

An Analysis about the Pure Electric Vehicle Sales Prediction Based on the BP Neural Network

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Abstract. With the increasing demand for pure electric vehicles among Chinese residents, being able to accurately forecast the future sales volume of pure electric vehicles has become a hot topic of research in today's society. In this paper, the sales volume of pure electric vehicles from January 2020 to December 2021 have been collected. And based on the monthly sales volume of 24 months, the BP neural network model has been used to test the data, and the sales volume of pure electric vehicles from January to December 2021 has been predicted with the trained model. Comparing its prediction results with the actual sales volume, it has been found that the BP neural network model can predict the future sales volume of electric vehicles well; and based on the prediction results, it can provide some useful references for the production planning and the raw material procurement.

Keywords: The BP neural network; Pure electric vehicle; Sales volume prediction.

1. Introduction

In the promotion of green development level, continuous improvement of ecological environment, Chinese residents' environmental protection ideas are held. According to the institute's report, in the first half of 2019, the pure electric vehicle sales have exceeded 765,000 units, with 430,700 units sold in the Chinese market, accounting for 56.3 percent. From sales volume shows, Chinese pure electric vehicle market is one of the new energy vehicle research and production directions. Relative to the integrated fuel vehicles, more and more vehicles are being replaced by pure electric vehicles. In recent years, with the joint efforts of enterprises and government departments, the electric vehicles have been greatly improved in innovation in the key issues of cost, quality, distance and capital[1].

In terms of methods, different forecasting methods are used by many scholars. Xu Yuemei[2] has done a good job of predicting the trend of the stock. Wang Muqi [3] has predicted the LncRNA related to the patocellular carcinoma and obtained the desired effect. Xu Jiahui [4] has used the graph network to predict surface water quality and put forward reasonable suggestions for the government. And Ren Yafei[5] also has predicted surface water quality by using the BP neural network model. The BP neural network model is suitable for solving complex causality of the uncertainty of judgment, classification, reasoning and recognition, having the strong adaptability in learning, fault tolerance and the nonlinear map; nowadays, it is applicable to the prediction of tunnel magma eruption, the prediction of the maximum bearing capacity of water resources and the prediction of oil production, etc [6]. Therefore, this paper combines the historical sales data of pure electric vehicles, and uses the BP neural network model to predict the future sales of pure electric vehicles, so as to provide useful reference for the production planning, raw material procurement and sales strategy of enterprises.

2. The BP Neural Network

In the 1940s, artificial neural network technology began to rise with the rapid development of information technology. In this century, it has made further development, comparing with the theoretical aspect, and has become gradually mature. According to statistics, the BP neural network has been widely used so far in various fields, such as medicine, economics, agriculture and other fields. The birth of the BP neural network has added a new way of solving the problem that modern computer cannot realize, and has played an indispensable role.

2.1 Overview of the BP neural network

Reviewing the development of the BP neural network, the role of the BP neural network is becoming more and more important. It was first proposed in 1986 by scientists such as Rumelhart and McClelland, and has been widely applied to many areas of modern society. The structure of the BP neural network algorithm is composed of three layers (input layer, hidden layer, output layer). In the study of practical problems, as long as the hidden layer contains enough neurons, it can approach the continuous function of arbitrary complexity with arbitrary accuracy. However, when the amount of sample data collected is relatively large, it is very large, in order to reduce the scale of the BP neural network, the number of hidden layers should be increased appropriately, and the scale of the BP neural network should be reduced.

The BP neural network is through its own learning and training to determine when the expected value of the given input value is very close to the output value, so the BP neural network should not determine the mathematical expression of input and output variables in advance. The BP neural network model is usually constructed by gradient descent method, which uses gradient technology to find the optimal value, in order to minimize the objective function. Among them, the size of the Learning Rate will have different effects. A small learning rate will take a lot of time in the iteration process, while a large learning rate will easily produce a large fluctuation when the weight is updated. When the defects of learning rate are exposed, the adaptive learning rate is adopted. In order to improve the training speed of the model, the momentum coefficient is introduced. It usually takes many experiments to determine. The BP neural network algorithm includes two processes: signal forward propagation and error backward propagation. In forward propagation, input signals are first transmitted to input layers with multiple neurons. When neurons receive signals from the outside world, they continue to transmit with the help of connections between layers, and these connections correspond to certain weights. Secondly, the signal processed by the input layer is transmitted to the output layer through the hidden layer. Finally, these signals are nonlinearly processed by the functional neurons in the output layer to produce the final output value. If the output value obtained by forward propagation deviates too much from the expected value, the model will start backward propagation of errors. In the process of back propagation, the error will be evenly distributed to each layer of neurons, each neuron to adjust the weight of neurons, hidden layer and output layer threshold, so that the output value error of the BP network algorithm will continuously reduce until it reaches the expected value. This process is the execution of repeated loops.

