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Neural Network Implementation Based on Particle Swarm Optimization in Teaching Quality Evaluation

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Abstract. Aiming at the defects of traditional teaching quality evaluation system, this paper proposes a neural network trained by particle swarm optimization algorithm for the comprehensive evaluation of college teachers' teaching quality. We establish the main index system that affects the teaching quality as the main setting parameters of the system. On this basis, the given index value is used as input, and the estimated score is used as output. Then, PSO is used to optimize the initial weight and threshold of BP neural network to solve the defect that it is easy to fall into local optimum. Finally, through simulation analysis and combined with the teaching case of an efficient ideological and political teacher, the complex relationship between multiple indicators that affect their teaching quality evaluation and the evaluation results was fitted, making the model have good recognition accuracy. The experimental results show that the scheme overcomes the subjective factors of the evaluation subject in the evaluation process, and it can better solve the dynamic problem of given usual scores in the teaching process.

Keywords. PSO; BP neural network; teaching quality; evaluation; index system

1. Introduction

The ideological and political theory course in vocational colleges is the main battlefield of ideological and political education for college students. Although vocational colleges have made reforms in teaching methods and models, its effectiveness is not strong. The evaluation of the teaching quality of ideological and political courses is an important link in ideological and political education teaching, which is of great significance for improving teaching quality, mobilizing teachers' work enthusiasm, and enhancing the effectiveness of teaching. Using scientific methods to comprehensively and reasonably evaluate the quality of classroom teaching is of great significance for evaluating the teaching level and quality of schools. However, it is difficult to form a systematic evaluation system simply to evaluate the teaching level and quality because of the heavy workload and complex statistics. In recent years, some scholars have considered using neural networks to improve the accuracy of relevant evaluation standards [1]. Since the neural network algorithm has strong nonlinear function approximation ability, it has good analysis ability for relevant fuzzy indexes or inaccurate parameters. However, due to the complexity of the neural network training process, it requires more prior knowledge and requires higher requirements for operators. Therefore, when neural network is introduced into the evaluation of teaching quality, the result is inaccurate PSO has a strong global search ability and is very suitable for parameter

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optimization of neural networks. Therefore, according to the above characteristics, the radial basis function(RBF) neural network trained by particle swarm optimization (PSO) algorithm can be considered for the comprehensive evaluation of teachers' teaching quality to truly and effectively reflect teachers' teaching effect [2].

Considering the progress and limitation of neural network in teaching quality evaluation, this paper introduces PSO algorithm to optimize the original neural network model Firstly, according to the demand analysis, the existing evaluation factors of teaching quality are summarized, and the uncertain weight index system that affects teaching quality is sorted out. Then aiming at certain defects of the traditional neural network, the PSO algorithm is used to improve it, and the specific operation steps are provided. Finally, through case analysis about the Ideological and Political Theory Course Teachers of certain university, the improved algorithm was applied to the specific evaluation of the teaching quality of ideological and political courses, verifying the feasibility of the plan. The results show that it can improve the error accuracy and speed up the training convergence, which also has good robustness and generalization performance.

2. Principle Knowledge

2.1 Application Analysis of Neural Networks in Teaching Quality Evaluation

It is of great significance to improve the teaching quality in an all-round way in order to complete the fundamental task of establishing morality and cultivating people in higher vocational education with high quality, cultivate high-quality skilled talents for the Party and the country. The use of information technology in today's classroom teaching is a very important step through educational reform, and is also the core requirement for teachers to improve their working methods. Using scientific methods to comprehensively and reasonably evaluate the quality of classroom teaching is of great significance for evaluating the teaching level and quality of schools. However, it is difficult to form a systematic evaluation system simply to evaluate the teaching level and quality because of the heavy workload and complex statistics. In recent years, some scholars have considered using neural networks to improve the accuracy of relevant evaluation standards [1]. Since the neural network algorithm has strong nonlinear function approximation ability, it has good analysis ability for relevant fuzzy indexes or inaccurate parameters. However, due to the complexity of the neural network training process, it requires more prior knowledge and requires higher requirements for operators. Therefore, when neural network is introduced into the evaluation of teaching quality, the result is inaccurate PSO has a strong global search ability and is very suitable for parameter optimization of neural networks. Therefore, according to the above characteristics, the RBF neural network trained by particle swarm optimization (PSO) algorithm can be considered for the comprehensive evaluation of teachers' teaching quality to truly and effectively reflect teachers' teaching effect [2].

