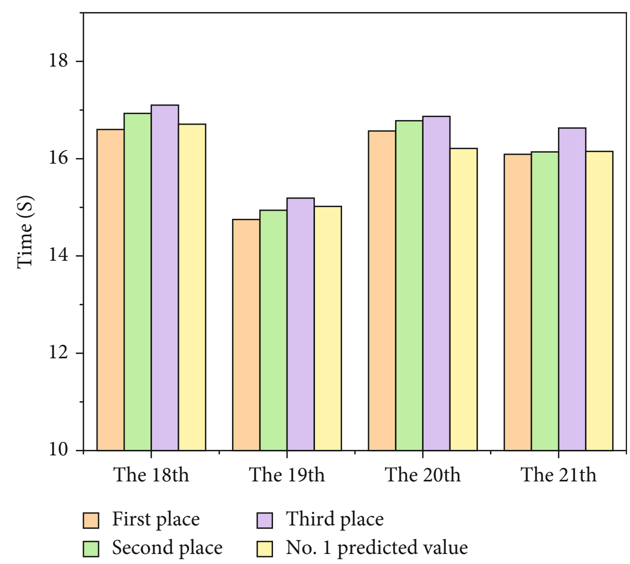

Figure 13: Actual and predicted results of the first place in 500 m women's speed skating in the 18th~21st Winter Olympic Games (subject to the next seconds).

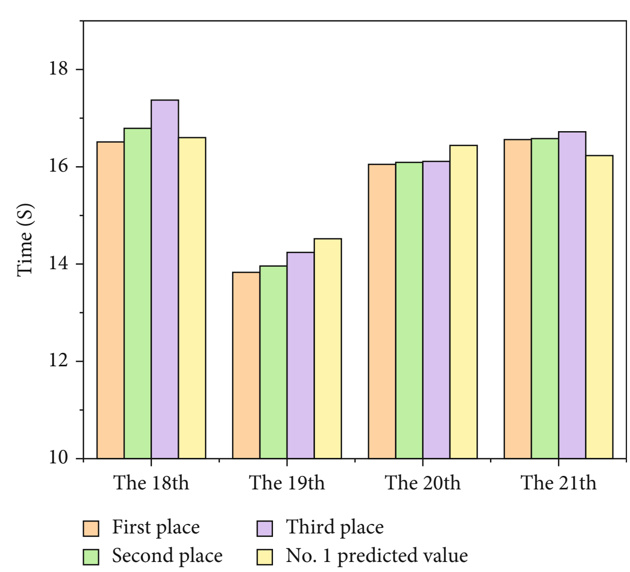

Figure 14: Actual and predicted results of the first place in 1000 m women's speed skating in the 18th~21st Winter Olympic Games (subject to the following seconds).

trained in the traditional predictive model. The figure below shows the training and learning outcomes for the corporate enterprise model.

As shown in Figure 9 below, the average relative error from model training is stable after 30 iterations of training for the traditional hypothesis model. After the 40th iteration, the average relative error in female model training is likely to be 0.0164. Fifteen sets of validation samples were used to study the predicted model and validate the model after training. The results of the validation show that the average relative error of the model coincides and the model does not fit linearly.

Using 345 sets of test samples, the traditional predictive model is used to predict and analyze basic sports performance after players have trained. The results of the preliminary analysis of the model are as follows.

Figures 10–12 are simulations, positive, and relative error graphs that detect the current hypothesis model. It is clearer that the two graphs of the predicted value and the actual valueshown in Figure 10 are essentially consistent, suggesting that the traditional hypothesis model can also accurately predict a player's basic fitness performance. From the last two figures, the relatively small predictive deviations of the predictive model also confirm that the enterprise model has a very good predictive effect.

As shown in Table 2, the mean square deviation and relative error of the linear adjustment of the rigid body model are 3.7841 and 0.0190. The predicted mean standard deviation and the relative error average are 4.1784 and 0.0194. From the statistical analysis above, it was proven that the conventional prediction model was suitable for classroom teaching. In all prediction processes, the accuracy of performance assumptions is very high and the expected test value

