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Performance Prediction Model of University Students Based on the Grey BP Neural Network

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Abstract

This article counted the best performance of students entrepreneurship courses from 2005 to 2014, and took the best performance prediction of 2014 entrepreneurship course as the research object. According to the best annual performance of entrepreneurship courses from 2005 to 2014, this article established the grade prediction model of series combination of GM (1, 1) grey prediction model and BP neural network prediction model, and the established model was used to predict the best annual performance of students entrepreneurship course. Through comparing the actual value of the best annual performance of 2014 entrepreneurship course and the predicted value c by the model, this article analyzed the application of grey BP neural network prediction model in the students entrepreneurship performance prediction. The research results showed that for entrepreneurship performance prediction problem, the grey BP neural network prediction model had high prediction precision , simple application, and it can be widely used, and had more advantages than single GM (1, 1) grey prediction model and BP neural network model.

Keywords*: Course performance; Entrepreneurial skill; Grey model; BP neural network; Prediction model*

1. Introduction

The prediction of competition entrepreneurship course performance has great practical value, and this prediction can provide training target for the competitors, and also can provide reference for the research of the development of entrepreneurship activities. The traditional prediction methods mainly include time series method, analogy method, regression analysis method, etc. These aspects take a large amount of data available for analysis as the basis, its research scope is often limited to the static problem. The entrepreneurship course performance prediction problem has the characteristics of less data available for analysis, larger data randomness, more influence factors and complex interaction and the relationship between various factors, which makes the prediction result of entrepreneurship course performance by the traditional prediction method not ideal. This article counted the best annual performance of curriculum activities from 2005 to 2013, and established grey BP neural network prediction model based on this data. This article studied its application in the entrepreneurship course performance prediction through the analysis of the established grey BP neural network prediction model.

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2. Grey BP Neural Network Model Introduction

2.1. Establishment Steps of BP Neural Network Prediction Model

BP neural network model is the most intensively studied neural network model by people in artificial neural network model. According to statistics, the application of BP neural network model accounts for 80% ~ 90% of artificial neural network model. BP neural network model has a three-layer neural network structure, including the input layer, hidden layer and output layer. Full connection is adopted between layers, repeated training and learning is carried out on the connection weight according to the error back propagation approach conducted by the training models, until its weight meets the requirements of each training mode. BP neural network model can approximate the arbitrary nonlinear function through the training of the existing training mode, can solve the problem of the nonlinear system quickly and accurately , so it is widely used in the function approximation, prediction, system identification, classification, and data compression, *etc.*

The establishment BP neural network model is completed through the following four steps:

(1) Research questions, extraction of elements and the collection of training mode; (2) Set the parameters of BP neural network according to the questions; (3) Establish the training sample, and enter the input quantity into the established BP neural network system, and compare the output quantity of the system and the expected mode, if there is error, perform (4), otherwise, return to (3); (4) Through back propagation, the connection weights between layers are corrected.

2.2. Establishment Steps of GM (1, 1) Grey Prediction Model

The grey system theory is based on the relational space, smooth discrete function, *etc.*, And defines the grey derivative and grey differential equation, and then the discrete data column is used to establish the dynamic model of the differential equation [6]. Grey prediction model uses the corresponding grey system theory to fully mine the explicit information and implicit information in the small sample data, and to find the relationship between various factors. Compared with the traditional probability statistics method, grey prediction model shows some superiority in dealing with small sample, poor information data. GM (1, 1) grey prediction model is easy to understand, with wide application range, high precision, and it is one of the most widely used models in the grey model.

