Research on higher Education Index Evaluation system based on optimized BP Neural Network

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Abstract: In 1998, UNESCO pointed out in the Declaration of the World Conference on higher Education that the 21st century will be an era of more emphasis on quality, higher education has entered a new era from quantity expansion to quality development, and the expansion of higher education has become a hot spot in the development of higher education all over the world, which has a profound impact on all dimensions of society and higher education system. In this paper, the higher education health evaluation model and the higher education continuity model are established. The health grade is divided into 4 grades and the sustainability grade is divided into 4 grades. In this paper, the primary and secondary index system is established respectively, and the principal component analysis method is used to extract 12 indexes into 3 first-level indexes. Then, take the three indicators as the input and the higher education health assessment as the output. Then the health evaluation model of higher education is constructed by using BP neural network evaluation model. In order to solve the problem that the convergence speed of BP neural network is dependent on samples, genetic algorithm is used to improve the convergence of the network. Finally, the health level of higher education in five countries is obtained.

1. Introduction

A hundred years plan, education-based, social development can not be separated from education, but also from higher education. As a talent training center, scientific research center and cultural communication center, higher education has unique advantages in promoting social development [1]. Nowadays, higher education has entered the stage of rapid development of "great reform, great development and great improvement ". Therefore, it is of great significance to scientifically determine the evaluation index system of higher education development quality and evaluate the quality level and development level of higher education development [2]. Therefore, this question has important guiding significance and practical value for promoting the sustainable development of higher education.

Focusing on the sustainable development of higher education, this paper evaluates the education system by establishing a corresponding index system, and then studies the model by optimizing the back propagation process of neural network [3].

2. National Higher Education Development Level Index System

2.1 Index screening

The time factor needs to be considered when measuring the health and sustainability of national higher education, so this paper draws lessons from the results of international education evaluation and sets three first-level indicators of higher education investment and higher education performance [4][5].

(1) Higher education basis: The establishment of colleges and universities is not overnight, the education of the school in the past will be reflected in all aspects of today's school achievements [6].

Therefore, measure the educational foundation of national higher education by our existing achievements [7].

(2) Higher education inputs: Investment in higher education is closely related to the current data of students in higher education, the quality of higher education and the number of people receiving higher education. The expansion of the enrollment scale of higher education can stimulate the improvement of the quality of higher education. The improvement of the quality of higher education will further expand the enrollment scale. At the same time, based on the level of national economic development and the national level of higher education, economic development is the basis of the development of higher education, affecting the speed and speed of the development of higher education.

(3) Higher education performance: Higher education performance is often associated with current students' post-graduation prospects and students preparing to enter the college. The prospect of students, the opportunity and fairness of education will affect the evaluation of national higher education

2.2 Sample Selection

After the above discussion, we selected 3 primary indicators ,12 secondary indicators, and analyzed the data of single country and single year as a sample. In multivariate statistical analysis, there are orders of magnitude or units of measurement differences in the collected data, which will affect the results of data analysis.

Tab 1. Index System

Indicator classification	Indicator classification
Higher education basis	Number of papers
	Degree Value (QS Rankings)
	Number of cumulative Nobel laureates
	Cumulative Fields Award winners
	Education index
Higher education inputs	Number of students
	Proportion of national education input
	Number of school boards
	Average tuition fees for higher education
Higher Education Performance	Students' prospects (employment rate)
	Access to education (enrolment)
	Equity (gender ratio)

First of all, carry on the dimensionless processing to the original data, after the dimensionless processing, each index is in the same order of magnitude, which ensures the realizability of the neural network and is suitable for comprehensive comparison and evaluation.

After normalization, the linear function is used to linearize the original data to the range of[0,1], so as to eliminate the adverse effects caused by singular sample data. The normalized formula is as follows:

$$X_{norm} = \frac{X - X_{min}}{X_{\max} - X_{\min}} \tag{1}$$

X_{norm} Where, normalized data, raw data,

$X_{\max}, X_{\min}$ are the maximum and minimum values of the original data set, respectively.

This method can achieve equal scaling of raw data.

3. Principal component analysis for index dimension reduction

For the 12 indicators obtained from the above processing, in order to avoid the impact of noise and extreme data on the convergence speed and effect, it is necessary to use the idea of dimensionality reduction to transform multiple indicators into several comprehensive indicators. Because the index set is classified in this paper, the principal components of the indicators in each index class can be extracted. Since the extraction of each index set has nothing to do with the year, the data of the United States, Australia, Germany, Japan, India and South Africa from 2013 to 2017 are analyzed directly.

