HIGH-SPEED RAILWAY PASSENGERS' CHOICES OF TRAVEL FORECAST BASED ON MATLAB NEURAL NETWORK

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Abstract: As a newly developing mode of transportation, high-speed railway is expanding its influences on national economy and social life. At present, domestic research on high-speed railway mostly focus on tech level, no systematic and comprehensive research have been done to the aspect of passenger travel. This study taking uses of Matlab 6.6 concentrates on environmental factors' effects on travel choices of High-speed railway passengers, building up a forecast model based on BP Artificial Neural network. Through the comparison and analysis of predicted and real data, effectiveness of this method is proved.

1 INSTRUCTION

Nowadays, the high-speed railway system is considered as one of the most impressive achievement in the railway-high-tech area around the world. It is prevailing in the currency of the railway developing projects in lots of countries, not only because of its huge transport capacity, fast-speed, and high security confidence and also due to that it owns perfect punctuality, convenience and comfort. What's more, it consumes less fuel and is friendlier to the environment. As an emerging way of transport with a fascinating prospect, high speed railway system is foisting his influence on regime economy growth, air transport and other aspects in our country's development in socio-economy level. Most of today's researches on high-speed railway in our country are focusing on tech level, and lost a system and overall discussing on the factors imposing on travelers. Travelers, as the clients of the high-speed railway , their trips should be covered and analyzed as a important issue in order to provide constructive advises, which may be significant in the future development of high-speed railway system.

High-speed railway system in our country transfers an enormous passenger flow every year. Unbalance is the passenger demand in both aspects of area and time that it is pretty difficult for people to predict the passenger travel trend. The ticket supply is often inadequate to meet the demand at certain times of a year. Besides, high-speed railway system's ability to transfer passengers is restricted to some limits like the volume of freight traffic. Due to the multifarious and complicated factors involved, in which most one are none-linear, apparent limitations may exist if traditional aggression methods were used. Nowadays, our economy's rapid development has brought significant improvement to people's life, as a consequence that Citizens have put more emphasis on degree of comfort and environmental factors rather than traditional factors like price, distance and time. If the high-speed railway system in our nation wants to serve better and accomplish its historical task of providing more conveniences to the public, it has to put sufficient attention on its environment construction. To reiterate, a forecast model on high-speed railway passengers' travel was built focused on the environmental factors in traveling.

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The artificial neural network grew up in the 1980s, developing through several periods including initial growth, upsurge and climax, troughs and the second rapid growth. The artificial neural network imitates the real biological neural network, consisting of quantities of neurons that have none-linear mapping ability and connecting each other with weight coefficients. The massive parallel structure helps the network to acquire wonderful characteristics like Automatic Knowledge Acquisition, robustness, fault-tolerance, learning ability and adaptability, and to show superiority in setting up models for complicated systems than traditional model analysis models.

Because of its specific structure and methods in dealing information, the artificial neural network is being made great use of in numerous actual applications, such as automatic control, image processing, pattern recognition, signal processing, robot control, welding, geographical analysis, data mining, military affairs, transportation application, mining industry, agriculture research, and meteorological analysis and so on. Among a few frequently-used neural networks, the BP neural network is used most extensively, and its practical utility is best embodied in forecasting time series like national economy and population development.

As a none-linear simulation technology with fault-tolerance, learning ability and adaptability, the artificial neural network provides a feasible and practicable solution to solving problems concerning high-speed railway passengers' travel choices.

2 PRINCIPLES AND THE STRUCTURE OF THE BP NEURAL NETWORK MODEL FOR FORECASTING PASSENGERS' TRAVEL CHOICES OUT OF ENVIRONMENTAL FACTORS

The study attempted to build a forecast model using BP neural network to research on environmental factors that affect high-speed railway passengers' travel choices based on a survey conducted from January 1 to January 30 in 2010 with 1270 questionnaires that were distributed at random to high-speed railway passengers. Environmental factors that affect passengers' travel choice are definitely of various kinds, the questionnaires used in the research picked two main aspects including comfort level and security level. Each of the aspects was set to separate into eight degrees from "extraordinary bad" to "extraordinary good", from which respondents could choose according to their own experiences and feelings. Considering that different means of conveyances would have various influences on passengers' selections, a third impact factor was taken into account, namely "means of conveyance". The options set in this factor were: 1.hard-seat, 2.soft-seat, 3.hard sleeper, 4.soft sleeper, 5.standing-room ticket, 6.unknown. For the reason that some other factors besides environmental factors would also have impacts on passengers' travel choices, all the others factors were concluded into a forth aspect falling under passengers' degree of satisfaction as a whole in order not to jeopardize the research on environmental factors. The options set in the forth aspect were also separated into eight degrees from "extraordinary satisfied" to "extraordinary unsatisfied" for respondents to choose from. In view of the prediction of passenger's next choice on various traffic modes, a fifth question was set as "The next traffic mode you would choose:", and the options were as follows: 1. the Multiple Units, 2. The Through Train, 3. The inter-city bus, 4. Aircrafts, 5. Self-driving. The ultimate result of the survey consisting of 1270 eligible questionnaire, from which 503 valid records were screened based on Rough Set methods.