The prediction problem of small sample data is solved by applying GM (1, 1) grey prediction model, first the data needs to be extracted from problems, to establish the original sequence, then smoothness inspection and processing are conducted on the established original sequence, the establishment of grey model is carried out on the original sequence meeting the requirements or the sequence after processing, and finally the model prediction value is tested. The specific steps are as follows:

(1) The corresponding original sequence is established according to the processed problems

$$x^{(0)} = (x^{(0)}(1), x^{(0)}(2), \cdots, x^{(0)}(n))$$

(2) The original sequence is tested, and the level ratio of the original sequence is

$$\lambda(k) = \frac{x^{(0)}(k-1)}{x^{(0)}(k)}, k = 2,3,\cdots,n$$

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If the level ratio values of the original sequence lie in the range $(e^{-\frac{2}{n+1}}, e^{\frac{2}{n+2}})$, the original sequence satisfies the smoothness requirement, and the establishment of prediction model can be carried out directly, otherwise, translation transformation processing can be conducted.

(3) AGO accumulation generation processing and mean generation processing are conducted on the original sequence, generating sequence $x^{(1)}$ and sequence $z^{(1)}$ respectively, and the corresponding grey differential equation is established

$$x^{(0)}(k) + az^{(1)}(k) = b, k = 2,3,\cdots,n$$

Thereinto, a is the development coefficient of the model, and b is the coordination coefficient of the model.

(4) Let $u = (a,b)^T$, the development coefficient a and coordination coefficient b are solved by the least square method $\hat{u} = (a,b)^T = (B^T B)^{-1} B^T Y$. Among them, Y and B are $Y = (x^{(0)}(2), x^{(0)}(3), \cdots, x^{(0)}(n))^T$

$$B = \begin{bmatrix} -z^{(1)}(2) & -z^{(1)}(3) & \cdots & -z^{(1)}(n) \\ 1 & 1 & \cdots & 1 \end{bmatrix}^T$$

$$x^{(1)}(k+1) = (x^{(0)}(1) - \frac{b}{a})e^{-ak} + \frac{b}{a}$$

Finally $x^{(1)}(k+1) = (x^{(0)}(1) - \frac{b}{a})e^{-ak} + \frac{b}{a}$ is obtained through grey differential equation

(5) The obtained prediction model is tested to test whether the residual error, absolute correlation degree and the mean variance ratio of the obtained sequence by the prediction model and the original sequence meet the precision requirements.

2.3. Grey BP Neural Network Model Introduction

The grey BP neural network prediction model in this article adopts the series form of GM (1, 1) grey prediction model and BP neural network prediction model, that is, the prediction result of GM (1, 1) grey prediction model is taken as the input, actual result as the output, to establish sample data, and the weighting training is conducted on the established BP neural network. This article counted the best annual performance of course activities from 2005 to 2013, taking the performance from 2005 to 2011 as the basis, and the sample data of grey BP neural network prediction model was established, to train the established neural network model. At the same time, the established prediction model was applied to predict the best annual performance of courses in 2013 and 2014, which was compared with the actual value of the best performance of the course in two years, to test the precision of the established prediction model.

3. Establishment of Grey BP Neural Network Prediction Model

Seven individual activities of entrepreneurship course activities correlate each other, and the performance of activities influences each other. When conducting the performance prediction on it, the relationship between the activities needs to be taken into account. For the grey BP neural network prediction model established in this article, its

BP neural network model fully studies the relationship between activities performance, its GM (1, 1) grey prediction model makes full use of the time sequence of statistical data, and mines the temporal relations of data.

3.1. Processing of the Original Data

Before learning the grey BP neural network prediction model training, normalization processing is conducted on the total score and individual event result of all the students, to make its sample values lie in the interval [0, 1]. That is, select the maximum of the activities in the best annual values of outstanding students from 2005 to 2013, which is taken as the denominator, the performance of other years of its corresponding project is taken as the numerator, and various performance is processed, to obtain the processed data as shown in Table 1

Table 1. Normalization Data of the Best Annual Performance of Course Activities from 2003 to 2013

