Construction of comprehensive evaluation model for university students based on BP neural network

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Abstract: Improving students' comprehensive quality and cultivating students' innovative and entrepreneurial abilities have become the purpose of formulating training programs for all majors in Colleges and universities, and comprehensive evaluation is one of the important methods to examine students' comprehensive quality. Taking Tianjin University Renai College as an example, this paper proposes students' comprehensive evaluation model based on BP neural network, and uses MATLAB tools to simulate the data and verify it. The results show that the BP neural network can effectively reduce the degree of human disturbance and get a real and objective result, which has a wide range of applicability.

1. Introduction

"Developing the country through science and education" is an important development strategy implemented by the State Council and the Party Central Committee in accordance with China's national conditions. It is true that the continuous improvement of people's living standards can't be separated from the cultivation of high-tech talents throughout the development of the world economy. As an important part of College Students' education and management work, comprehensive evaluation of students is helpful for them to have a comprehensive and objective understanding of themselves, and is also an important basis for quality education reform in Colleges and universities.

At present, some scholars have been exploring how to evaluate students' comprehensive quality scientifically and reasonably. For example, a set of scientific evaluation index system from five aspects has been set up, such as how to improve students' comprehensive quality, ideology and politics, and has optimized it(Yang Zhang, 2014); Wei Jing, Lu Ting and so on have evaluated the comprehensive quality of students in 30 domestic colleges and universities. Based on the analysis of the scheme, a new evaluation method of developmental and advisory evaluation is proposed (Jing Wei, 2018). Some scholars have used the method of quantitative analysis to establish a mathematical model for evaluation, but mainly concentrated on AHP or fuzzy analysis. Fuzzy mathematics theory can be to make a comprehensive evaluation of College Students' performance (Fengjiao Pang, 2018). And AHP also can be used to establish a model to examine students' comprehensive quality (Junxian Yang, 2015). The rationality of weights is directly related to the effectiveness of these methods. Therefore, this paper introduces the BP neural network model, through the BP neural network adaptive and self-learning principle, to analyze this more complex, multi-factor, multi-variable nonlinear process, so as to make the evaluation results more objective and fair.

2. The construction and algorithm of BP neural network

2.1Basic Principle

Neural network is a new information processing system which simulates human brain based on the preliminary understanding of human brain structure and activity mechanism. It imitates

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biological neural network from the structure to simulate the fault tolerance and learning ability of biological neural network system (Junhui Yang, 2011). The main principle of BP neural network is to make the evaluation result closest to the expected value through self-training, learning rules and calculating. It is an intelligent information system, which can be used to evaluate the uncertain functional relationship among various factors (Ka Hu, 2017). Therefore, it is widely used in classification, identification, prediction, regression and other fields.

2.2 Algorithm Steps

A typical BP neural network can be divided into three layers: input layer, hidden layer and output layer. It is mainly composed of the connection weights between neurons and neurons. It is assumed that the number of input neurons is M, the number of hidden layer neurons is I, and the number of output layer neurons is J. The weights from the input layer to the hidden layer are W_{mi}, from the hidden layer to the output layer are W_{ij}, the hidden layer transfer function is Sigmoid, and the output layer transfer function is linear (Ming Chen, 2013).

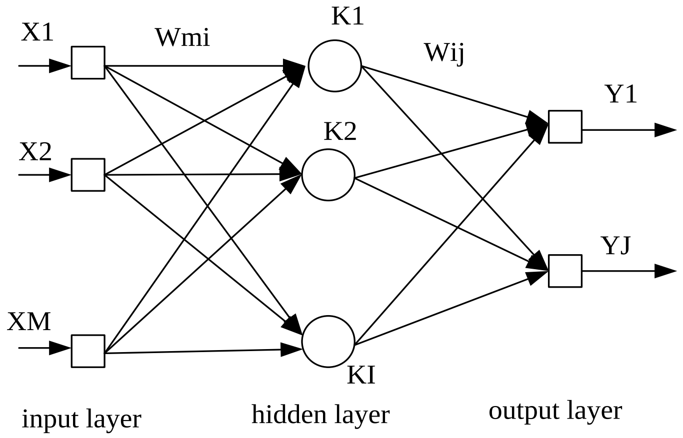

Figure 1: Three tier of BP network.

