International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 4 Issue 7 ǁ July. 2016 ǁ PP. 59-66

Research on Freeway Passenger Flow Prediction Based on Neural Network

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Abstract: The growth of social activities scale, the increase of population flow and flow velocity, and the continuous development of car industry have brought more and more heavy load to the highway intercity transportation and its management system. Against this backdrop, how to greatly improve the utilization rate of traffic infrastructure and transportation equipment by analyzing and forecasting the traffic of the highway has become an important research topic. Based on the existing forecasting model and aiming at the the non-linearity, complexity and uncertainty of transportation itself, this paper uses BP neural network predication model to predict the Shenzhen Jihe highway passenger flow. MATLAB is used to predict the simulation and interface the highway traffic system.
Keywords: BP neural network; expressway; passenger flow prediction; simulation

I. INTRODUCTION

In recent years, the highway construction in our country is developing rapidly, which is related with the increase of investment in highway construction. Then with auto industry has become the pillar industry of national economy, this issue has been affirmed by the state and the people, the development of highway can effectively promote China's economic development [1].

Looking back on the past, in more than ten years, China's highway construction has gone through dramatic change. Although the expressway transportation industry in our country has been greatly improved because of the continuous improvement of the highway mileage and the rapid development of the automobile industry, but still in the early stages. From a macro point of view, our country highway passenger transport system is still not perfect, still exists a lot of problems we need to solve, one-sided and radical phenomenon is easy to appear in the development of the highway road. Only reasonable positioning of the target market of the highway transport industry, can make the mode of transport in the increasingly competitive market to win a place [2].

This paper adopt a reasonable prediction model in order to analysis and forecast of passenger flow in Shenzhen Jihe highway based on the actual national situations.This can guide the system of expressway passenger transportation to a better direction . At the same time, it is also a benefit to better guide and settlement of highway transport management in the existence of many problems [3].

II. BRIEF INTRODUCTION ABOUT PASSENGER FLOW FORECASTING METHODS

In today's world, there are more than 300 kinds of methods to forecast the freeway passenger. They are summed up in a total of two categories:qualitative prediction[4] and quantitative prediction. The main methods of qualitative prediction are Delphi method; the main methods of quantitative prediction are gray model prediction method [5], exponential smoothing method [6], regression analysis method [7], elastic prediction method [7], and so on. The advantages and disadvantages of the above methods are analyzed briefly:

(1) gray model prediction method

The most prominent advantage of the gray model prediction method is that it does not use the original data, and it use the new data generated by the original data. This can avoid the complex relationship between the parameters of system model, so as to seek the inherent law of the system itself.According to the known information, it can study and predict the unknown field, and thus being fully aware of the whole system can be achieved. So this is a more suitable forecasting method.

(2) exponential smoothing forecasting

Smoothing method is that in the forecast, the correlation factor and the forecast target only have the relations with the time, also can understand that in the forecast does not need the future forecast value . Because the passenger traffic volume is not a linear change, it is a common method to choose the three exponential smoothing method to predict . Using this kind of prediction method, the weighted coefficient is larger, the new

data having a greater effect, it can make the model more high sensitivity, also can make it faster to adapt to a new level, but it also has disadvantage. That is the prediction method relatively easy to produce allergic [8].

(3) regression forecasting analysis

Experience tells us that in the regression analysis, we must first to select the factors closely related to several of expressway passenger transport volume, such as per capita GDP, national industrial output value, population and so on.In the theory, the above indicators can be used as the independent variables. However, in the actual situation, the cumulative error will be larger. Therefore, we should choose a little less independent variables, and select the independent variables with high independence.

(4) elastic prediction analysis

This method is relatively simple, but there are some problems. Highway passenger transport increased amount will show a gradually slowing trend, because of the further perfection and development of the means of communication.The elasticity coefficient will some of the decline, which will enable predictive value and the actual value error exists between the two.

III. BP NEURAL NETWORK

BP neural network is a kind of artificial neural network, it is a intelligent systems which can simulate the human brain work, and is also a kind of information technology with parallel processing capability [9]. At the same time, "self-learning" can be carried out through the BP neural network samples in the pasts. Based on the neural network can better identify the training samples among the correlation characteristics between parameters and parameters,which in the predictive ability of complex system, the BP neural network work better than other traditional statistical analysis method. If the training sample is small, and there are random errors, the advantage of the neural network will be more obvious compared with the general statistical model. This paper is based on the prediction method of BP neural network to predict the freeway passenger flow[10].