The BP Neural network usually consists of three layers including the input layer, the hidden layer and the output layer. The numbers of nodes in the input and output layer are decided by sample dimensions constructed by data processor, and the number of nodes in the hidden layer is determined by both of the numbers of the input and output layer. The work process of the Neural network is composed of two stages, one is the work period, in which the weights connected each nodes are fixed and calculating each unit's state change in order to keep stability; the other is the learning period, in which each calculation unit's state is fixed while the weights connecting them are changeable and modified. A neural network is train for the purpose that a group of input vectors could produce a group of expecting and efficient output vectors. The training process is realized through certain process (Learning Algorithm) in which the network's weights are modified based on a series of training samples.

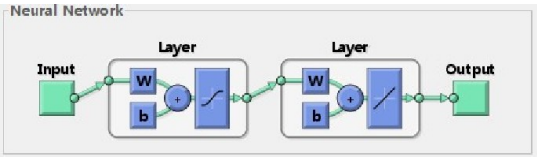

Figure 1: Structure of BP Neural network.

The BP Neural network model for forecasting passengers' choices of travel out of environmental factors consists of two parts: data processing unit and the BP Neural network. The real data of passengers' travel was processed in the first part and formed the sample for experiment. The input layer of the BP neural network is set to include four nodes according to the four influence factors in the investigation data, each of which separately represents the degree of comfort, the security standard, the pattern of embarkation and the general satisfication degree. The output layer has one node representing the choices of travel for the next time. The number o nodes for hidden layer could refer to the formula below:

$$L<n-1 \quad (1)$$

$$L<(m+n)1/2+a \quad (2)$$

$$L<\log 2n \quad (3)$$

In the formulae above, n represents the number of nodes in the input layer; l represents the number of nodes in the hidden layer; m represents the number o nodes in the output layer; a could be any constant between 0 and 10.
This study picks 5 as the number of the hidden-layer's nodes based on experiences.

3 METHODS FOR FORECASTING PASSENGERS' CHOICES OF TRAVEL OUT OF ENVIRONMENTAL FACTORS BASED ON BP NEURAL NETWORK

When using the BP neural network model to forecast the passengers' behaviors, two main steps are built including data processing and the neural network establishment. The concrete algorithm is as follows:

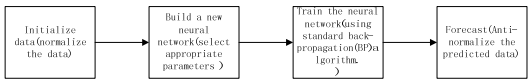

Figure 2: Algorithm process of the BP neural network forecast model.

Step 1: 400 sets of data for training are randomly selected from 503 sets of original data that are effective. The other 103 sets of effective data are used for forecasting. Input represents the input data and output represents the output data.

```
k=rand(1,503);
[m,n]=sort(k);
input_train=input(n(1:400),:)';
output_train=output(n(1:400),:)';
input_test=input(n(401:503),:)';
output_test=output(n(401:503),:)';
```

Step 2: Normalization of data for training. To normalize the training data can largely improve the Network's training speed and accuracy. Function mapminmax in Matlab is chosen to normalize the training data.

```
[inputn,inputps]=mapminmax(input_tra
in);
[outputn,outputps]=mapminmax(output_
train);
```

Step 3: Build up the Neural network.

```
net=newff(inputn,outputn,5);
```

Step 4: Establishment of neural network parameters. With data normalized, less iteration times are needed when the number of experiment data is not enormous. The learning rate usually is set between 0.01~0.1 according to various models. So do the choice for the goal of accuracy .
The learning rate is chose at 0.05 in this study and iteration times is set at 1000 based on experience. The goal of the training is initially set at 1 e-10.

```
net.trainParam.lr = 0.05;
net.trainParam.epochs = 1000;
net.trainParam.goal = 1e-10;
```

Step 5: Training for BP neural network. The neural network training's performance depends on choices of transfer function, training function and many other parameters. Here the most commonly used functions in the matlab neural toolbox are taken as the tool for training the BP Neural network.
net=train(net,inputn,outputn);

Step 6: normalization of the predicted data and the counter-normalization of the BP neural network's forecast outputs. Because the training data has been normalizd before, the same process should be taken to the data or forecasting. Use the trained Neural network to forecast output data and counter-normalize the output
data.

```
inputn_test=mapminmax('apply',input_te
st,inputps);
an=sim(net,inputn_test);
BPoutput=mapminmax('reverse',an,output
ps);
```

Step 7: Analyze the forecast result and error.

4 APPLICATION AND THE FORECASTING RESULT

In order to evaluate the forecast result, the survey data was used to conduct a simulation research based on Matlab 6.6. A BP Neural network consisting of four input nodes, one output node and five nodes in the hidden layer was built and trained to forecast the environmental factors' impacts on High-speed railway passengers' travel choices, and the result is shown in figure3. Figure 4 represents the forecast error in the training and forecasting process with the neural network. Figure 5 shows the training performance of the network.