Considering the progress and limitation of neural network in teaching quality evaluation, this paper introduces PSO algorithm to optimize the original neural network model Firstly, according to the demand analysis, the existing evaluation factors of teaching quality are summarized, and the uncertain weight index system that affects teaching quality is sorted out. Then aiming at some defects of the traditional neural network, the PSO algorithm is used to improve it, and the specific operation steps are provided. Finally, the improved algorithm is applied to the specific teaching quality evaluation through case analysis to test the feasibility of the scheme. The results show that it can improve the error accuracy and speed up the training convergence, and has good robustness and generalization performance.

2.2 PSO Algorithm

Particle swarm optimization is an evolutionary computing technology based on swarm intelligence. Inspired by the modeling and simulation results of bird group behavior, it tries to make particles fly to the solution space and fall at the optimal solution. PSO is simple in principle and easy to implement. It has good global search ability and fast calculation speed for many optimization problems. Therefore, PSO has attracted the attention of scholars in the field of evolutionary computing since it was proposed, and has gradually become a research hotspot. The basic idea of PSO algorithm is as follows: firstly, PSO is initialized as a group of random particles. The position of particles represents the potential solution of the optimization problem in the search space. The speed of particles determines their flight direction and distance. All particles have fitness values determined by a fitness function; Then, the particles follow the current particles to search in the solution space and find the optimal solution through iteration [3]. Assume that the current position and velocity of each particle are and respectively, the optimal solution pi generated by searching from the initial iteration found by the particle so far to the current iteration number, and the current optimal solution g of the whole population. The particle updates its velocity and position according to the following equations.

$$v_{i+1} = wv_i + c_1 r_1 (p_i - x_i) + c_2 r_2 (g - x_i) \tag{1}$$

$$x_{i+1} = x_i + v_{i+1} \tag{2}$$

The procedures of PSO neural network algorithm flow is depicted as follows:

Step 1: Initialize the speed and position of all particles;

Step 2: use fitness function to evaluate all particles;

Step 3: Use fitness function to update individual extreme value and global extreme value;

Step 4: iterate the speed and position according to Formula (1) and Formula (2); Step 5: Repeat the above equations (2) to (4) until the iteration stop conditions are met.

2.3 BP Neural Network

BP network is a feedforward network with one or more hidden layers, including input layer, multiple hidden layers and output layer. All layers are fully connected. The activation function of each hidden node is sigmoid function. The activation function of the output node is different according to different applications. If it is used for classification, sigmoid function or hard limit function is used; If it is used for function approximation, linear transformation function is used. Figure l shows the topology of a three-layer BP network. The learning algorithm of BP network generally adopts the error back propagation algorithm, which includes forward propagation and back propagation. That is, when the output layer cannot get the expected output, the error signal propagates from the output layer to the input layer and adjusts the connection weights between layers and the bias values of neurons along the way, to continuously reduce the error signal [4]. However, BP algorithm generally has the following problems: long training time, low learning efficiency, local minima, lack of theoretical guidance in selecting the number of hidden nodes in the network, etc.

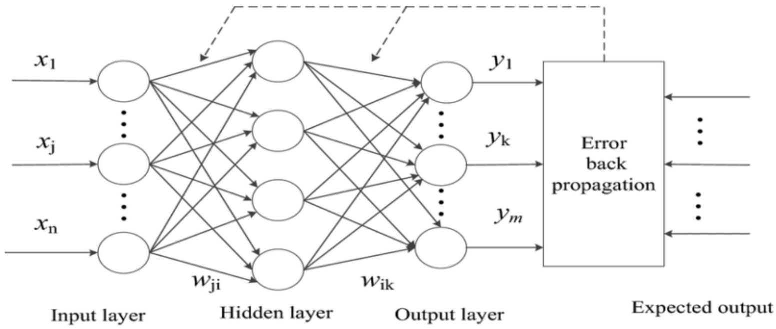

Figure 1. Topological structure of three-layer BP network

3. Evaluation Method of Teaching Quality Based on PSO-BP

3.1 Teaching Quality Evaluation Index System

At present, multiple interactive classroom teaching evaluation platforms are widely used in colleges and universities, which can accurately display the indicators of various observation scales and overcome the shortcomings of different traditional evaluation standards [5]. Based on the theory of management by objectives and by means of mathematical statistics, this paper establishes an evaluation system of teaching quality. According to the specific situation of the school, it is divided into 3 first level indicators and 13 second level indicators, as shown in table 1.