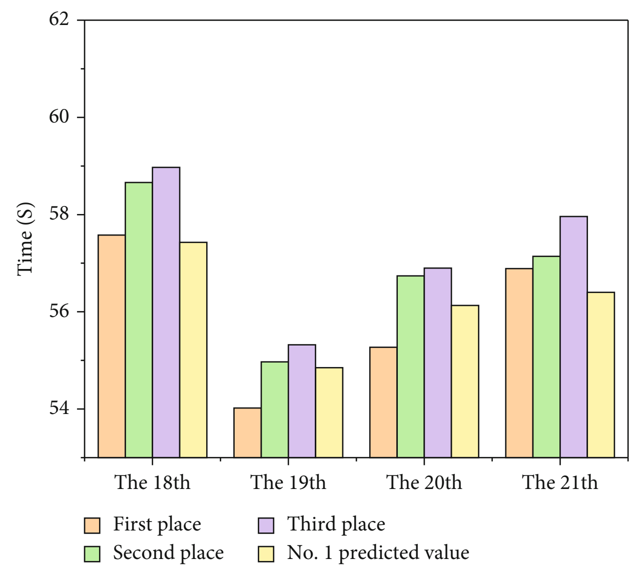

FIGURE 15: Actual and predicted results of the first place in 1500 m women's speed skating in the 18th~21st Winter Olympic Games (subject to the following seconds).

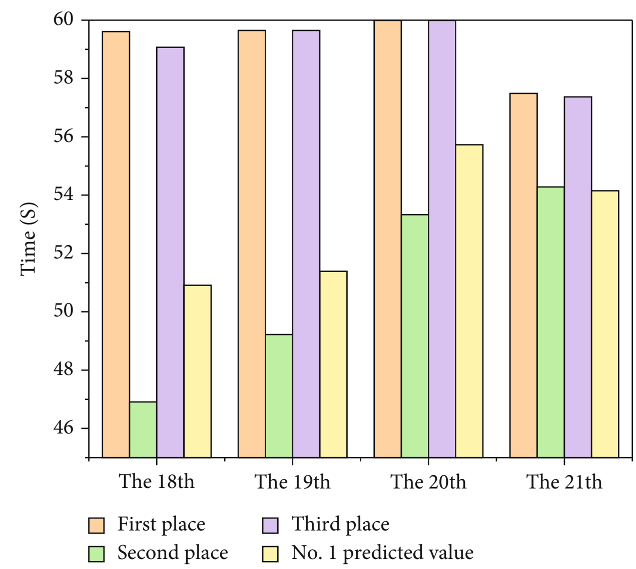

FIGURE 17: Actual and predicted results of the first place in women's speed skating 5000 m in the 18th~21st Winter Olympic Games (subject to the next seconds).

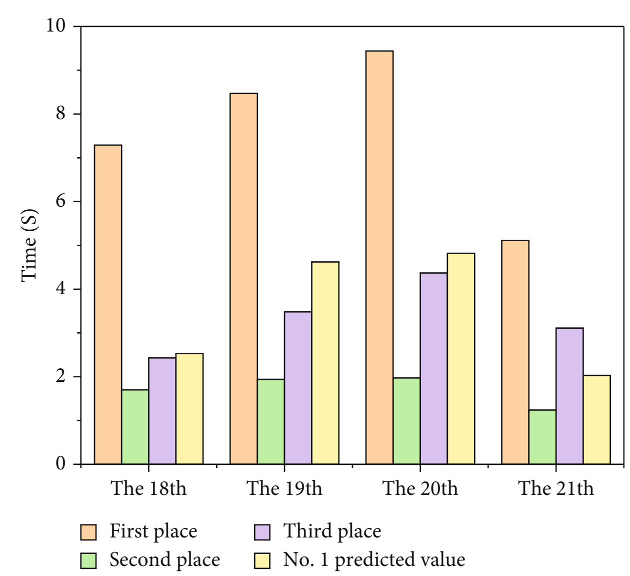

FIGURE 16: Actual and predicted results of the first place in 3000 m women's speed skating in the 18th~21st Winter Olympic Games (subject to the following seconds).

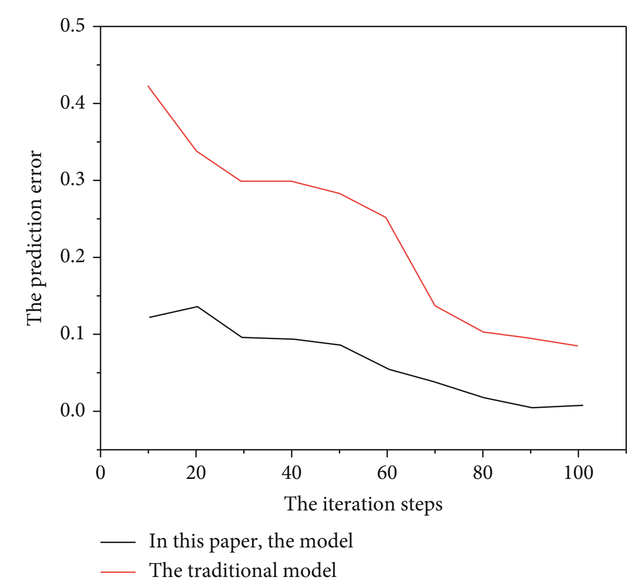

FIGURE 18: Prediction error analysis.

is close to the expected expectation value. This suggests that traditional prediction models can be used to predict players' basic sport performance.

