ISSN 1816-6075 (Print), 1818-0523 (Online)
Journal of System and Management Sciences
Vol. 3 (2013) No. 1, pp. 41-50

A comparative study on predict effects of railway passenger travel choice based on two soft computing methods

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Abstract: The travelling factors acting on the railway passengers changes greatly with the passengers' choice. With the help of the modern information computing technology, the factors were integrated to realize quantitative analyze according to the travel purpose and travel cost. The detailed comparative study was implemented with the two soft computing methods: genetic algorithm, BP neural network. The two methods with different idea, applicable range applicable and the key parameters set were also studied in this model. The anylized methods were also proved effective and applied for predicting the railway passengers travel choice through the empirical study with soft-computing supporting.

Keywords: Railway Passenger, Travel Choice, Genetic Algorithm, BP Neural Network, Comparative

1. Introduction

Railway is an effective way to solve the rapid transportation problem of large number of passengers on a major thoroughfare. In recent years, along with the accelerating process of urbanization in China, there is increasingly demand for transportation between big cities, and China is stepping into the period of great construction and development of railway (Yao, 2010). The completion of different transportation modes between cities is increasingly fierce especially railway and aviation(Chen & Ji, 2008; Qiang & Yan, 2006). In order to better planning and coordination of the overall transportation system, and better construction and operation of railway network, so that the railway can make a bigger social and economic benefits, and one of the key issues is derived from the understanding of railway passengers' travel choices.

2. Analysis of Present Research

There are researches for passengers' travel choices (Wu & Xu,2007), but because of different starting points, apart from the great differences among the above related research methods, models, experimental conclusions and theoretical details, they are also not suitable for the deep-seated reveal of railway passengers' travel choice problem. In existing prediction models (He & Wang, 2009; Ma, et al., 2009), quantitative factors are only for the macro data in a specific section (such as certain administrative areas), ignoring some important details of travel choice that would be considered by residents, such as soft factors like comfort, punctuality, safety etc. Thus the problem information can be considered incompletely, missing some important factors, what's more, not making a scientific and objective analysis for the weight of the factors, and the discussion of the constrains is also very vague in the prediction model. So it is necessary to make comparative research and discussion about the application scope, the relevant parameters and constraints of different soft computing methods. In this paper, Genetic Algorithms and Neural Network are two examples of soft computing methods for a comparative research (Jin & Jia, 2008).

3. Study on Railway Passenger Travel Choice Prediction Based on Genetic Algorithm

Genetic algorithm (GA) is a random search method. It decreases the effect of original values greatly through crossover and mutation operations, and it can easily find out the global optimal results (He & Wang, 2009).

Passengers make travel choices will be influenced by some objective, potential factors. Through analyzing the passengers' characteristics and different factors' effects on passengers, we got a flow chart of passenger travel.

3.1. Model

The problem was described as: there were m travel modes and n batches of passengers (category) waiting to be distributed.

Before the target allocation, the key considerations of each batch of the target and each travel mode's weight on each target has been evaluated and sorted. J-approved visitors' "travel value" is w_j , i-approved travel mode's weight on j-approved target is p_{ij} , and each travel mode's "trial" benefit value on each target is $u_{ij} = w_j * p_{ij}$. Among them, u_{ij} stands for each batch of the passenger's size of the degree of the effectiveness of the "trial". The purpose is to meet the basic principles of the target allocation and pursuit of the overall effectiveness of the best, which is seeking $\max(\sum_{j=1}^{n} u_{ij})$.

3.2. Methods

This paper used binary encoding and the number of individuals was 40. In addition, the max number of generations was 50 and the generation gap was 0.90.

This paper used PN instead of passenger numbers and TV instead of travel value.

Based on the numerical analysis of questionnaires, the standard value of the price dimension is 3.16, the standard value of the time dimension is 2.69 and the standard value of the environmental dimension is 4.47.

Choices for passengers to choose for travel：

①EMUs ②Direct train ③Coach ④Aircraft ⑤MICE

According To the Purpose

Passengers for business always focus on convenience and comfort, but have low sensitivity of the cost, so the weight for the price dimension is 0,for the time dimension is 0.6 and for the environment is 0.4, that is, for the purpose of business, "travel value" is 0.6*2.69+0.4*4.47=3.402. Passengers for tourism often focus on comfort and fare levels, and have high sensitivity of the cost, so the weight for the price dimension is 0.3 and for the environment is 0.7, that is for the purpose of tourism, "travel value” is 0.7*4.47+0.3*3.16=4.077. Work, school and other commuter passenger traffic often takes fare for the primary consideration, and has certain requirements on punctuality, so the "travel value" for the passengers whose purpose is going to work is 0.6*2.69+0.4*3.16=2.878, passengers to school's "travel value " is 0.2*2.69+0.8*3.16=3.066. Passengers for home have low requirements for the comfort, often focus on the price level and have high sensitivity for the costs, so the "travel value" is 1*3.16=3.16. Passengers for transfer have high requirements for time, so the "travel value" is 1*2.69 =2.69. Other passengers' weights are similar, that is, its "travel value" is 0.3*2.69+0.3*4.47+0.4*3.16=3.412.