The learning process of BP algorithm is composed of forward and backward propagation. The information propagates forward from the input layer at first. If the result can't meet the expectation after the output layer, the error signal will be propagated back and the original path will be returned. By feeding back the errors of the nodes in the output layer by layer to the input layer, the reference errors of each connection point are calculated, and the weights of each connection are adjusted accordingly, so that the network can finally get satisfactory results.

3. Comprehensive evaluation model and implementation of students based on BP neural network

3.1 Data collection

This stage will be divided into two steps.

3.1.1 Determining the grading of graduates' career development

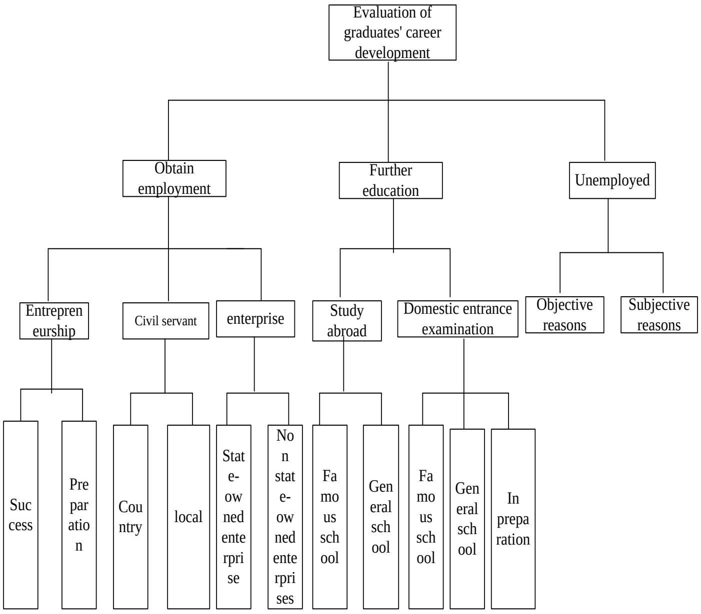

Figure 2: Graduate career development system.

In recent years, the quality of graduates' employment has attracted wide attention from students themselves and all walks of life in society. It is an important index to test the quality of higher education (Linxin Xiong, 2017). Through e-mail, Weixin, QQ and other tools, this paper contacts some of the graduates of Engineering Management Majors of Class 2013. A total of 80 pieces of data are collected. After statistical analysis of their current career development, the evaluation grade of graduates' career development is established by referring to the training requirements of students in our college (see Figure 2). The final evaluation criteria are: excellent: [7,10]; good: [6,7]; medium: [4,6]; poor: [0,4]:

3.1.2 Establishing a comprehensive evaluation index system for students

The comprehensive evaluation system of college students should include moral education quality, professional quality and ability quality. This system should reflect the overall quality of college students (Bin Lin, 2017). Only in this way can we accurately grasp the law of students' growth through comprehensive evaluation, guide students to grow into talents, and improve the professional training program. On the basis of in-depth interviews with department leaders, professional teachers and counselors, combined with the Ministry of Education documents and relevant literature, this paper constructs an index system and specific scoring rules for school students, as shown in Table 1 and Table 2.

Table 1: Comprehensive evaluation index system.

Comprehensive evaluation of students	Ideological and moral	Advanced thinking (Party members)
		Observe school rules and regulations
	Curriculum achievement	Professional course results
		Elective course results
		Practice
	Innovation ability	competition
		Research
		Paper publication
		Serial number

According to the above principles, the above 80 graduates were evaluated and scored, and the original test data (part) were collected as shown in Table 3.

3.2 Network training process

Table 2: Grading rules.

Scoring index	scoring rubric
Advanced Thinking(a_1)	The formal party members get 10 points, the probationary party members get 8 points, and the applications have 6 points, and the other 5 points.
Observe school rules and regulations(a_2)	10 points without penalty, 5 points for warning, 0 points for punishment.
Professional course results (a_3)	Professional courses averaged 10 out of 90, 8 out of 80 to 89, 6 out of 70 to 79, 4 out of 60 to 69, and 2 out of 60 and below.
Elective course results (a_4)	The average score for elective courses was 10 for 90 points and above, 8 for 80-89, 6 for 70-79, 4 for 60-69, and 2 for 60 and below.
Practice (a_5)	10 points for two or more practice experiences, 6 points for one practice experience and 2 points for non-practice experience
Competition (a_6)	Foreign or national competitions won 10 points, municipal competitions won 8 points, school competitions won 6 points, participated in 4 points, not participated in 2 points
Research (a_7)	State-level projects get 10 points, municipal projects get 8 points, school-level projects get 6 points, horizontal projects get 2 points, and non-participated projects get 1 point.
Paper publication(a_8)	EI, SCI or SSCI scored 10, core journals scored 8, general journals scored 6, and unpublished journals scored 2.
Serial number(a_9)	More than 2, 10 points, 1-2 points 6 points, 4 points did not get.

