Prediction of Total order amount based on BP Neural Network optimized by Genetic Algorithm

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Abstract: Two forward neural networks were established in this study. Training and learning of factor data and prediction results were conducted respectively then the weights and thresholds of the two networks are optimized by genetic algorithm, finally the set of target values can still be predicted without factor data. In order to predict the total order amount of a training institution outside school, the genetic algorithm is used to optimize the BP neural network to establish an effective prediction model based on the analysis of the influence factors of the total order amount. This model not only has the strong learning ability of BP neural network, but also combines the excellent global searching ability of genetic algorithm. The innovation of this study is to use the network 1 training factor data to get the corresponding annual value, and then the network 2 training continuous 3 years' factor data forecast results for the value of the fourth year. The whole process of solving the fourth year's value does not need the factor data of this year.

1. Introduction

With the rapid development of China's economy, education has received great attention. Besides school education, extracurricular schools and training institutions also play an indispensable role, and the development of various institutions is becoming more and more perfect. The total amount of orders is a measure of the size of an organization. The total amount of orders is determined by a number of factors, such as the size of schools, the number of first-rate teachers, teaching-hour subsidy and so on. This study only selects some influential factors to make an accurate prediction of the total amount of future orders, so as to enable the company to arrange for the directors.

Artificial neural network, to some extent, mimics the information processing, storage and retrieval function of the human brain nervous system, which is a kind of simplification, abstraction and Simulation of the neural network of human brain. The Back Propagation (BP) learning algorithm proposed by Rumelhart and others in 1985 is more commonly used. It uses the error of the output to estimate the error of the direct preamble of the output layer, and then estimates the error of the previous layer with this error, and then the error estimate of all layers can be obtained [1].

2. Genetic Algorithm And Bp Neural Network

2.1 Genetic Algorithm

Genetic Algorithm (GA) is a model that simulates the genetic selection and natural elimination of natural organisms during evolution. GA uses group search technology, and the population represents a group of problem solutions. By applying the genetic manipulation of selection, crossover and mutation to the parent population, the population is produced, and then the population evolves gradually to the state of the optimal solution [2].

2.2 BP Neural Network

BP neural network is also called back propagation neural network. The network model is generally composed of input layer, hidden layer, output layer and interlayer nodes. All the neurons in each layer are connected, but there is no connection between the neurons in the same layer. The main idea of BP neural network algorithm is as follows: for some input learning samples " x1,x2,...,xm ", it is known that the corresponding some output samples are " t1,t2,...,tn ", using the error between the actual output of the network and the target vector (t1,t2,...,tn) to modify its weight value. So that yl (l=1,2... , n) is infinitely close to the expected tl, that is, the adjusted weight value minimizes the total network error[1,6]. A typical three-layer BP neural network model is shown in Figure 1.

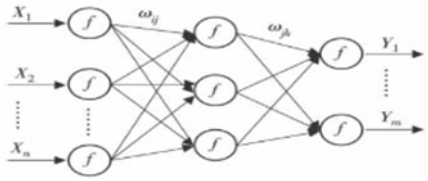

Fig. 1. A typical three-layer BP neural network model

In summary, BP neural network has good learning ability and precise search ability, while GA has strong global search capability. Therefore, GA is used to reduce the search scope and then use BP neural network to solve the problem accurately.

3. Design Of Secondary Prediction Model

3.1 Data Selection

In this study, nine factors affecting the total number of orders were selected, including the number of first-rate teachers, the number of consultants, the area of the school, the amount of publicity, the number of teaching evaluation, the number of students, the ratio of students to the school, teaching-hour subsidy and the number of courses. The data used in this paper are the total orders and factors data of a school in 2000 -2016.

As mentioned above, two BP neural networks were constructed to train data twice. Network 1 is training factor data. Factor data and target values from 2000 to 2013 are used as training objects. The network model 1 takes the data of nine factors as input vector and the actual value of order amount of corresponding year as the target output, that is, the number of neurons in the input layer is 9 and the number of neurons in the output layer is 1. Network 2 uses the factor data prediction results of the previous three years as input vector and the factor data prediction results of the fourth year as output vectors that is, inputting the factor data prediction results of 2000, 2001 and 2002, and predicting the factor data prediction results of 2003. Then the forecast was compared with the actual value in 2003, and so on, until to 2013. These factor data prediction results of the 11 groups were used for training and learning in network 2. So the number of neurons in input layer and output layer in network 2 is 3 and 1. The remaining data for 2014, 2015 and 2016 will be used as test data to verify the accuracy of the forecast, as follows: enter factor data for 2011, 2012, 2013, and use network model 1 to get the forecast results for the corresponding year. Then the network model 2 is used to predict the value of 2014 from the factor data prediction results of these three years, the whole process does not appear the factor data of 2014, and so on.