3.1 BP neural network learning process

BP neural network is one of the most typical and the most useful of artificial neural network, but there is not yet a very accurate and effective formula can directly get the structure of BP neural network[11]. Neural network modeling is mainly divided into two parts: the first part is to choose the appropriate training samples. In the second part, adjusting the BP neural network algorithm mainly is refers to by adjusting the weight and threshold to improve the convergence speed of the neural network. BP algorithm as a teacher of learning algorithm, whose probably thought is: input learning samples, using gradient descent method on the network weights and biases continuously adjusted. Finally try to make the output as close as possible to the desired[12].

3.2 BP neural network model

For the model of BP neural network, it is mainly to determine the number of layers, the choice of input variables, the determination of output variables, the number of nodes in the hidden layer, and the choice of the training function and transfer function [13].

3.2.1 Determination of the number of network layers

In this paper, the BP neural network for the highway passenger flow forecast, according to the summary of previous experience, three layer BP neural network is enough to solve any non-linear and complex function [14].

3.2.2 Design of input layer

The most important problem of building the model is the choice of the independent variable. When choosing independent variables, there are two main choices: one is the selecting the factors which have a very close relationship with the output results;two is the independent variables should maintain the relative independence[15]. Based on results of other papers,we choose the following six factors which have an impact on the highway passenger flow as input variables, year, GDP per capital, total industrial output, investment in fixed assets value, population and national passenger volume.

3.2.3 Design of output layer

The dimension of the output layer can be determined according to the requirements of users, this paper predicts the passenger flow of Shenzhen Jihe highway, so the dimension of the output layer is one.

3.2.4 Design of hidden layer

BP networks usually have one or more hidden layers. This paper determined the layer number of the hidden layer is one. $m = \sqrt{n + l} + \alpha$ is a formula for determining the number of hidden layer neurons in the current optimization. l is the number of output neuron , n is the number of input neuron number, α is a constant from 1 to 10. So the value of m is in [4, 13].Through trial and error, when the number of hidden nodes is 5, the error of prediction analysis is the least.

3.2.5 Selection Of Transfer Function

The choice of transfer function determines the connection form of the neuron, which plays an important role in the network training [16]. According to the nature of the research question,we can select the appropriate transfer function. BP network commonly used transfer function:

(1)S type of logarithmic function, the reference formula is:

$$f = \frac{2}{e^{(-2n)} + 1}$$

(2)S type of tangent function , the reference formula is:

$$f = \frac{2}{1 + e^{(-2n)}} - 1$$

(3)Pure linear function,the reference formula is:

$$y = x$$

IV. SHENZHEN JIHE EXPRESSWAY PASSENGER FLOW FORECAST

Shenzhen JiHe expressway is located in the territory of Shenzhen, which refers to the highway between the HeZhou Airport and HeAo. It is reported that Shenzhen JiHe expressway traffic jam is very serious. For the driver is "an intestinal stem road, two bitter tears". So it is very necessary to study the expressway passenger flow.

4.1 Data Collection And Arrangement

The dependent variable of BP neural network output layer is Shenzhen JiHe expressway passenger flow over the calendar year statistics, as shown in table 1.

Table 1: statistics about JiHe expressway passenger flow

Time(year)	Total（one hundred people）
1999	2194
2000	10821
2001	13527
2002	18197
2003	23605
2004	29714
2005	37621
2006	41565
2007	48387
2008	48022
2009	50479
2010	61869
2011	66134
2012	65801
2013	70508
2014	84585

The independent variable of BP neural network input layer is the main factors affecting the changes of freeway traffic flow, as shown in table 2.

Table 2 the main factors influencing the changes of traffic flow of freeway

year	GDP per capital	industrial production	fixed assets investment value(trillions yuan)	Population(ten thousand people)	passenger volume (ten thousand people)
1999	89677.05	35861.5	2.99	125786	1269004
2000	99214.55	40033.6	3.29	126743	1347392
2001	109655.17	43580.6	3.72	127627	1402798
2002	120332.69	47431.3	4.35	128453	1475257
2003	135822.76	54945.5	5.56	129227	1464335
2004	159878.34	65210	7.05	129988	1624526
2006	216314.43	91310.9	10.99	13.1448	1860487
2007	265810.31	110534.4	13.73	13.2126	2050680
2008	314045.43	130260.2	17.28	13.2802	2682114
2009	340902.81	135239.9	22.46	13.345	2779081
2010	401512.8	160029.6	27.81	13.4091	3052738
2011	473104.05	175417.3	31.1	13.4735	3286220
2012	519470.1	194836.1	36.48	13.5404	3557010
2013	568845	209746.9	43.65	13.6072	1853463
2014	636463	227981.1	50.2	13.6782	2206656

4.2 Building Model

Based on the BP neural network model of the nonlinear function fitting process, it can be divided into three links:BP neural network construction, BP neural network training and BP neural network prediction.