Taking the comprehensive evaluation process of students as a BP neural network system, we can set up a "three-layer" BP neural network by taking the comprehensive evaluation results of students as outputs and various factors affecting students' comprehensive evaluation scores as inputs.

Suppose the above are a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8, a_9.

Table 3: Raw data of students' comprehensive evaluation results (part).

Serial number	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	Serial number
1	8	10	10	10	6	10	8	8	10	excellent
2	6	10	6	8	6	6	2	2	6	middle
3	10	10	8	8	6	8	8	6	6	excellent
4	6	10	10	4	10	4	6	6	6	good
5	10	10	8	8	10	8	6	2	10	excellent
6	5	10	4	6	2	2	1	2	6	poor

3.2.1 Data initialization

BP neural network deals with the data between [0,1], but from table 3 it can be seen that the scores of different students are quite different, and the values are greater than 1. In order to make the data comparable, this paper will standardize the data obtained, that is, using the maximum and minimum method to standardize the processing, the input and output will be converted to [0,1] The value of an interval. The formula is as follows:

$$x = \frac{x_i - \min x_i}{\max x_i - \min x_i} \tag{1}$$

Among them, Xi represents the score of the first student, min Xi represents the minimum score of the group collected, and Max Xi represents the maximum of all scores. The processed data are shown in Table 4.

The data of 50 students were used as training network, and the rest data were used as test data.

3.2.2 The number of neurons in each layer

The number of neurons in the first input layer is 9. The number of neurons in the second hidden layer is difficult to determine. If the number of neurons in the first input layer is too small to train the network or to identify different samples, the fault tolerance rate is poor, but if the number of hidden layer units exceeds a certain limit, the learning time will be prolonged. There is no way to minimize the error. So far, there are no authoritative rules to determine the number of neurons in the hidden layer. At present, the more commonly used formulas are:

$$q = \sqrt{n + m} + \frac{a}{2} \tag{2}$$

Among them, n is the number of nodes in the input layer, M is the number of nodes in the output layer, and a is the number of training samples.

According to this formula, the number of hidden layer nodes is 18, and the number of neurons in the third output layer is 1, that is, the students' comprehensive score.

Although this paper intends to determine the number of hidden layer neurons as the above formula, but in fact the number is not fixed, according to the principle of BP neural network, the same sample set with different number of hidden layer nodes will be trained until the output is stable. Finally, according to the test results, the number of hidden layer nodes with minimum output error is determined as the optimal number of nodes.

3.2.3 Simulation process

In this experiment, 50 students' data were selected as training network, the remaining data as test data, see (Table 5). The software environment was MATLAB7, logsig was used as transfer (activation) function, L-M optimization algorithm (trainlm) was selected as training function, and the training parameters were: neural network. The target error is 0.001, and the maximum iteration number is 1000. The simulation process and results are shown below (Figure 3), (Figure 4).

Table 4: Standard data sheet (part).

Serial number	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9
1	0.60	1.00	1.00	1.00	0.50	1.00	1.00	1.00	1.00
2	0.20	1.00	0.33	0.67	0.50	0.50	0.14	0.00	0.00
3	1.00	1.00	0.67	0.67	0.50	0.75	1.00	0.67	0.00
4	0.20	1.00	1.00	0.13	1.00	0.25	0.71	0.67	0.00
5	1.00	1.00	0.67	0.75	1.00	0.75	0.71	0.00	1.00
6	0.00	1.00	0.00	0.50	0.00	0.00	1.00	0.00	0.00

Table 5: Test data (part).