Test of applicability of principal component analysis:

Since the principal component analysis requires a strong correlation between variables, it is necessary to judge whether the principal component analysis method is feasible or not according to the correlation coefficient between the index variables. Generally speaking, if most of them are greater than or equal to 0.3, the principal component analysis method is feasible.

If the correlation coefficient $r\left(X_i, X_j\right)$ between indicators X_i and indicators X_j is set, then:

$$r\left(X_i, X_j\right)=\frac{\operatorname{cov}\left(X_i, X_j\right)}{\sqrt{Var\left(X_i\right) Var\left(X_j\right)}} \tag{2}$$

Where $\operatorname{cov}\left(X_i, X_j\right)$ is the covariance, the variance $Var\left(X_i\right)$, and the variance $Var\left(X_j\right)$.

KMO(Kaiser-Meyer-Olkin):

The KMO value is 0 − 1, the closer it is to 1, which indicates that the sum of square of simple correlation coefficient between all variables is much larger than the sum of square of partial correlation coefficient, and the more suitable for principal component analysis.

Among them, Kaiser give a test standard: $KMO > 0.9$, very suitable; $0.8 < KMO < 0.9$, suitable; $0.7 < KMO < 0.8$, general; $0.6 < KMO < 0.7$, not very suitable; $KMO < 0.6$, not suitable.

According to the problem environment, the calculated *KMO* value is 0.561. In summary, most of the coefficients of correlation coefficient test are greater than 0.3, and the *KMO* test value is 0.561, which is suitable for principal component analysis.

Principal component extraction process:

First, according to the size of the eigenvalue, if the eigenvalue is greater than 1, then it can be selected as the princess component.

Second, according to the cumulative contribution rate, the principal component should contain most of the data information. If the cumulative variance contribution rate of the principal component is greater than 80, these can be selected as the main component extraction results.

Third, according to the scattered distribution of the lithotripsy map, the eigenvalues of the principal components before the inflection point in the graph are very large, which can explain the original variables more completely. Therefore, several principal components before the inflection point appear are selected as the main component extraction results.

According to the total variance of principal component analysis, the first principal component is extracted according to the eigen value and the percent age of variance. The percentage of principal component variance is 87.764,72.625and 75.951 respectively. Therefore, the national higher education evaluation is divided into three principal components, namely, higher education foundation, higher education input and higher education performance.

The scoring process of principal component analysis:

Factor score coefficient and standardized raw variable data are the basis for obtaining the score of each component. The formula can be expressed as:

$$F_i=\beta_{i1} X_1+\beta_{i2} X_2+\cdots+\beta_{in} X_n \tag{3}$$

Fi is the score of the factor on the variable Xp.

The comprehensive score of principal component is obtained by multiplying the score of each component with the contribution rate of principal component after rotation. Specific expressions are:

$$High\ education\ basis=0.092 F_1+0.0438 F_2+0.37 F_3-0.065 F_4-0.187 F_5 \tag{4}$$

$$High\ education\ inputs = 0.469F_6 - 0.322F_7 + 0.434F_8 + 0.017F_9 \tag{5}$$

$$High\ education\ performance = 0.092F_{10} + 0.438F_{11} + 0.374F_{12} \tag{6}$$

From the above, through principal component analysis, each index of national higher education can be divided into three categories, and the weight of each index in each component is different. It is necessary to establish the expression of calculating each level index according to the above relationship.

4. National Health Assessment Model for Higher Education

4.1 Model construction and fitness of BP neural network

The input comes from three primary index data preprocessed through principal component analysis. The grade has 10 Levels ranging from 1 to 10. We grade the health status of higher education in the United States by 10 and that of South Africa by 1.tes is the 10 standard, and that of South Africa is the 1 standard.

Set $r(X_i, X_j)$ as the correlation coefficient between indicator X_i and indicator X_j then

$$r(X_i, X_j) = \frac{\mathrm{cov}(X_i, X_j)}{\sqrt{Var(X_i)Var(X_j)}} \tag{7}$$

Where $\mathrm{cov}(X_i, X_j)$ is the co-variance of X_i, X_j, $Var(X_i)$ is the variance of X_i and $Var(X_j)$ is the variance of X_j

In this paper, we need to judge whether the input is appropriate according to the correlation coefficient between all index variables, as long as they are not less than 0.3, they can be used as input to calculate the results.

