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Application of An Improved Particle Swarm Optimization Neural Network Model in the Prediction of Physical Education in China

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With the scientific development of the sports industry, as a kind of important quantitative analysis method, the prediction in the field of physical is bound to be paid more and more attention. People's requirements on the accuracy of the data will be more and more high. From the athletes' selection to the athletes' performance prediction, it depends on the statistics of a large number of historical data. As a result, the development of modern mathematics and computer technology is widely used in the field of physical education, such as grey theory, fuzzy mathematics, and neural network and so on. Grey forecasting model is suitable for analysing the nonlinear and uncertain system. But this method usually has a large prediction error. Artificial neural network has a strong self-learning function, so it can train the predictable data. However, it requires a large sample data set. Therefore, this paper tries to use the particle swarm optimization algorithm to optimize the parameters of neural network, and uses a discrete method to improve the neural network, so as to achieve the purpose of accurate prediction. The experimental results show that the fitting residuals of the neural network algorithm are small, and the prediction accuracy is high.

1. Introduction

With the scientific development of the sports industry, as a kind of important quantitative analysis method, the prediction in the field of physical is bound to be paid more and more attention. People's requirements on the accuracy of the data will be more and more high. From the athletes' selection to the athletes' performance prediction, it depends on the statistics of a large number of historical data. As a result, the development of modern mathematics and computer technology is widely used in the field of physical education, such as gray theory, fuzzy mathematics, neural network and so on (Liu Sifeng (2004), Sun Xiaojun (2009), and Lu Gang, Xu Xigen (2005)). Here, we introduce several common methods of prediction in sports field.

Linear prediction method. The linear prediction method is generally included the average forecasting method, linear regression forecasting method, etc. The linear feature of the object is obvious in sports system. The linear model can not only express the quantitative relationship between the main variables, but also eliminate the factors that are not interested. This not only captures the main contradiction of the problem, but also reduces the influence of the secondary factors. However, the defect of linear prediction method cannot be ignored. For example, the average smoothness prediction with a very strong lag, and the linear regression forecasting method must have a large sample size (Zhang Yunliang (2008), Zhao Nie (2008), and Lin Yinping, Wang Jianjun (2007)). Nonlinear forecasting method. There are a large number of non-linear objects in sports system. Try to make nonlinear problems linearization is a method of traditional nonlinear problems. Then, the theory and method of linear model is used to analyze the problem. However, due to the special nature of the nonlinear problem is different from the linear problem, it will cause the loss of the characteristics (Zhang Bo (2014), Zhao Wenjuan, Yang Xuezhi (2012), and YANG Liyong (2004)). Neural network and artificial intelligence forecasting method. The neural network can learn from the sample data automatically, and without the complicated query and presentation process. It can be used to approximate the function of the law of the sample data. Artificial intelligence expert system integrated with the experience of experts, combined with quantitative calculation. So, it makes the problem more realistic. Therefore, neural network and artificial

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intelligence has opened up a broad development prospects for the prediction of complex system in sports field (Zhang Yuhua (2012), Li Jing, Wu Qixun (2007)).
Therefore, this paper tries to use the particle swarm optimization algorithm to optimize the parameters of neural network, and uses a discrete method to improve the neural network, so as to achieve the purpose of accurate prediction. The experimental results show that the fitting residuals of the neural network algorithm are small, and the prediction accuracy is high.

2. Relate work

2.1 PSO model

In the PSO algorithm, the solution of each optimization problem is the state of a particle in the search space. The fitness value of particles is determined by a fitness function, and each particle has a speed which directly affects the movement distance of particles. According to the current situation of particles and particle swarm, the algorithm searches in the solution space. PSO initial values are random values of the state of a group of particles, and then update their speed and position according to Formula 1 and 2.