The transfer function plays an important role in the establishment of the BP network. When the transfer function is not used, it is the same as the result without adding hidden layer, but the signal of each layer is only the output value obtained after linear processing of the signal of the previous layer. Most of the general transfer functions are nonlinear, which not only improves the prediction accuracy of the network algorithm, but also improves the ability of the BP network model to model the data information. When the nonlinear function is used as the activation function, each hidden unit is weighted and summed, and then solved by this function, the results of the solution function are weighted and summed again, and the final output value is obtained, which will make the BP neural network more meaningful and more applicable.

2.2 The BP neural network model

The BP neural network model is shown in Figure 1. In the process of learning, there are roughly three steps.

- (1) Forward propagation, input sample - input layer - each hidden layer - output layer [9].
- (2) Judge whether the model is transferred to the back propagation stage, if the actual output of the output layer is compared with the expected output
If the error is too large, the error will be backtransmitted.
- (3) In the reverse transmission, the weight of each layer unit is continuously modified until the output error is reduced to acceptable

Or until the preset number of learning times [10-11].

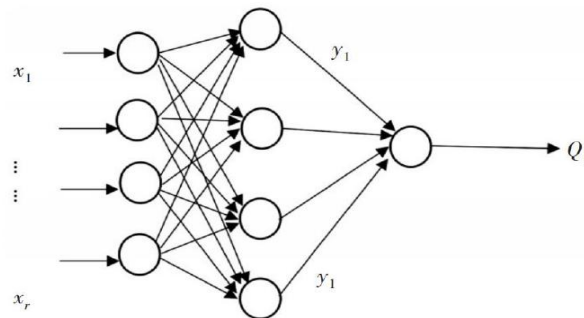


Fig. 1 Structure diagram of BP neural network

(1) Signal forward propagation process

Assumes that the input for $x = (x_1, x_2, \dots, x_n)^T$, a unit of hidden layer, the output of $y = (y_1, y_2, \dots, y_n)^T$, Output layer has n units, the output of $p = (p_1, p_2, \dots, p_n)^T$, the target output for $q = (q_1, q_2, \dots, q_n)^T$. The transfer function from hidden layer to output layer is f , and the transfer function of output layer is h . The calculation formula is as follows:

$$y_j = f\left(\sum_{i=1}^n w_{ij}x_i - \theta\right) = f\left(\sum_{i=0}^n w_{ij}x_i\right) \quad (1)$$

Type, y_j said the first j a hidden layer neurons of the output, w as the weight vector, $w_{0j} = \theta$, $x_0 = -1$. f is the activation function, and the sigmoid function is generally selected.

$$f(x) = \frac{1}{1 + e^{-ax}} \quad (2)$$

$$p_l = h\left(\sum_{j=0}^g w_{lj}y_j\right) \quad (3)$$

Where, p_l represents the output of the LTH neuron in the output layer. The error between the network output and the target output to:

$$\varepsilon = \frac{1}{2} \sum_{l=1}^m (q_l - p_l)^2 \quad (4)$$

Because the function value decreases the fastest direction of negative gradient direction [12], has set a step , every time down the negative. Gradient direction adjustment unit, then the weight is adjusted for each time:

$$\Delta w_{pq} = -\eta \frac{\partial \varepsilon}{\partial w_{pq}} \quad (5)$$

Among them, the for learning rate.

(2) Error backpropagation

Weight adjustment iteration formula: hidden layer to output layer

$$w_{jk}(t+1) = w_{jk}(t) + \eta \delta_k y_j \quad (6)$$

Weight adjustment iteration formula: input layer to hidden layer

$$w_{ij}(t+1) = w_{ij}(t) + \eta \delta_j x_i \quad (7)$$

3. Simulation Experiment

3.1 Experimental Environment

In order to better verify the accuracy and rationality of the sales prediction of pure electric vehicles under the BP neural network model, the experiment was completed in MATLAB software.