Components	Higher Educatio n Basic	Higher Educatio n Basic	Higher Education Per formance
Higher Education Ba sic	1	0.35	0.45
Higher Education Ba sic	0.35	1	0.41
Higher Education Per formance	0.45	0.41	1

Fig 1. Level of correlation of inputs

4.2 Overview and Model Construction of BP Neural Network

Artificial neural network is a system composed of a large number of neurons, which simulates the way the brain nerve processes information and transforms information. The mechanism of the network is that the input signal propagates from the input layer to the output layer through the hidden layer, and the state of the neurons in each layer only affects the state of the neurons in the next layer. If the output layer does not get the desired output, it is converted to back propagation, that is, an error signal is returned along the original connection path and the connection weight of each layer is modified.

The modeling of speech feature signal classification algorithm based on BP neural network includes three steps: BP neural network construction, BP neural network training and BP neural network evaluation. The algorithm flow is shown in Figure 2.

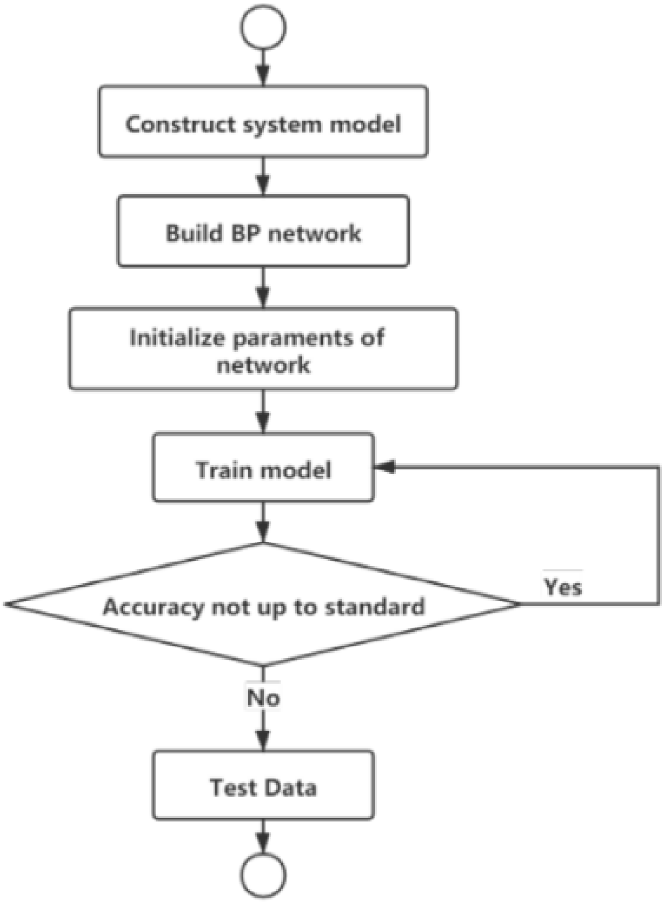

Fig 2. Algorithm flow (modification diagram)

After constructing the model, a large amount of data is needed to train the neural network. We consider using the behavior anchor quantification method to define 10 levels of horizontal scale and construct the standard data set to train the network.

Tab 2. Indicators for the comprehensive evaluation of health status in national higher education

Horizontal scale	Higher education Basis	Higher education inputs	Higher education performance
1	$-2 \leq x1 \leq -1.65$	$-2 \leq x1 \leq -1.65$	$-2 \leq x1 \leq -1.65$
2	$-1.65 \leq x1 \leq -1.3$	$-2.1 \leq x2 \leq -1.75$	$-2.1 \leq x2 \leq -1.75$
3	$-1.3 \leq x1 \leq -0.95$	$-1.75 \leq x2 \leq -1.4$	$0.7 \leq x3 \leq 0.35$
4	$-0.95 \leq x1 \leq -0.6$	$-1.4 \leq x2 \leq -1.05$	$0.35 \leq x3 \leq 0$
5	$-0.6 \leq x1 \leq -0.25$	$-1.05 \leq x2 \leq -0.7$	$0 \leq x3 \leq -0.35$
6	$-0.25 \leq x1 \leq 0.1$	$-0.7 \leq x2 \leq -0.35$	$-0.35 \leq x3 \leq -0.7$
7	$0.1 \leq x1 \leq 0.45$	$-0.35 \leq x2 \leq 0$	$-0.7 \leq x3 \leq -1.05$
8	$0.45 \leq x1 \leq 0.8$	$0 \leq x2 \leq 0.35$	$-1.05 \leq x3 \leq -1.4$
9	$0.8 \leq x1 \leq 1.15$	$0.35 \leq x2 \leq 0.7$	$1.4 \leq x3 \leq -1.75$
10	$1.15 \leq x1 \leq 1.5$	$0.7 \leq x2 \leq 1.05$	$-1.75 \leq x3 \leq -2.1$