	Innovation point	Creative design	Entrepreneurship preparation	Planning	Implementation	Benefit	Future development
2003	0.9670	0.9949	0.8207	0.9422	0.9752	0.9403	0.9593
2004	0.9692	0.9795	0.8587	0.9541	0.9898	0.9212	0.9741
2005	0.9259	0.9795	0.7293	0.9889	0.9898	1.0000	0.9778
2006	0.9795	0.9692	0.8421	0.9783	0.9708	0.8845	0.9799
2007	0.9648	1.0000	0.8566	0.9586	1.0000	0.9041	0.9656
2008	0.9861	0.9231	1.0000	1.0000	0.9679	0.9158	1.0000
2009	0.9486	0.9846	0.8178	0.9533	0.9182	0.8204	0.9601
2010	0.9501	0.9692	0.8126	0.9516	0.9387	0.8802	0.9453
2011	0.9773	0.9385	0.8195	0.9635	0.9650	0.9977	0.9300
2012	0.9200	0.9538	0.8259	0.9360	0.9460	0.8949	0.9341
2013	1.0000	0.9538	0.8051	0.9811	0.9460	0.9026	0.9554

Based on the counted single activity score, GM (1, 1) grey model of equivalent dimensions addition is established. First take the data from 2006 to 2007 of each activity respectively to conduct the GM (1, 1) grey model modeling, and predict the normalization processing data corresponding to the performance of 2007. Take the data from 2005 to 2006 to predict the normalization processing data corresponding to the performance of 2008 and so on, to obtain the prediction value of normalization data corresponding to the performance of 2008-2014. The obtained prediction data is as shown in Table 2

Table 2. Prediction Data of the Best Annual Performance of Course Activities From 2007 to 2013

	Innovation point	Creative design	Entrepreneurship preparation	Planning	Implementation	Benefit	Future development
2008	0.9687	0.9658	0.7958	0.9980	0.9647	0.9003	0.9831
2009	0.9958	1.0037	0.9419	0.9454	0.9972	0.8353	0.9623
2010	0.9835	0.9197	1.0728	1.0011	0.9767	0.9331	1.0023
2011	0.9506	0.9536	0.8555	0.9654	0.8832	0.8011	0.9698
2012	0.9259	1.0053	0.6994	0.9205	0.9124	0.8361	0.9148

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	Innovation point	Creative design	Entrepreneurship preparation	Planning	Implementation	Benefit	Future development
2013	0.9878	0.9190	0.8183	0.9664	0.9884	1.0928	0.9154
2014	0.9198	0.9384	0.8372	0.9350	0.9572	0.9385	0.9253

3.2. Establishment of the Training Sample

The grey BP neural network prediction model in this article takes the prediction value of seven individual activities performance of students' scores by GM (1, 1) grey prediction model as the input, and the actual performance as the output. There are seven samples in the training samples, including the prediction data and actual data of grey prediction model from 2007 to 2011 respectively as the input and output. Let the input and output matrix be P and T respectively, there is

$$P=\begin{bmatrix} 0.9687 & 0.9658 & 0.7958 & 0.9980 & 0.9647 & 0.9003 & 0.9831 \\ 0.9958 & 1.0037 & 0.9419 & 0.9454 & 0.9972 & 0.8353 & 0.9623 \\ 0.9835 & 0.9197 & 1.0728 & 1.0011 & 0.9767 & 0.9331 & 1.0023 \\ 0.9506 & 0.9536 & 0.8555 & 0.9654 & 0.8832 & 0.8011 & 0.9698 \\ 0.9259 & 1.0053 & 0.6994 & 0.9205 & 0.9124 & 0.8361 & 0.9148 \end{bmatrix}^T$$

$$T=\begin{bmatrix} 0.9648 & 1.0000 & 0.8566 & 0.9586 & 1.0000 & 0.9401 & 0.9656 \\ 0.9861 & 0.9231 & 1.0000 & 1.0000 & 0.9679 & 0.9158 & 1.0000 \\ 0.9486 & 0.9846 & 0.8178 & 0.9533 & 0.9182 & 0.8204 & 0.9601 \\ 0.9501 & 0.9692 & 0.8126 & 0.9516 & 0.9387 & 0.8802 & 0.9453 \\ 0.9773 & 0.9385 & 0.8195 & 0.9635 & 0.9650 & 0.9977 & 0.9300 \end{bmatrix}^T$$