3.2 Normalization Of Data

The number of factors of each factor in the original data sample is very different. In order to facilitate the network calculation, the data samples of the original factors should be normalized. The network model 1 uses premnmx function to make the processed data uniformly distributed in the range of [-1,1]. The conversion formula is as follows:

$$P=2(p-minp)/(maxp-minp)-1 \quad (1)$$

$$T=2(t-mint)/(maxt-mint)-1 \quad (2)$$

Among them, p and t are the input samples and the target output of the original factor data respectively, minp and maxp are the minimum and maximum value of p, mint and maxt are the minimum and maximum value of the target vector t. P and T are the input samples and the output samples after the function normalization, respectively. The simulated values of the training should be reduced to the original quantity level by postmnmx.

Network model 2 also normalizes the prediction results of factor data. The conversion formula is as follows:

$$P1=(p1-p1min)/(p1max-p1min) \quad (3)$$

$$T1=(t1-t1min)/(t1max-t1min) \quad (4)$$

Among them, p1 and t1 is the sample input and target output of the original factor data prediction results, p1min and p1max is the minimum and maximum value of p1, t1min and t1max is the minimum and maximum value of t1. P1, T1 are the input samples and the target samples after the function normalization respectively, the training results should be reduced by the following formula

$$a1=A1.*(t1max-t1min)+t1min \quad (5)$$

3.3 Modeling Of Parameters

- initialization of parameters: The training functions of the BP algorithm for gradient descent momentum and adaptive lr are adopted in the two networks. The learning rate of network 1 is 0.035, the maximum iteration number is 10000 times, the target error is 10-6; the learning rate of the network 2 is 0.05, the maximum iteration number is 30000, the target error is 10-5, the performance function is MSE function, each operation 50 time shows a training process, the other values are the default values.
- transfer function: The transfer function of the hidden layer of the network 1 is hyperbolic tangent S shape function tansig, and the transfer function of the output layer is a linear function purelin. The transfer function of the hidden layer of network 2 is hyperbolic tangent S shape function tansig, and the transfer function of output layer is logarithmic S shape function logsig.
- the determination of the number of nodes in the hidden layer: The number of neurons in the hidden layer and the number of neurons in the input layer are approximately as follows: d=2N+1. The number of neurons in the 1 input layer of the network is 9, the output layer is 1, so the number of hidden layer nodes is 19, the number of neurons in the 2 input layer of the network is 3, the output is 1, and the number of hidden layer nodes is 7.

4. The Implementation Of Bp Neural Network Optimized By Ga

- Initialization of the population: The real coding is used to encode the individual, and the individual contains the weight value and threshold of the whole BP neural network. Each is composed of four parts: the weight of the input layer and the hidden layer, the threshold of the hidden layer, the weight of the hidden layer and the output layer, and the threshold of the output layer. R is the number of nodes in the input layer, S1 is the number of hidden layer nodes, and S2 is the number of nodes in the output layer.
  The number of weights: R*S1+S1*S2;
  The number of threshold values: S1+S2;
  The individual encoding length is:
  S= S1*R+S2*S1+S1+S2.
  The GA population size of the optimized network 1 is set to 250, and the evolution number is 1000. The GA population size of the optimized network 2 is 50, and the evolution number is 1000.
- Fitness function: In this study, fitness function is defined as the reciprocal of error square sum

of neural network: val=1/SE.

- Genetic manipulation – Selection: The "roulette" choice method is simple and practical. It is a proportion based choice, which determines the possibility of children's reservation by using the proportion of each individual's fitness. If the fitness of is fi and the population size is NP, the probability of being selected is:
  Pi=fi/∑fi (i=1,2,3,…,NP)
- Genetic manipulation – Crossover: The crossover operation is carried out by the monarch scheme, and the probability of crossover is Pc=0.8.
- Genetic manipulation –Mutation: According to the mutation probability Pm=0.09, some individuals are selected randomly, and then the ectopic is selected randomly. The binary of the bit is reversed and a new individual is generated.

The newly generated group returns to the (2) step, then carries out a round operation, optimizes the individual fitness value again, cycles many times, until the number of iterations reaches the set value or the fitness value to the set target, then the optimal weight and threshold are obtained[3].