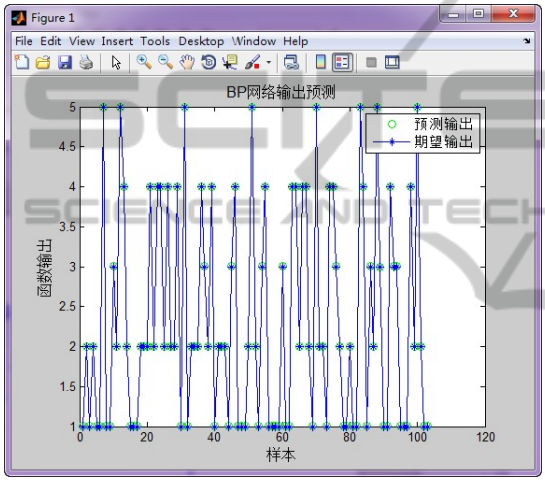

Figure 3: The BP neural network's forecast result on passengers' travel choices.

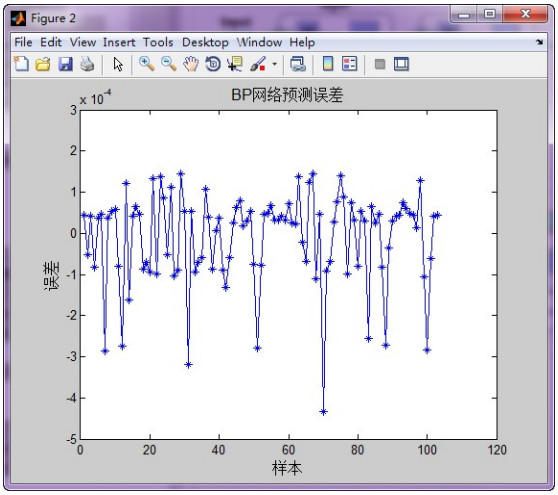

Figure 4: The forecast error of the BP neural network model.

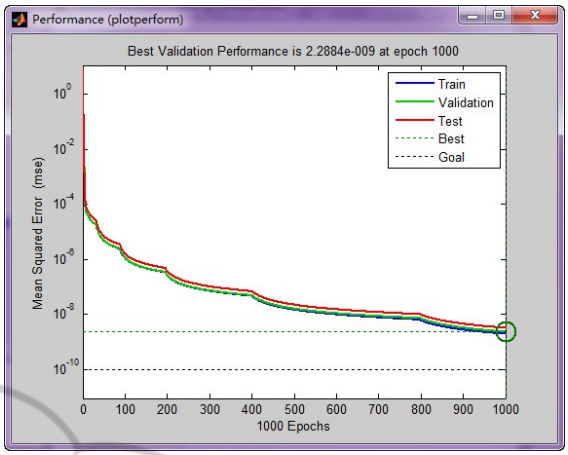

Figure 5: The training performance of the BP neural network.

After 1000 times of learning process, the BP Neural network achieved the best performance with a minimum error of 2.2884e-009, and the network came to a convergence ending the training process. The forecast result concluded in this research is scientific and accurate, demonstrating the validity of using BP neural network in analyzing environmental factors' effects on High-speed railway passengers' travel choices.

5 CONCLUSIONS

Based on the establishment of BP neural network, we take the influences that the complicated and non-linear environmental factors have on High-speed railway travel into the extent that it can be predicted and analyzed. The neural network built in this experiment is of high accuracy. In practical application, only with a few basic information including travel mode, comfort degree, security level and degree of satisfaction could researchers use this model to forecast what kind of mode passengers will take for travel in their next trip. Through controlling variables, we could also study what will change in passengers' travel choices in the event of various environmental factors. Thus, it will aid in decision-making of forecasting traffic flow. At the mean time, our government could control or improve those factors that have enormous implications in affecting people 's choices according to our model's result, so as to better macro-control our traffic systems and improve citizen's travel quality.

The specific characteristics of neural network that it has a good simulation of nonlinear operation and can deal with self-organizing and self-learning problems

make it unnecessary for us to analyze in detail what distinctive futures like safety and comfort degrees and how big the influence on choosing traveling means each factor has, but simply to choose formats of study samples data and some parameters of learning process for neural network, we can make the neural network learn by itself, thus avoiding the condition that the man-made model that was built according to the traditional methods does not match with the actual situation, which leads to inaccuracy.

But, in terms of the environmental factors affecting traveling, it is certain that the factors we choose might be incomplete, and we can't eliminate the influences of other factors such as price and time besides the environmental factors on the choices of travel modes. What is more, a better solution of choosing parameters for the established BP neural network may exist. How to establish a more effective neural network model remains a valuable subject. The research is based on the popular topics on environmental factors in recent years, establishing a BP neural network model with a small error and high precision, which could be a beneficial and promising explore in this area. To reiterate, a further experiment and research is expected.

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