Table 1. Teaching quality evaluation index system of ideological and political courses

1st class index	2nd class index	Person number	Bad	Qualified	Good	Excellent
Teaching method	Appropriate learning guidance X1	50	12	6	15	17
	Mobilize students' interest and initiative X2	50	2	18	25	5
	Adopt various teaching aids X3	50	8	3	20	18
	Strong language expression ability X4	50	0	6	19	15
	The thinking is active X5	50	1	18	12	19
Teaching content	Rich content and appropriate details X6	50	0	10	15	25
	Focus on quality education and practical ability X7	50	3	7	8	32
	Clear organization X8	50	10	26	4	10
	The auxiliary content is properly arranged X9	50	3	29	8	10
Teaching	Caring for students X10	50	1	14	16	19

attitude	Outstanding teaching style and characteristics X11	50	7	25	8	10
	Focus on interaction and communication X12	50	11	11	13	15
	High information literacy X13	50	0	28	4	8

3.2 PSO Optimization of BP Neural Network

Because signal-to-noise ratio (SNR) is a common standard to evaluate the effect of noise reduction, SNR is chosen as one of the evaluation criteria. In this study, the effective signal refers to the music data signal, and the noise signal refers to the mixed noise data. When the SNR is low, the noise is serious, which will seriously affect the sound quality of the music signal. On the contrary, the higher the SNR, the lower the noise signal intensity, the better the audio quality. However, the pursuit of high signal-to-noise ratio will affect the auditory effect of electronic music signal, so the objective evaluation criterion of audio perception is introduced. The objective evaluation standard of audio perception is recommended by ITU-R BS.1387. This evaluation parameter is generally negative, and the larger the value, the smaller the difference, namely, the better the music signal effect. In order to comprehensively evaluate the noise reduction effect of the proposed method on electronic music, two evaluation indexes, signal-to-noise ratio (SNR) and objective evaluation standard of audio perception, are finally adopted in this experiment.

BP algorithm itself is an excellent local search algorithm. In addition, BPNN is very sensitive to the initial network weight, so it is easy to fall into the defect of local optimum PSO can roughly search in the global scope to obtain an initial solution, so that the BP relay neural network can complete the gradient search, strengthen the thinning ability, and conduct more careful search. In this way, the optimal initial weights and thresholds can be acquired, and the output error of the neural network can be further reduced.

The specific process of PSO-BP optimization algorithm is described as follows:

(1) PSO optimizes the initial weight value w and offset b This process is a bit like data migration, which is equal to using particles to try as parameters of the network, then training the threshold of the network, and randomly initializing the position and speed of each particle in the population;

(2) The particle is taken as the initial weight value and threshold value to be brought into the BP neural network and the prediction error of the training set after training is taken as the fitness value; Load network input (arbitrary point in space) and output (corresponding joint angle value); Limit the initial particles and filter them to a custom range;

(3) Get the position vector of a single particle by splicing

$$pos_n = (w_{11}, w_{11}, a_{11}, b_{11}, ..., w_{ij}, w_{jk}, a_{ij}, b_{ij}) \tag{3}$$

Initial the rate vector of each particle as:

$$v_n = (v_{n1}, v_{n2}, ..., v_{nd}) \tag{4}$$

The optimal location record of the newly obtained individual particles during the iteration search process is

$$Pbest_n = (P_{n1}, ...P_{nd}) \tag{5}$$

The optimal value of current population is:

$$gbest_n = (P_{g1}, \ldots P_{gd}) \tag{6}$$

(4) After each update of particle position, determine whether the limited position component exceeds the predetermined range. If it does, manually set the position as the boundary value; For each particle, its fitness value is compared with the best position $pbest_n$ it passes through, and if it is better, it will be taken as the current best position; Iterate the proess until the requirements are met.