In the construction of BP neural network, the structure of BP neural network can be determined according to the nature of the studied problem. In this paper, because the nonlinear function has two input independent variables, an output dependent variable, the structure of the BP neural network is 2-5-1, the algorithm flow is shown in Figure 1 [17].

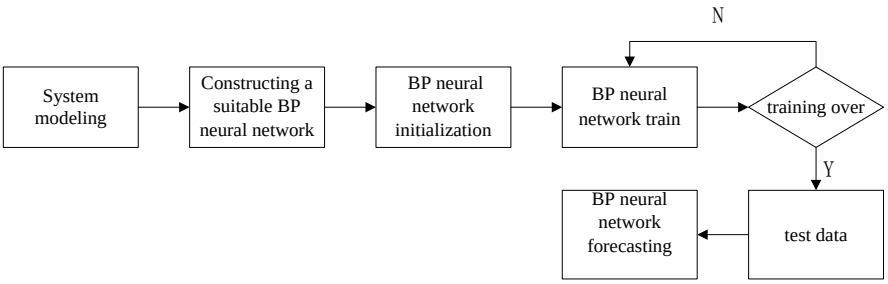

Fig. 1 algorithm flow

4.3 MATLAB implementation

4.3.1 Matlab programming

First, create two matrix in the workpace,which is input variables and output variables, as shown in figure 2. According to the nonlinear function equation,we can get 16 groups of input and output data, the data will be saved in the data.mat file.

Fig.2 ecreating a matrix

In the group,we select 10 group of data as the network training data from the input and output data in the workpace randomly , the 6 group of data as the network test data, and integrate the data needed to be trained. Procedures are as follows:

```
%% empty environment variable
close all
clear all
%% training data prediction data extraction and normalization
%download input / output data
load data factor response
%random ordering from 1 to 16
k=rand(1,16);
[m,n]=sort(k);
%find out training data and forecast data
factor_train=factor(n(1:10),:)';
response_train=response(n(1:10));
factor_test=factor(n(11:16),:)';
response_test=response(n(11:16));
%sample input and output data normalization
[factorn,factorps]=mapminmax(factor_train);
[responsen,responseps]=mapminmax(response_train);
```

Ten groups of training data were randomly selected to train the BP neural network, so that it can predict the nonlinear and complex functions. Procedures are as follows:

```
%% BP network training
% %initialize network structure
net=newff(factorn,responsen,5);
%% network parameter configuration(epochs is 300,learning rate is 0.1,goal is 0.00004）
net.trainParam.epochs=300;
net.trainParam.lr=0.1;
net.trainParam.goal=0.00004;
%network training
net=train(net,factorn,responsen);
```

BP neural network has been trained to predict nonlinear, complex function output, and through the BP neural network to predict the output and expected output in two aspects to analyze the fitting ability of BP neural network. Procedures are as follows:

```
%% BP network prediction
% intergrating prediction data
factorn_test=mapminmax('apply',factor_test,factorps);
%network predictive output
an=sim(net,factorn_test);
%network output anti intergration
BPresponse=mapminmax('reverse',an,responseps);
%% result analysis
figure(1)
plot(BPresponse,':og')
hold on
plot(response_test,'-*');
legend('actual output ','expected output ')
title('BP neural network predictive output ','fontsize',12)
ylabel('function output ','fontsize',12)
xlabel('sample','fontsize',12)
%prediction error
error=BPresponse-response_test;
figure(2)
plot(error,'-*')
title('BP network prediction error ','fontsize',12)
```

```
ylabel('error','fontsize',12)
xlabel('sample','fontsize',12)
figure(3)
plot((response_test-BPresponse)./BPresponse,'-*');
title('percentage of neural network prediction error ')
errorsum=sum(abs(error))
```

4.3.2 forecast simulation results

We treat the passenger flow as the output, BP neural network prediction, prediction error as shown in figure 3, 4:

