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Prediction model of fire rescue times based on BP neural network

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Abstract: Based on the fire rescue data of a place from 2016 to 2019, this paper first establishes the BP neural network algorithm, constructs the prediction model of fire rescue times in months, and then solves it with MATLAB software to obtain the prediction value of alarm times from January to December 2021. Finally, the accuracy of the prediction model is proved by verifying the number of police calls in 2020, and the stability of the model is strong according to the BP neural network training chart.

1. Introduction

With the rapid development of China's economy, the complexity of urban space environment rises sharply, various accidents and disasters occur frequently, and the safety risk is increasing. The tasks undertaken by fire rescue teams also show a trend of diversification and complexity. For each alarm incident, the fire rescue team will record it in detail.

Based on the local data from January 1, 2016 to December 31, 2019, this paper establishes a prediction model of fire rescue alarm times in months; Take the data from January 1, 2020 to December 31, 2020 as the validation data set of the model, and compare the predicted value with the actual value to evaluate the accuracy and stability of the model. Then, the number of fire rescue calls in each month of 2021 is predicted and the data table is completed. The stability is analyzed by comparing with the average value of data in each month from 2016 to 2020.

2. Model Establishment and Solution

2.1 Model Preparation

Firstly, extract the number of fire rescue alarms in each month from 2016 to 2020, as shown in Table 1.

Table 1: Number of fire rescue calls in each month from 2016 to 2020

	2016	2017	2018	2019	2020
Jan	79	58	54	67	28
Feb	95	28	129	76	46
Mar	98	44	68	73	56
Apr	51	14	71	44	46
May	275	148	107	138	62
Jun	67	87	119	146	55
Jul	63	23	59	72	25
Aug	40	42	50	30	29
Sep	50	49	46	41	72
Oct	31	33	44	26	25
Nov	38	65	40	25	51
Dec	43	68	63	36	62

2.2 Model Establishment and Solution

BP (back propagation) neural network is a multilayer feedforward network trained according to the error back propagation algorithm. The basic principle of processing information by BP neural network model is that the input signal acts on the output node through the hidden layer node, and the output signal is obtained by nonlinear transformation. By adjusting the link strength value between the input node and the hidden layer node, and the link strength and threshold between the hidden layer node and the output node, the error decreases at the fastest speed. After many times of training, the sum of squares of the error of the neural network is minimized, the training is terminated, and the network weight and threshold are determined.

The algorithm steps of BP neural network model are roughly as follows:

(1) Network initialization: assign a group of random numbers in (- 1,1) interval to each link weight. Set network structure parameters: error function E, calculation accuracy value ϵ and maximum learning times M;

(2) Input the kth training sample x(k) and the corresponding expected output d(k);

(3) Calculate the input and output of each neuron in the hidden layer;

(4) The input of each neuron in the input layer and each neuron in the hidden layer is used to modify the link weight, and the output of each neuron in the output layer and each neuron in the hidden layer is used to modify the link weight;

(5) Calculate the global error of network training;

(6) Judge whether the error meets the preset accuracy requirements. If so, end the algorithm. Otherwise, go to step (2), select the next training sample and the corresponding expected output, and continue a new round of learning and training.

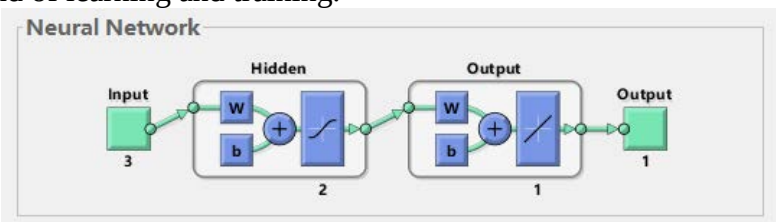

Figure 1: Neural network model

This paper takes the data from January 2016 to December 2020 as the input layer, sets the hidden layer of two-layer neural network, and constructs a BP neural network model with three inputs and one output, as shown in Figure 1.

Figure 2 and Figure 3 show the training process predicted by the neural network model. It can be seen from Figure 2 that the training value is almost the same as the test value, and the difference with the verification value is small. Figure 3 shows that most of the residual analysis results fluctuate less than 1, and the independence between various variables is good, which reflects the high accuracy of the prediction results of the model.