$$v_{id}^{(t+1)} = wv_{id}^{(t)} + c_1 r_1 (P_{id} - x_{id}^t) + c_2 r_2 (P_{gd} - x_{id}^t) \tag{7}$$

$$p_{id}^{(t+1)} = p_{id}^{(t)} + v_{id}^{(t+1)} \tag{8}$$

where w is the inertia weight value, PSO can adjust the global and local optimization ability by introducing the inertia weight value. The appropriate inertia weight can avoid falling into the local optimum and leaving the global optimum. Part of the key codes for such process is described as follows:

```
    for Teaching=1:particlesize
    trans_x=x(Teaching,:);
    W1=zeros(InDim,HiddenNum);
    B1=zeros(HiddenNum,1);
    W2=zeros(HiddenNum,OutDim);
    B2=zeros(OutDim,1);
    W1=trans_x(1,1:HiddenNum);
    B1=trans_x(1,HiddenNum+1:2*HiddenNum)';
    W2=trans_x(1,2*HiddenNum+1:3*HiddenNum)';
    B2=trans_x(1,3*HiddenNum+1);
    Hiddenout=logsig(SamIn*W1+repmat(B1',SamNum,1));
Networkout=Hiddenout*W2+repmat(B2',SamNum,1);
    Error=Networkout-SamOut;
    SSE=sumsqr(Error)
f(Teaching)=SSE;
 end
```

4. Algorithm Implementation and Tests

The simulation data is established based on the main indicators given by a teacher's usual performance, and the main parameter indicators are consistent with the given options in Table 1. The Ideological and Political Theory Course teachers are encouraged to collect daily accumulated question types and topics to form their own school-based resource library. In order to meet the challenges of education big data application in management norms, security, privacy protection and other aspects, it is the application scope of data governance in the field of education, which helps to make education decisions more scientific and promote more accurate education services. Convert and standardize the collected data for subsequent analysis and application, such as formatting data, unifying units, converting data types, etc. Once data is processed and analyzed, it must be stored and managed in a secure and easily accessible manner. This may involve storing data in databases, cloud storage, or other systems, and implementing backup and recovery strategies to prevent data loss. Finally, the results of data analysis are presented to stakeholders in an easily understandable and actionable format. This may involve creating visualizations, reports, or dashboards to highlight key findings and trends in the data. Finally, the data of 10 students is used as training samples, and the rest 40 is used as test samples. The evaluation target value involved in the experiment can be obtained by some standard estimation method or average value calculation method, and the collected information can be filtered and cleaned to obtain a standardized data set.

The relevant initialization parameters of the prediction model are set as follows: acceleration factor c1=1, c2=1.5, the initial weight value adopts the linear weight decreasing strategy, and the maximum number of iterations is 100. After the network training, the trained simulation function is used to obtain the network output to check the ratio between the output and the actual result value to obtain the network test error, as shown in tables 2 and 3. Once the structure and algorithm of the neural network are determined, the accuracy of the mathematical model is closely related to the number of input training samples. The more training samples, the more accurately the mathematical model can describe the quality of educational information resource management based on various evaluation indicators. It can be seen that the test results are very close to the original data, that is, the model can accurately determine the teaching effect according to various evaluation indicators.

Table 2. The output result of neural network.

NO.	1	2	3	4	5	6	7	8	9	10
Experts evaluation	0.415	0.420	0.263	0.935	0.441	0.352	0.000	0.824	0.026	1.000
Network output	0.426	0.413	0.264	0.938	0.441	0.358	-0.0009	0.825	0.028	0.999

Table 3. Test value after normalization.

NO.	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13
1	0.921	0.725	1.000	0.917	0.648	0.800	0.999	0.812	0.775	0.750	0.800	0.989	0.900
2	0.718	0.546	0.799	0.916	0.759	0.701	0.889	0.237	0.364	0.645	0.900	1.000	0.802
3	0.354	0.183	0.415	0.583	0.465	0.500	0.794	0.810	0.715	0.333	0.000	0.345	0.200
4	0.500	0.335	0.802	0.659	0.689	0.500	0.636	0.634	0.183	0.500	0.200	0.564	0.300

Before the prediction of PSO-BP neural network, it is necessary to train the network to have associative memory and prediction ability. A new neural network is established in MATLAB neural network toolbox to test samples. The training function of P neural network is Trainlm function by default BLF: weight learning function. The default value is Learngdm. The training process for the selected samples is shown in figure 2. It can be seen that there is still some optimization space between the network error and the target output error, which can verify that the output value after network learning can reduce the error. The optimized value is closer to the expected value, and the error will be smaller than the training of the BP neural network before PSO optimization. The PSO optimized model will not have the problem of local optimization, and the PSO-BP network model has faster convergence speed and smaller error.