(2) Comparison of the forecasting model in this paper with the traditional forecasting model

As shown in Table 3 below, the MSE and MAPE obtained after the detection of the BP neural network were 2.6547 and 0.0164, respectively. The current MSE and MAPE obtained after the test are 4.3215 and 0.0197. The values of the index of the previous two deviations are higher than the latter. The real effect of the previous hypothesis is stronger, and the ability of the whole model to self-study and generalize is stronger. Subsequent analysis of the model has shown that the BP neural network model developed in this study is more suitable for solving optimal control correlation problems. Therefore, the BP neural network model developed in this article is more suitable for solving the problem of predicting player fitness.

Taking the top three competition results of women's speed skating 500 m, 1000 m, 1500 m, 3000 m, and 5000 m in the 1st~17th Winter Olympic Games as samples, the above algorithm is used for the generation training of Shenluo network model, and the competition results of women's speed skating 500 m, 1000 m, 1500 m, 3000 m, and 5000 m in the 18th~21st Winter Olympic Games are tested [18]. The relevant data and calculation results are shown in Figures 13–17.

From Figures 13–17, the calculated value obtained by the BP neural network prediction model has high fitting accuracy with the actual value. The predicted value calculated by the BP neural network model may be inconsistent with the actual value. What it expresses is only a trend that sports performance may develop and change in the future.

The collected speed skating results are statistically analyzed and least square fitted, and the data are analyzed in MATLAB simulation software. The neural network adopts a three-layer network structure, and the learning and training parameters are $\mathrm{NE}_{j^*}(t) = 1 + 9e^{-t/1024} = 12$, the speed skating performance test set, the number of yards is 1024, the interference intensity of environmental information on the prediction model is set to 13 dB, the time interval of data sampling is 1.5D, and the number of iterations is 10000.

Taking the above collected speed skating performance statistical samples as the test set, the speed skating performance prediction model is simulated and analyzed, and the comparison results of prediction errors of different methods are obtained, as shown in Figure 18.

Based on the results of the above modeling, the following conclusions are drawn: (1) With the increase of iteration steps, the prediction error decreases, because through multiple iterations, more a priori information of speed skating performance is used, which improves the prediction accuracy. (2) The error of speed skating performance prediction using this model is less than that of traditional methods, and the maximum difference is 35.98%. Because this method uses factor analysis and neural network training to cluster and fuse the data information of speed skating performance, it improves the prediction accuracy and has a good performance in convergence and robustness.

5. Conclusion

First, a dimensional reduction is performed on a sample of sports performance data collected by analysis of key components. The MATLAB simulation test is then performed on the generated hypothesis model, and the accuracy of the hypothesis results of the hypothesis model and the traditional hypothesis model is evaluated by MAPE and MSE. Finally, the preliminary results of the women's 500 m, 1000 m, 1500 m, 3000 m, and 5000 m races at the Winter Olympics were predicted, and a BP neural network model based on basic component analysis and genetic algorithms proved to be more suitable for athletes' speed skating. In the assumptions of results, this suggests that the neural network prediction model is characterized by low initial data, high accuracy, and better reflection of development trends in specific sports performance levels. Predicting sports performance using neural network models is important for scientifically guiding training and enriching the theory of competitive sports training, and further discussion and research is needed.

Data Availability

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

Conflicts of Interest

The authors declare no competing interests.

Acknowledgments

This work is supported by the Hebei Province "Three Three Three Talent Project" funded project (Research on the Path to Realize the Construction of a Powerful Ice and Snow Country under the Background of the New Era) (No. A202101081) and part of Heilongjiang Province Higher Education Teaching Reform General Project (Research on Collaborative Innovation Development of Heilongjiang Province Ice and Snow Professional Talents and Universities Joint Training under the Background of 2022 Winter Olympics) (No. SJGY20190733) or Heilongjiang provincial ordinary undergraduate colleges and universities young innovative talent training program project (Research on the strategy of building a strong ice and snow country in the context of Beijing 2022) (UNPYSCT-2018110) and part of the Heilongjiang philosophy and social science research project (Research on the construction path of ice and snow power under the background of 2022 Winter Olympics) (No. 18TYC236) and 2018 Heilongjiang Provincial Department of Education Basic Research Business Expenses Research Project (Humanities and Social Sciences Youth Innovative Talents Project) (Promoting China's Ice and Snow Culture Industry in the Background of the 2022 Beijing Winter Olympics) (No. 135309319).