$$v_{id} = wv_{id} + c_1 Rand() * (p_{id} - x_{id}) + c_2 Rand() * (p_{gd} - x_{id}) \tag{1}$$

$$x_{id} = x_{id} + v_{id} \tag{2}$$

Where the v_{id} is the speed of particle, c_1, c_2 is acceleration coefficient, *Rand()* is random value between 0 and 1. The x_{id} is current position of particle, the p_{id} is the current extreme value of particle. In Formula 1, there are three items on the right side of the equation. The first term is the product of the velocity of last time v_{id} and the inertia factor *w*. The inertia factor is the effect of velocity of last time on current velocity. At the same time, the inertia factor *w* has a great influence on the optimization performance. The larger *w* value is conducive to jump out of local minima, and the smaller *w* value is conducive to the convergence of the algorithm. The second one is the difference of the behaviour of the particles themselves. The third one is the difference of the particle swarm behaviour. The second item and third item is known as the particles of consciousness.

2.2 Neural network model

BP network is a feed forward network of multilayer structure, we mainly introduced the three layer of the BP network, that is, the input layer, hidden layer and output layer. All layers are connected between each layer, and the neurons are not connected in the same layer. Figure 1 shows the BP neural network structure with a hidden layer, the node number of the input layer and output layer is determined by actual situation, and the node number of hidden layer is calculated by the following formula. N_H indicates the number of nodes in the hidden layer, N_i is the number of nodes in the input layer, and N_0 is the number of nodes in the output layer:

$$N_H = \sqrt{N_i + N_0} + L, \quad L = 0,1,2,\cdots,10 \tag{3}$$

There are many kinds of the activation function of the neurons in hidden layer, such as a step function, quasi linear function, sigmoid function and hyperbolic function; typical excitation functions are as follows:

$$F(x) = \frac{1}{1 + e^{-2x/u_0}} \tag{4}$$

Derivative function:

$$f'(x) = \frac{2}{u_0} f(x)(1 - f(x)) \tag{5}$$

Error function:

$$E = \frac{1}{2} \sum_{k=1}^{N} (Q_k - Y_k)^2 \tag{6}$$

Next, we give a topological map of the neural network model.

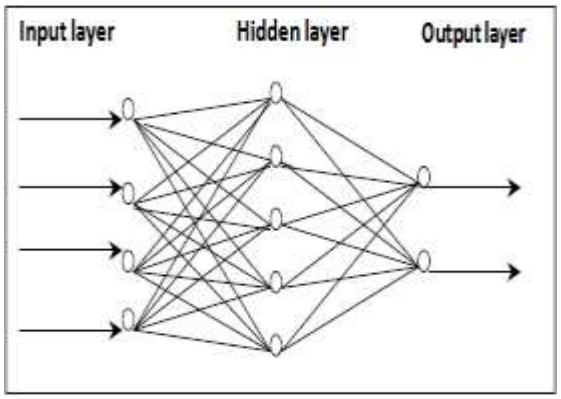

Figure 1: Topology of the BP neural network

3. Improvement of PSO-BP neural network

The basic PSO algorithm can only be used in continuous space, while the discrete binary PSO algorithm can solve the discrete space optimization problem effectively. In the discrete PSO algorithm, the position of the particles is only two states which are 0 or 1. The method of velocity updating is similar to that of a continuous PSO, and the position of the update is determined by the state transition probability of the particle velocity. The greater the speed, the greater the probability of a particle is 1. The Sigmoid function can satisfy this requirement, so the speed of this paper is converted to sigmoid function. In addition, we have to set a upper and lower range of v_{id} to ensure that the value of sigmoid (v_{id}) cannot be too close to 0 or 1. The discrete particle swarm optimization algorithm is as follows:

$$v_{id} = wv_{id} + c_1 r_1 (p_{id} - x_{id}) + c_2 r_2 (p_{gd} - x_{id}) + c_3 r_3 (p_{id} - p_{gd}) \tag{7}$$

$$x_{id} = \begin{cases} 1 & \rho_{id} < sigmoid(v_{id}) \\ 0 & \rho_{id} \geq sigmoid(v_{id}) \end{cases} \tag{8}$$

Where ρ_{id} is the random value between 0 and 1, other parameters are consistent with the basic PSO algorithm.