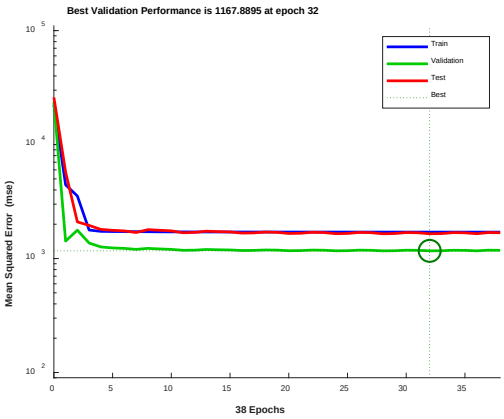

Figure 2: Training curve

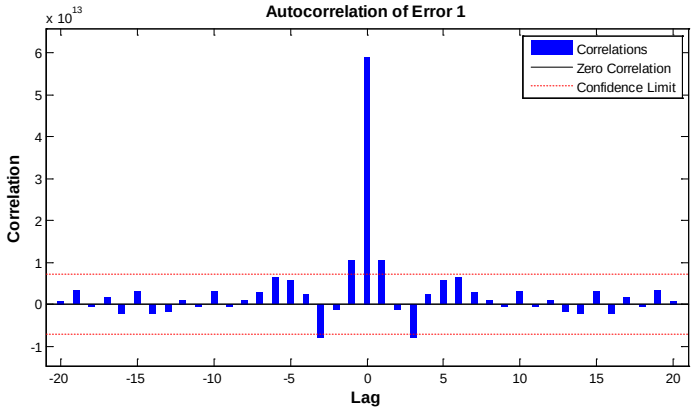

Figure 3: Residual analysis

After training the BP neural network for many times to achieve the preset accuracy, take the alarm data from January 2016 to December 2019 as the input vector, use the model to predict the fire alarm times from January to December 2020, compare and analyze with the actual alarm times, and calculate the absolute value of the relative error. See Table 2 for the specific data.

Table 2: Comparative analysis of predicted value and actual value of BP neural network

Time	Predicted value	Actual value	Absolute value of relative error
2020.01	30	28	7.14%
2020.02	43	46	6.52%
2020.03	55	56	1.80%
2020.04	48	46	4.30%
2020.05	67	62	8.06%
2020.06	56	55	1.81%
2020.07	24	25	4.00%
2020.08	30	29	3.45%
2020.09	66	72	8.33%
2020.10	27	25	8.00%
2020.11	54	51	5.90%
2020.12	64	62	3.20%

According to the data in Table 2, the maximum absolute value of the relative error between the predicted value and the actual value is 8.33%, so within the allowable error range of 10%, it can be considered that the accuracy of the BP neural network model algorithm is high; By analyzing Figure 2, it can be seen that after many trainings, the model curve tends to be horizontal, and it can be considered that the BP neural network model algorithm has strong stability.

Taking the fire rescue alarm data from January 2016 to December 2020 as the input vector, the model is used to predict the number of fire rescue alarms from January to December 2021. The red part in Figure 4 is the prediction curve after matlab operation. The predicted value of the number of alarms from January to December 2021 is shown in Table 3.

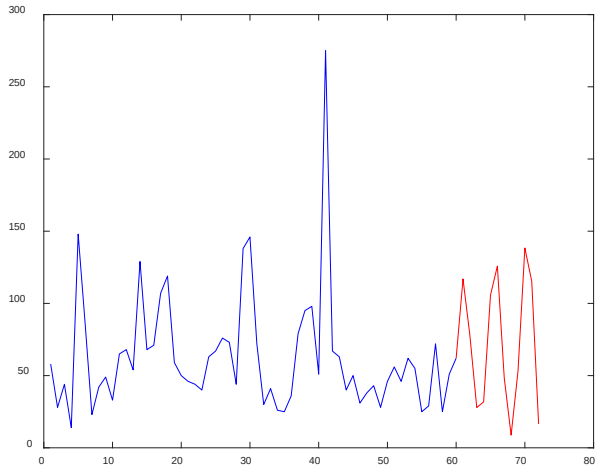

Figure 4: Forecast results of the number of police calls from January to December 2021

Table 3: Forecast results of police frequency from January to December 2021

Month	Predicted value (Times)
2021.01	117
2021.02	78
2021.03	28
2021.04	32
2021.05	106
2021.06	125
2021.07	48
2021.08	8
2021.09	52
2021.10	136
2021.11	115
2021.12	16

3. Model Evaluation

By reading a large number of excellent literature, this paper establishes a series of scientific assumptions, uses Excel, MATLAB, R software, SPSS and other software to reasonably process and analyze the data, and simplifies a variety of mathematical models in order to achieve ideal modeling results. The BP neural network algorithm used has good training effect. It is verified that the prediction results in 2020 have small error, high accuracy and strong stability, and are satisfied with the model results.

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