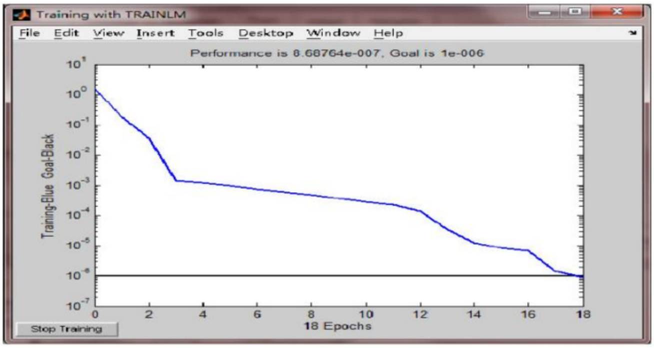

Figure 2. Training process graph.

After the model training is completed, 40 test datasets are imported to test the model. Sort the teacher data by grade. If the grades are the same, the teacher data will be sorted by the alphabetical order of the name characters. If the alphabetical order of the names is the same, the teacher data will be sorted by age. The sorted information of N teachers will be output. The comparison results are shown in figure 3. It can be seen intuitively that BP algorithm and PSO-BP algorithm can better approximate the nonlinear actual course scores. The approximation effect of PSO optimized BP neural network is obviously better than that of BP algorithm, and the convergence speed is also much higher than that of traditional algorithm; In terms of prediction accuracy, PSO-BP also shows good performance, as shown in figure 4.

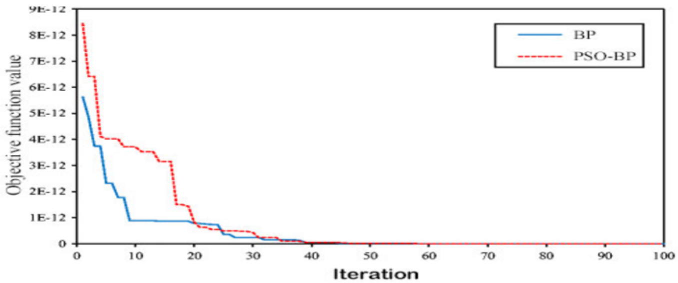

Figure 3. Prediction convergence comparison by two models

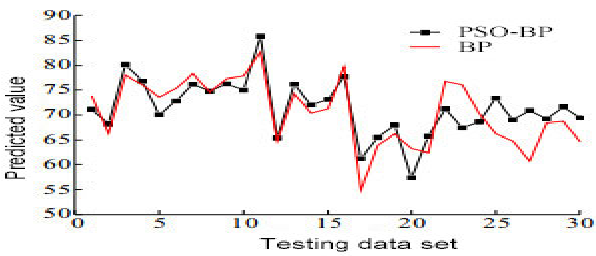

Figure 4. Prediction error comparison by two models

To sum up, PSO-BP algorithm and BP algorithm can obtain better prediction results. The former has better global optimization ability than the latter, effectively improving the prediction accuracy, and achieving higher prediction accuracy for teaching quality at all levels.

5. Conclusion

This paper presents a PSO optimized neural network prediction model for teaching evaluation. Our model can use the teacher's teaching manual or the teacher's usual performance recorded in the smart classroom to combine with the student's evaluation to conduct education data mining. Then, in the quantization process, PSO algorithm is applied to optimize the connection weights and thresholds of the neural network, to find the globally optimal network parameters. The data of simulation analysis comes from the real sampling in the ideological and political teaching process of a university, and the feasibility of the scheme is proved by establishing the model simulation under MATLAB. In addition, the experiment proves that this method overcomes the defects of traditional BP neural network, adds new content to computer teaching management, and has certain application value in college teaching quality evaluation.

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