4. Simulation experiment and result analysis

4.1 data preparation

The decathlon is a comprehensive sports event, which is composed of running, jumping and throwing. It is the comprehensive embodiment of the strength, speed and speed endurance of the athletes. In this paper, we select the excellent results of the men's decathlon of our country from 1995 to 2007 as the sample data set. According to the universal indicators of decathlon, we use the improved PSO-BPNN algorithm to predict the total score of decathlon in next three years. This paper provides some references for the scientific selection and scientific training for athletes, so as to select the outstanding athletes from the backup talents. Next, we give the original data set in Table 1.

Table 1: The original data set

100m	broad jump	Shot-put	high jump	400m	110m hurdles	Discus	Pole vault	Javelin	1500m	Total Score
11.11	7.11	13.36	1.9	51.95	14.89	43.42	4.6	60.98	307.6	7463
10.87	6.88	12.15	1.91	48.94	15.11	38.16	4.4	55.8	271.88	7479
11.09	7.66	14.11	1.96	53.87	15.51	42.18	4.6	61.31	299.56	7571
11.02	7.43	14.42	1.99	51.15	14.73	44.16	4.2	58.24	284.05	7780
10.56	7.73	14.48	1.9	49.16	14.35	41.74	4.4	55.08	302.42	7850
10.71	7.38	13.67	1.97	49.39	14.69	37.86	4.7	54.98	272.72	7875
11.03	7.23	15.02	1.96	50.76	15.1	46.78	5	59.14	298.11	7908
11.13	7.38	13.29	1.96	49.52	14.67	47.63	4.7	59.16	270.75	8021
10.68	7.76	15.11	2	46.71	14.48	43.66	5	65.48	269.48	8646
10.74	7.79	16.32	2.06	48.06	14.1	48.86	5.1	60.12	280.12	8730
10.54	8.03	16.08	2.02	48.36	13.99	47.89	4.85	66.14	282.33	8815
10.7	7.76	16.42	2.07	48.05	14.07	49.36	4.9	59.86	259.25	8832
10.44	8.01	15.72	2.03	46.97	14.33	46.56	5	65.24	275	8847
10.43	8.08	16.69	2.07	48.51	13.98	48.56	5	62.58	282.1	8891
10.54	7.9	16.78	2.04	48.08	13.73	48.33	4.9	72.32	277.2	8994
10.64	8.11	15.33	2.12	47.79	13.92	47.92	4.8	70.16	261.98	9026

4.2 Data pre-processing of decathlon index

Table 1 reflects the sample of the decathlon. As the dimensions of the various indicators are different, so we cannot make a direct comparison. In order to make the index have comparability, and to speed up the convergence rate of the BP neural network, this paper has carried on the normalized processing to each index:

1) For qualitative indicators: using expert scoring method to determine its data, and we have a normalized treatment of various indicators.

2) For quantitative indicators: the following formula is used to normalize.

$$x_i = \frac{x_i - x_{i\min}}{x_{i\max} - x_{\min}} \tag{9}$$

Where, the normalized values for the i th indicator is x_i, the minimum value of the i th indicator is $x_{i\min}$, and the maximum value of the i th indicator is $x_{i\max}$.

Then, we carry out the standard processing of the sample data set of the first thirteen rows. The results of data standardization are shown in Table 2.

Table 2: Standard processing

100m	broad jump	Shot-put	high jump	400m	110m hurdles	Discus	Pole vault	Javelin	1500m
1.414	-1.4	-1.14	-1.5	1.447	0.811	-0.476	-0.6094	-0.13	1.8592
0.432	-2.1	-2.02	-1.3	-0.14	1.244	-1.889	-1.374	-1.15	-0.629
1.332	0.05	-0.6	-0.6	2.458	2.031	-0.809	-0.6094	-0.07	1.2992
1.046	-0.6	-0.37	-0.1	1.025	0.496	-0.277	-2.1387	-0.67	0.2188
-0.84	0.24	-0.33	-1.5	-0.02	-0.25	-0.927	-1.374	-1.3	1.4984
-0.22	-0.7	-0.92	-0.4	0.098	0.417	-1.97	-0.227	-1.32	-0.571
1.087	-1.1	0.062	-0.6	0.82	1.224	0.4267	0.92	-0.5	1.1982
1.496	-0.7	-1.19	-0.6	0.166	0.378	0.655	-0.227	-0.49	-0.708
-0.35	0.33	0.128	0.04	-1.31	0.004	-0.412	0.92	0.752	-0.796
-0.1	0.41	1.007	0.95	-0.6	-0.74	0.9855	1.3024	-0.3	-0.055
-0.92	1.06	0.832	0.34	-0.44	-0.96	0.7249	0.3465	0.882	0.099
-0.26	0.33	1.079	1.11	-0.61	-0.8	1.1198	0.5377	-0.35	-1.509
-1.33	1	0.571	0.5	-1.18	-0.29	0.3676	0.92	0.705	-0.412