Serial number	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9
1	0.60	1.00	0.667	0.67	0.00	1.00	0.71	0.00	1.00
2	0.60	1.00	1.00	1.00	0.00	0.75	0.71	0.67	1.00
3	1.00	1.00	0.67	1.00	0.00	0.25	0.00	0.00	0.00
4	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	1.00
5	0.20	1.00	0. 67	1.00	0.00	0.25	0.00	0.00	1.00
6	0.00	1.00	0.33	0.33	1.00	0.00	0.00	0.00	0.00
7	0.20	1.00	0. 67	0.67	0.00	1.00	0.71	0.00	1.00
8	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	1.00	1.00	1.00	0.00	1.00	0.71	0.67	1.00
10	0.20	1.00	0. 67	0.67	1.00	1.00	0.14	0.00	1.00

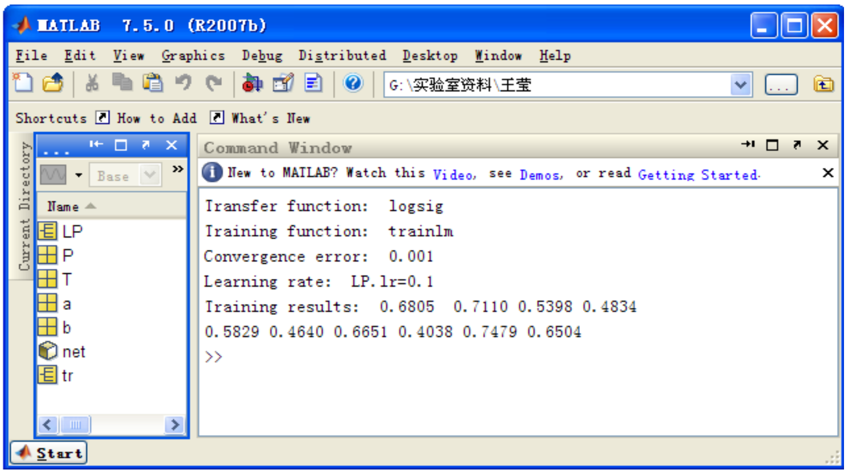

Figure 3: Data test results.

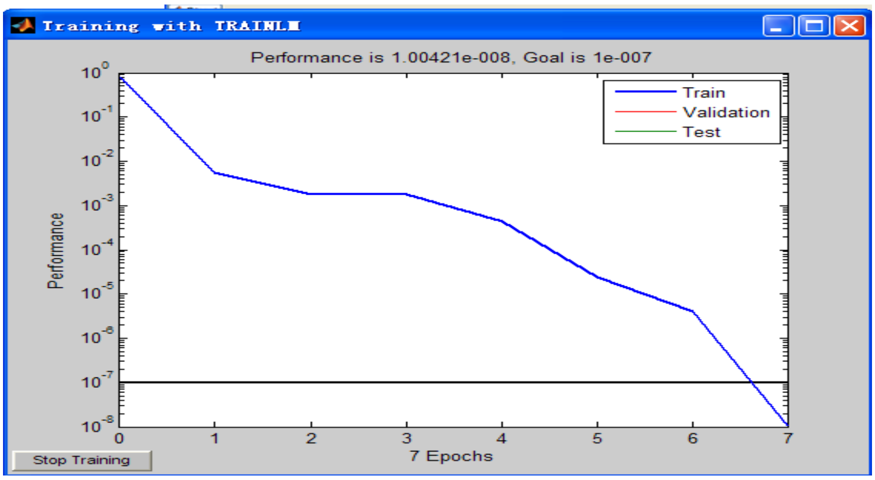

Figure 4: Training error and steps.

Table 6: Comparison table of students' comprehensive evaluation training results (part).

Expected output	6.80	7.40	5.70	5.20	5.70	4.80	6.60	4.00	7.30	6.60
Training results	6.80	7.10	5.40	4.80	5.80	4.60	6.60	4.00	7.50	6.50

As can be seen from the above table, the fitting degree between the test results and the actual values of the sampled data is very high, and the error is very small, indicating that the network training results are more accurate (see Table 6). The results of BP neural network evaluation are basically consistent with the actual situation of students after graduation, which shows the effectiveness of the model for comprehensive evaluation of students.

4. Conclusions

The comprehensive evaluation of students is a key link in the process of higher education, and also an important basis for the inspection, adjustment and control of the educational system itself. In this paper, according to the professional training objectives to select the appropriate index system, using MATLAB tools, the establishment of BP neural network for comprehensive evaluation of College students. The model has a strong generalization ability. Through independent learning and constant training and correction, the results can meet the requirements of scientific, objective and applicable comprehensive evaluation for students in Colleges and universities. It is easy to operate quickly and has high accuracy. It is helpful for students to fully understand their advantages and disadvantages and to plan the future rationally. The direction of career development is also a kind of feedback to the quality of higher education, which promotes the continuous improvement and improvement of higher education management.

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