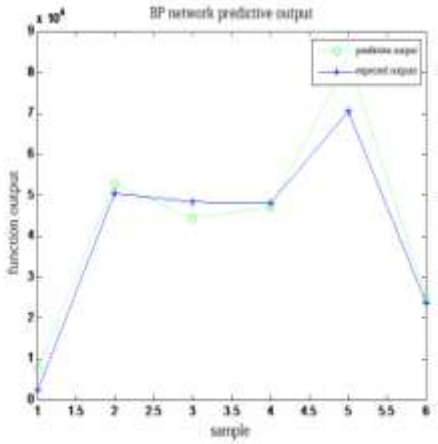

Fig.3 BP neural network prediction

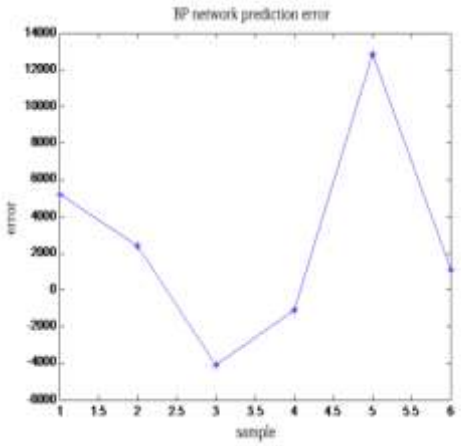

Fig.4 prediction error of BP neural network

Results: because the input parameters of BP neural network are small, the model can not fit the very accurate nonlinear complex function, and the error between the output and the expected output is relatively large. If conditions permit, by using different training function training network, the BP neural network algorithm can be improved.

4.4 Freeway system interfaced

Through the graphical user interface,the freeway system can be interfaced: interface design, import data, write the program, run the program. Display the interface of freeway passenger flow prediction , as shown in figure 5.

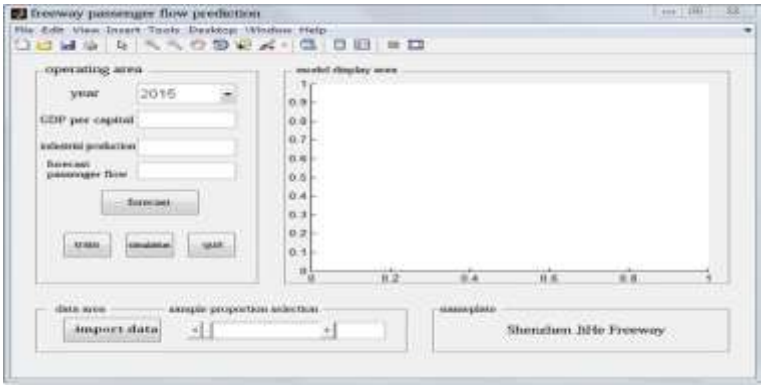

Fig.5 the interface of freeway passenger flow prediction

In the operating area,we can select the years, input the corresponding GDP per capita , industrial output value; data import, select the appropriate sample proportion; click on training, simulation, prediction, then it can show error percentage figure as well as the value of passenger flow prediction , as shown in Figure 6.

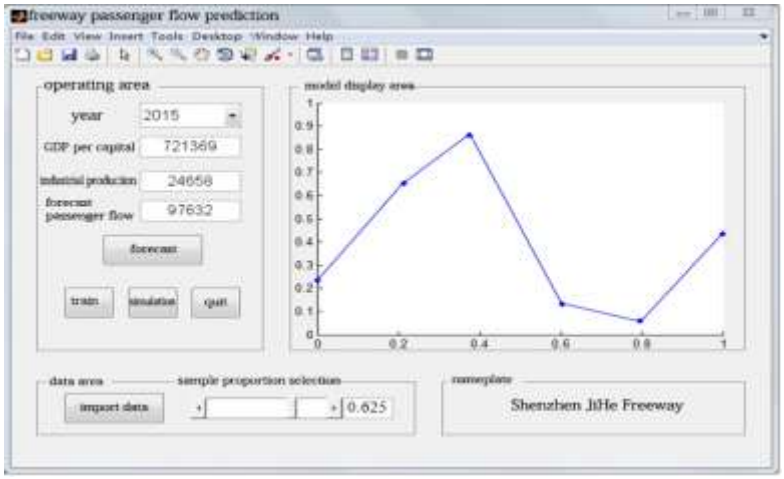

Fig.6 results chart of the interface of freeway passenger flow prediction

V. CONCLUSIONS

With the Shenzhen Jihe highway traffic as the research object and based on the analysis of traffic and various influencing factors, aiming at the the non-linear complex system, the paper proposes the BP neural network model for the forecast of expressway traffic volume. Therefore, choosing the best network structure is the key to the design of the network.Neural network model is a kind of non-liner mapping. Learning and training through a large number of samples made this mapping be the best approach to the travel time of object of the study[18].By using MATLAB software, the simulation model of neural network prediction is programmed, and the passenger flow prediction and error analysis are obtained.From the prediction results, the prediction results of the 3 layer BP neural network model are relatively correct.

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