4.3 Data pre-processing of decathlon index

Next, we train the neural network model. After many tests, the system has a minimum of fitting residuals when the nodes number of hidden layers is 5. Therefore, this paper is a BPNN 13-5-1 model. Training results are shown in figure 2. Finally, we predict the total score of decathlon in the next three years. Prediction results are shown in figure 3. The experimental results show that the prediction accuracy of modify PSO-BP neural network algorithm is better than the artificial neural network and grey forecasting model.

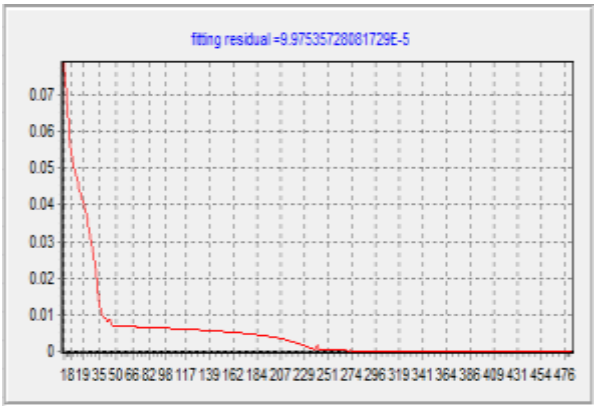

Figure 2: The number of hidden layer nodes is 5 in neural network training (N=500)

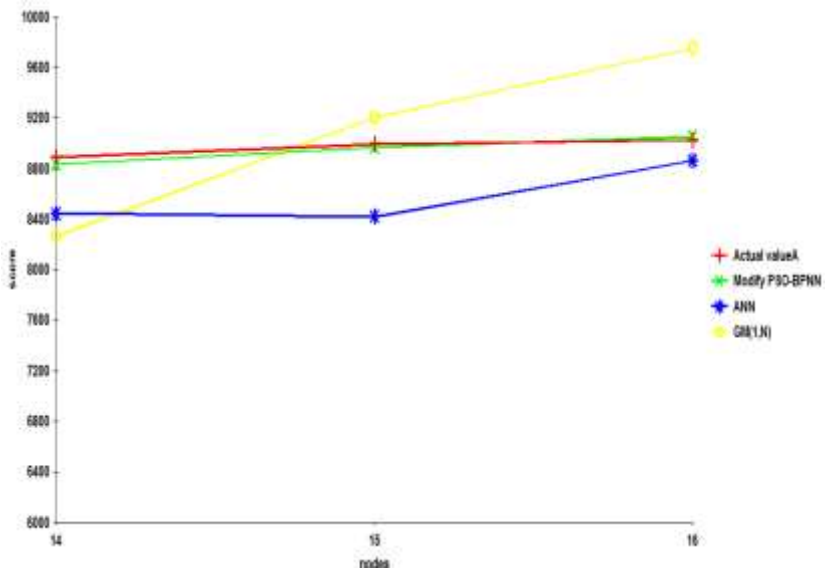

Figure 3: The prediction curve of Optimized PSO-BPNN model

5. Conclusions

This paper tries to use the particle swarm optimization algorithm to optimize the parameters of neural network, and uses a discrete method to improve the neural network, so as to achieve the purpose of accurate prediction. The experimental results show that the fitting residuals of the neural network algorithm are small, and the prediction accuracy is high.

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