3.2 Data Sources

This paper uses the monthly sales data of pure electric vehicles on the official website of China Association of Automobile Manufacturers as experimental data. The sales data are shown in Figure 2.

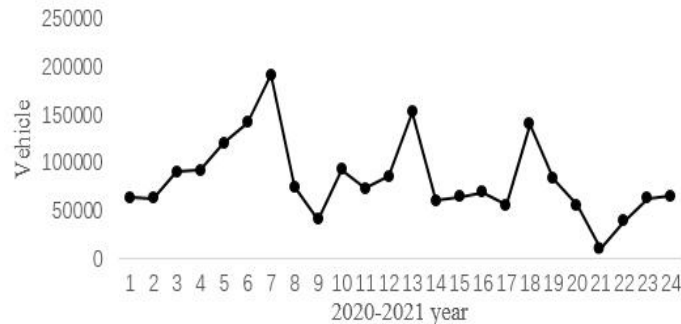


Fig. 2 Monthly Automobile Sales Data from January 2020 to December 2021

3.3 Experimental Process

Before considering the output vector of the neural network, the input vector should be determined. In this paper, the output vector is defined as one layer, and the input vector of the network model is defined as two dimensions, that is, the input layer is two layers. In the BP neural network, the number of hidden layer neurons plays a very important role. If the number of hidden layers is too large, the error will be very small for the training sample, but very large for the calibration sample. Through a large number of trial calculations, the number of neurons in the hidden layer is finally determined to be 9, which is proved to have small error by experiments.

3.4 Analysis of experimental results

We use the actual sales data of 2020 to predict the sales volume of 2021. The prediction result obtained after MATLAB simulation experiment is shown in Figure 3.

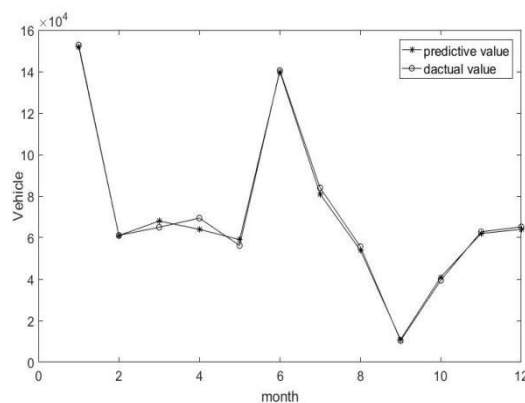


Fig. 3 Prediction Results

As shown in Figure 4, the prediction result analysis table of pure electric vehicle sales volume is obtained by summarizing the real value and predicted value, as shown in Table 1.

Table 1. Analysis of the predicted sales results of pure electric vehicles

month	1	2	3	4	5	6	7	8	9	10	11	12
predictive value	15.2	6.1	6.8	6.4	5.9	14	8.1	5.39	1.09	4.1	6.2	6.4
actual value	15.28	6.11	6.5	6.94	5.62	14.05	8.4	5.57	1.04	3.95	6.28	6.52
relative error	0.59	0.16	4.41	2.06	4.75	0.36	3.70	3.34	4.59	3.66	1.29	1.87

It can be seen from the prediction results that the predicted value is very close to the true value. The relative error between the predicted sales volume and the actual sales volume in 2021 is within the range of 5%, which proves that the BP neural network model predicts the sales volume is considerable and has a good prediction effect.

4. Conclusion

In the environment of green development, in order to build a green and low-carbon country, more and more residents prefer to choose pure electric vehicles. Accurate prediction of their sales volume can not only improve the utilization of resources, but also effectively reduce costs. In this paper, based on the data collected from big data search, the BP neural network model is used for testing, and the trained model is used to predict the monthly sales volume of pure electric vehicles in 2021. The analysis of the results shows that this model is feasible and has a good prediction effect, and the production plan and procurement strategy are reasonably arranged for the forecast results of product sales. Formulate sales strategies corresponding to China's large automobile market environment. The BP neural network studied in this paper can solve practical problems, such as the existence of qualitative problems that the model can not be handled well, in the future can be optimized for the BP neural network model, more widely applied to various problems, to achieve higher precision prediction results.

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