3.3. Establishment of BP Neural Network Prediction Model

The hidden layer of neural network prediction model in this article is one layer. From the foregoing, neural network has seven inputs and seven outputs, that is, the number of neurons in the input layer and output layer are 7. The empirical formula can be used for the research of the number of neurons in hidden layer:

$$i=\sqrt{n+m}+a \tag{1}$$

Thereinto, n is the number of neurons in the input layer, m is the number of neurons in the output layer, a value is between 0 and 1, and this model takes 7 as the number of neurons in hidden layer by the empirical formula above.

There are many kinds of transfer function, training function, learning function and performance function of BP neural network model, for example, the transfer function includes S-type logarithmic function, S-type tangent function and pure linear function, *etc.*, training function includes BFGS quasi Newton BP algorithm function, gradient descent BP algorithm function and gradient descent momentum BP algorithm function, *etc.*, learning function includes gradient descent weight learning function, gradient descent momentum weight learning function, *etc.*, and performance function includes the mean square error performance function and mean square error normalized performance function, etc. The BP neural network model selects the S-type tangent function transfer function and pure linear function, gradient descent momentum BP algorithm function, gradient descent momentum weight learning function and mean square error normalized performance function. At the same time, the BP neural network model selects the maximum training time is 10000, the training precision is 0.005, and the training interval is 500 times.

4. Model Solution and Analysis

MATLAB software is used to conduct the network weight training on the established grey BP neural network prediction model above for simulation platform and the set training sample and training parameters. Through the repeated training of BP neural network, the weight of BP neural network is trained finally, and the corresponding grey BP neural network prediction model is established. The established grey BP neural network is tested by using the data of test sample, and the established sample precision can be obtained.

4.1. Training Performance Analysis of Grey BP Neural Network

The weight training is conducted on the established BP neural network by using the established sample data, BP neural network training parameters. In order to analyze the training process and model precision of the established grey BP neural network, this article studies the training process and training result of grey BP neural network.

Figure 1, is the training process graph of the model, and Figure 2, is the training result graph of the model. The x-axis of figure 1 is the number of training of the BP neural network, and y-axis is the training precision of BP neural network. It can be seen that the weight training of BP neural network model repeats the cycle of 1518 times, and its precision is 0.00492.