References

[1] X. Sun and Y. Lei, "Research on financial early warning of mining listed companies based on BP neural network model," *Resources Policy*, vol. 73, no. 2, article 102223, 2021.

[2] F. Qian, L. Chen, J. Li, C. Ding, and J. Wang, "Direct prediction of the toxic gas diffusion rule in a real environment based on LSTM," *International Journal of Environmental Research and Public Health*, vol. 16, no. 12, p. 2133, 2019.

[3] X. Ma, J. Guo, K. Xiao, and X. Sun, "PRBP: prediction of RNA-binding proteins using a random forest algorithm combined with an RNA-binding residue predictor," *IEEE/ACM Transactions on Computational Biology & Bioinformatics*, vol. 12, no. 6, pp. 1385–1393, 2015.

[4] S. Chang, M. Leng, H. Wu, and J. Thompson, "Aircraft ice accretion prediction using neural network and wavelet packet transform," *Aircraft Engineering & Aerospace Technology*, vol. 88, no. 1, pp. 128–136, 2016.

[5] J. Degang, X. Ao, and X. Xiaoxian, "Prediction and analysis of air quality based on FCM and BP neural network," *Meteorological and Environmental Research*, vol. 9, no. 3, pp. 76–78, 2018.

[6] J. C. Lee, S. C. Shin, and S. Y. Kim, "An optimal design of wind turbine and ship structure based on neuro-response surface method," *International Journal of Naval Architecture and Ocean Engineering*, vol. 7, no. 4, pp. 750–769, 2015.

[7] H. W. Xing, Z. C. Liu, W. Zhang, and T. J. Liu, "Prediction of pelletizing performance based on svm-bp neural network composite model," *Revista de la Facultad de Ingenieria*, vol. 32, no. 10, pp. 646–653, 2017.

[8] Z. Zhang, "Bp neural network trade volume prediction and enterprises HRM optimization model based on es-lm training," *Journal of Intelligent and Fuzzy Systems*, vol. 39, no. 4, pp. 5883–5894, 2020.

[9] J. Wu, C. Liu, Z. Liang, and C. Zhang, "Research on the room air conditioner long-term performance prediction and optimization strategy," *Journal of Mechanical Engineering*, vol. 51, no. 18, pp. 158–166, 2015.

[10] D. Li and W. Ning, "Research on premium income prediction based on LSTM neural network," *Advances in Social Sciences Research Journal*, vol. 6, no. 11, pp. 256–260, 2019.

[11] W. Na, Q. Zhu, Z. Su, and Q. Jiang, "Research on well production prediction based on improved extreme learning machine," *International Journal of Modelling Identification and Control*, vol. 23, no. 3, p. 238, 2015.

[12] T. Le and J. Zhao, "A data fusion algorithm based on neural network research in building environment of wireless sensor network," *International Journal of Future Generation Communication and Networking*, vol. 8, no. 4, pp. 295–306, 2015.

[13] T. Y. Tseng and Q. Luo, "Company employee quality evaluation model based on BP neural network," *Journal of Intelligent and Fuzzy Systems*, vol. 40, no. 5, pp. 1–10, 2020.

[14] W. Chen, X. Li, X. Chen, and Y. Xiong, "Research on influence mechanism of running clothing fatigue based on bp neural network," *Journal of Intelligent and Fuzzy Systems*, vol. 40, no. 8, pp. 1–11, 2020.

[15] L. Zheng, "Research on the performance evaluation method for cold chain logistics of agriculture products based on BP neural network mode," *Open Cybernetics & Systemics Journal*, vol. 9, no. 1, pp. 2168–2172, 2015.

[16] X. Xia, "Study on the application of BP neural network in air quality prediction based on adaptive chaos fruit fly optimization algorithm," *MATEC Web of Conferences*, vol. 336, no. 1, p. 07002, 2021.

[17] K. Hu, X. Bai, Z. Zhang, and M. A. Vaz, "Prediction of submarine pipeline equilibrium scour depth based on machine learning applications considering the flow incident angle," *Applied Ocean research*, vol. 112, no. 3, article 102717, 2021.

[18] H. Zhang, J. Zhao, and C. Chen, "Groundwater level prediction based on neural networks: a case study in Linze, northwestern China," *E3S Web of Conferences*, vol. 266, no. 1, article 09005, 2021.