The model transfer function is $f(x) = 1/(1+c^x)$. We set learning rate by 0.001 and accuracy by 10-5 .175 groups of experimental data were selected as training data for 10000 times training to meet the precision standard, and the remaining 175 groups of data were used as rediction data. Subsequently, the data from the United States and South Africa were substituted into the neural network to verify whether it was consistent with the preset classification.

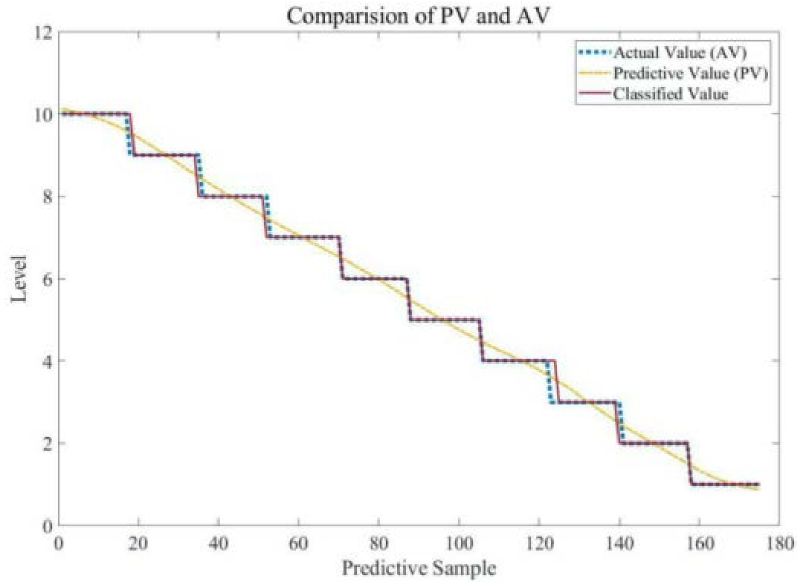

Fig 3. Comparision of PV and AV

5. Improvement of Neural Network Genetic Algorithm

5.1 Establishment of genetic algorithm

In many tests, we find that the trained neural network has a certain effect, but its convergence time is longer, and the deviation of the test results is larger with the difference of samples. Simple BP neural network is difficult to achieve good evaluation results, because the random selection of network weights and parameters will greatly affect the accuracy of the network. Therefore, this paper uses genetic algorithm for the back propagation process of neural network, and uses the optimal individual trained by this algorithm to optimize the weight and threshold of the network. It has six steps:

1. Code individual and initialize population. The initial population size of this experiment is 20.
2. Calculate the fitness function in this case as the reciprocal of the sum of the squared errors of the neural network:

$$f = \frac{1}{SE} \tag{8}$$

SE is the sum of square errors between the predicted output and the expected output of the neural network.

3. Select individuals. The selection of individuals can be carried out according to the probability value.
4. Cross gen. The optimal individual does not cross operations, but directly replicates into the next generation. Our cross probability is 0.2.
5. Gen Mutate. The mutation operation of the non-optimal individual produces another new individual. In this experiment, the probability of variation is 0.1.
6. Cycle. The evolutionary algebra is set to output the optimal results over 100 generations

5.2 Outcome of issues

Based on our national model of health assessment in higher education, we can obtain specific ratings of five countries, see Table 3.

Tab 3. Specific Ratings of Five Countries

Country	United States	German	Japan	Australia	South Africa
Ratings	10	6	5	6	1

6. Conclusion

The expansion and popularization of higher education has become a hot spot in the development of higher education all over the world. around the health evaluation model of higher education system, this paper mainly selects 12 indicators to measure the health status of higher education in our country. After standardized treatment, the first principal component was extracted as the first-level index by principal component analysis. The evaluation models of higher education foundation, higher education investment and higher education performance are established. Then the BP neural network and the improved neural network are used to construct the higher education health evaluation model to adjust the number of nodes in the hidden layer, and finally get the health level of higher education in five countries.

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