5. Model Training And Simulation Results And Analysis

The BP neural network based on genetic algorithm optimization is implemented by MATLAB. The 17 sets of data collected are divided into two parts: training 1 from the 2000 to 2013 factor data and results, then training 2 from the prediction results of the factor data from 2000 to 2013, and then using the remaining 3 sets of data as test validation samples. That is to say, after completing the two training, enter the factor data of 2011, 2012 and 2013, and achieve the forecast of the total amount of the order in 2014, and so on[4,5]. The comparison between the predicted value and the actual value is as follows: in Table I, the prediction results of the BP neural algorithm are analyzed, and Table II is the analysis of the prediction results using the GA-BP neural algorithm.

TABLE I. Analysis of prediction results of bp neural algorithm

Particular year	Act-value (10000 yuan)	Pre-value (10000 yuan)	Abs-error (10000 yuan)	Relative error (%)
2014	210.6	289.258	78.658	37.349
2015	250.7	383.4963	132.7963	52.97
2016	221	232.3635	11.3635	5.1419

TABLE II. Analysis of prediction results of ga-bp neural algorithm

Particular year	Act-value (10000 yuan)	Pre-value (10000 yuan)	Abs-error (10000 yuan)	Relative error (%)
2014	210.6	211.8669	1.2669	0.60155
2015	250.7	251.8605	1.1605	0.46289
2016	221	222.3573	1.3573	0.61414

Comparing the relative errors between Table I and Table II, we can get that the prediction accuracy of GA-BP is much higher than that of BP neural network.

The following figures 2 to 5 compare the whole operation process under the GA-BP algorithm and the BP algorithm.

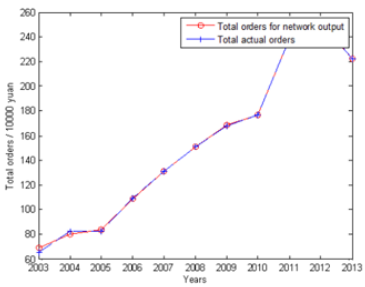

Fig. 2. BP Training results of reflection factor data in network 1, 2

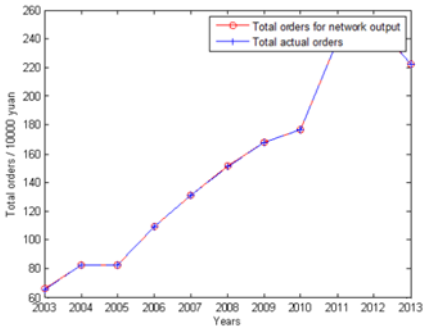

Fig. 3. GA-BP Training results of reflection factor data in network 1, 2

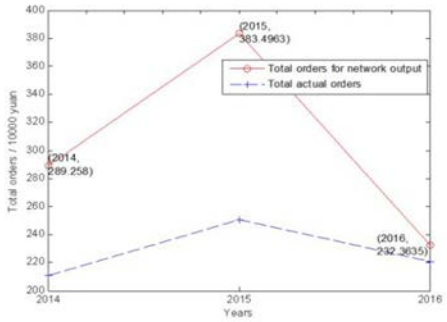

Fig. 4. BP Prediction results of reflection factor data in trained network 1, 2

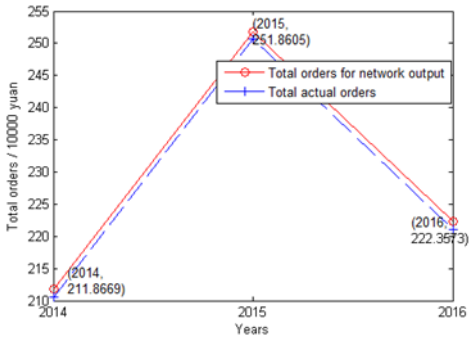

Fig. 5. GA-BP Prediction results of reflection factor data in trained network 1, 2

The trained BP neural network and the GA-BP neural network, based on the known data of 2014, 2015 and 2016, predicted the total amount of orders of 2017 shown in Table III (10000 yuan). According to the analysis of data changes over the past years, it can be seen that about 2 million yuan is in line with the actual situation, knowing that GA-BP neural network prediction is more accurate.

TABLE III. Comparison of prediction results between bp and ga-bp in 2017

BP	GA-BP
442.812	201.4284

The fitness function value is calculated on the basis of the normalization of experimental data. The fitness values of the first and second training reached their maximum after about 800 and 900 generations, respectively.

6. Conclusion

After secondary training, the value of the year can be predicted without any factor data. According to the analysis, BP neural network is easy to fall into local minimum, resulting in insufficient accuracy or even deviation. Using GA to optimize the weights and thresholds of BP neural network, the accuracy of prediction can be greatly improved.

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