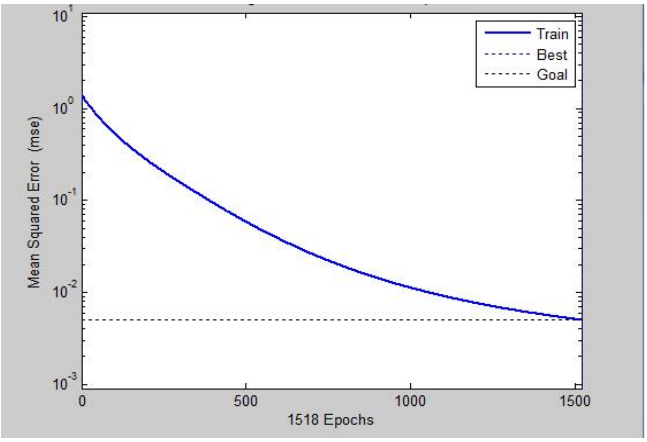

Figure 1. Training Process Graph

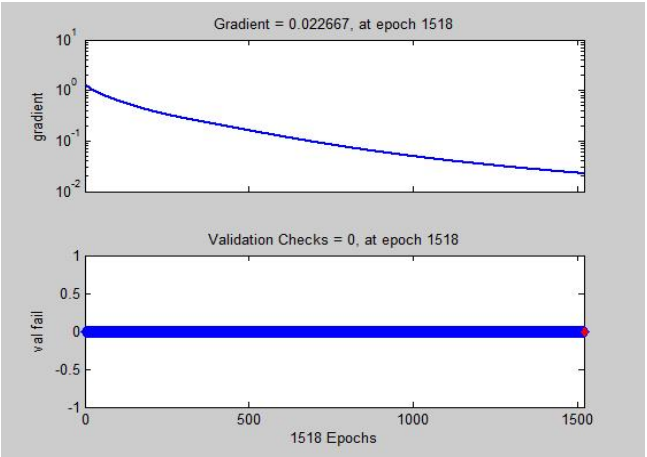

Figure 2. Training Result Graph

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4.2. Precision Test of Grey BP Neural Network

This article takes the data in 2012 and 2013 as the test sample to detect the precision of the grey BP neural network prediction model. The input of grey BP neural network prediction model is the best annual value of the courses of 2012 and 2013 obtained by using GM (1, 1) grey prediction model, the best value of the course. Through the comparison of the output value of grey BP neural network prediction model and the best annual performance of the courses of 2012 and 2013, prediction precision of grey BP neural network prediction model is analyzed. Let GM (1, 1) grey prediction model of 2012 and 2013, namely the input of grey BP neural network be P1 and P2 respectively, the output of the grey BP neural network be T1 and T2 respectively, and there is

$$P1 = [0.9878 \quad 0.9190 \quad 0.8183 \quad 0.9664 \quad 0.9884 \quad 1.0928 \quad 0.9154]^T$$

$$P2 = [0.9198 \quad 0.9384 \quad 0.8372 \quad 0.9350 \quad 0.9572 \quad 0.9385 \quad 0.9253]^T$$

Taking P1 and P2 as the output, get the simulation values

$$T1 = [0.9221 \quad 0.9481 \quad 0.8267 \quad 0.9411 \quad 0.9411 \quad 0.8992 \quad 0.9377]^T$$

$$T2 = [0.9238 \quad 0.9327 \quad 0.8401 \quad 0.9355 \quad 0.9591 \quad 0.9450 \quad 0.9268]^T$$

The deviation of the simulation values of normalization data of the best performance of Women's heptathlon and the actual value is compared with its actual value, as shown in Table 3

Table 3. Comparison of the Prediction Value and the Actual Value

		Innovation point	Creative design	Entrepreneurship preparation	Planning	Implementation	Benefit	Future development
2012	Actual value	0.9200	0.9538	0.8259	0.9360	0.9460	0.8949	0.9341
	Prediction deviations	0.0021	-0.0057	0.0008	0.0051	0.0019	0.0043	0.0036
	Deviation ratio	0.23%	0.60%	0.10%	0.54%	0.21%	0.48%	0.39%
2013	Actual value	0.9198	0.9384	0.8372	0.9350	0.9572	0.9385	0.9253
	Prediction deviations	0.0040	-0.0057	0.0029	0.0005	0.0019	0.0065	0.0015
	Deviation ratio	0.44%	0.61%	0.03%	0.06%	0.19%	0.69%	0.02%

From Table 4, the deviation ratio of the prediction value of all the scores of 2012 and 2013 courses by using the grey BP neural network model is less than 0.7%. In order to compare the prediction precision of course activities by grey BP neural network and GM (1, 1) grey prediction model.

5. Conclusion

For the comprehensive entrepreneurship course projects such as course activities, the activities performance also has certain mapping relation due to the interaction between individual activities. In order to better predict the activities performance, all the known data must be made full use of. Grey BP neural network prediction model has the characteristics of robustness, fault tolerance of BP neural network prediction model, and can make full use of GM (1, 1) grey prediction model to mine the temporal relations of

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data, for the problem of multi-factor protection its prediction precision is not inferior to that of GM (1, 1) grey prediction model.

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