Table 1: Travel value: According to the travel purpose.

PN	1	2	3	4	5	6	7
TV（w_j）	3.402	4.077	2.878	3.066	3.16	2.69	3.412

Table 2: Weights: According to the travel purpose.

i-j(p_{ij})	1	2	3	4	5
1	0.44	0.01	0.01	0.53	0.01
2	0.19	0.23	0.31	0.22	0.05
3	0.23	0.36	0.18	0.11	0.12
4	0.15	0.42	0.26	0.12	0.05
5	0.15	0.52	0.19	0.13	0.01
6	0.31	0.41	0.26	0.01	0.01
7	0.25	0.25	0.25	0.25	0.25

According To the Cost Mode

Because the travel time is included in the cost of production, passenger traffic at public expense will pay more attention to time and look for convenient, fast and punctuality while they are choosing the travel mode. Therefore they have higher selection bias of civil aviation and high-speed railway. Moreover, they have higher requirements about the frequency of the mode of transportation, departure time and arrival time. And they are less sensitive to the travel cost. So the weight for the time dimension is 0.42 and for the environment dimension is 0.58, that is, the "travel value" is 2.69+4.47*0.42*0.58=3.7224. However, passenger traffic at their own expense will have lower requirements for the quality of transport and higher sensitivity for the travel costs because they must pay for themselves. So the "travel value" is 0.8+0.2*3.16*4.47=3.422.

Table 3: Travel value: According to the cost mode.

PN	1	2
TV(w_j)	3.7224	3.422

Table 4: Weights: According to the cost mode.

i-j(p_{ij})	1	2	3	4	5
1	0.28	0.39	0.05	0.27	0.01
2	0.12	0.43	0.11	0.17	0.17

According To Income

The previous data showed that middle-income and less income stream of passengers have a preference for the traditional existing rail or road. And for the travel costs are the main considerations, they have a relatively low requirement for the transport quality such as comfort, convenience and punctuality. In addition, they have a relatively high degree of sensitivity for the fare level, so the fluctuations in fares will cause great changes in the passenger traffic distribution. So the "travel value" for the lower-income is 0.9*3.16+0.09*2.69+0.01*4.47=3.1308. And the "travel value" for the low-income passenger is 0.9*3.16+0.082*2.69+0.02*4.47=3.1486. The "travel value" for the middle-income passenger is 0.5*3.16+0.25*2.69+0.25*4.47=3.37.

Passengers who have high and higher income will take comfort, convenience and punctuality into consideration because they have high abilities to pay, and they always select high quality transportation services, such as high-speed railway, civil aviation. What's more, these passengers are less sensitive to the cost, so a certain range of fluctuations in travel mode will have a little influence on them. So the "travel value" for those high-income is 0.21*3.16+0.39*2.69+0.4*4.47=3.5007, and the "travel value" for the higher-income is 0.15*3.16+0.36*2.69+0.49*4.47=3.6327.

Table 5: Travel value: According to income.

PN	1	2	3	4	5
TV（w_j）	3.1308	3.1486	3.37	3.5007	3.6327

Table 6: Weights: According to income.

i-j(p_{ij})	1	2	3	4	5
1	0.01	0.37	0.11	0.01	0.01
2	0.01	0.57	0.31	0.02	0.01
3	0.01	0.03	0.41	0.05	0.01
4	0.68	0.02	0.07	0.42	0.43
5	0.28	0.01	0.09	0.50	0.54

3.3. Forecast Analysis

Firstly, because the background is under the spring festival, some predictions may not match exactly with the normal. During the spring festival, different passenger may have different considerations with the usual, such as the price, the time and the environmental dimension. Many people may take "as long as arrive the destination" into main consideration in the pessimistic circumstance, but not for the other factors.

According To the Purpose

Because the passengers for tourism have higher requirements for the time and environment, moreover, most of them are free trips; their sensitivity to the price level is relatively lower. The predicted result showed they would choose plane for their next trips, this is more objective. Passengers for home and transfer have higher requirements for time, so the predicted results are more objective.

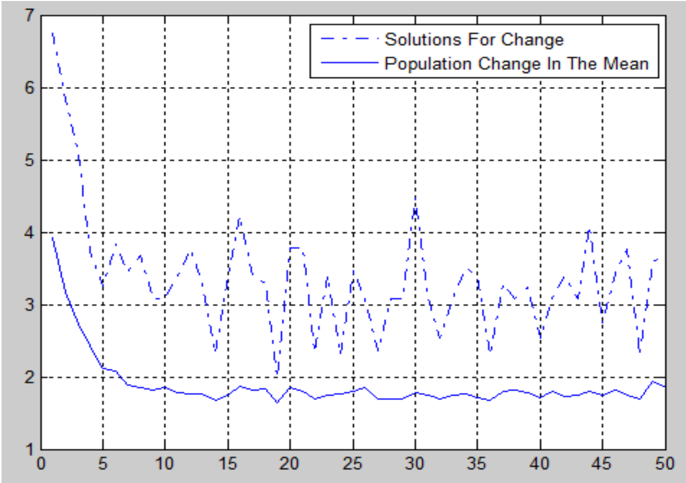

Fig. 1: Predictions: According to the travel.

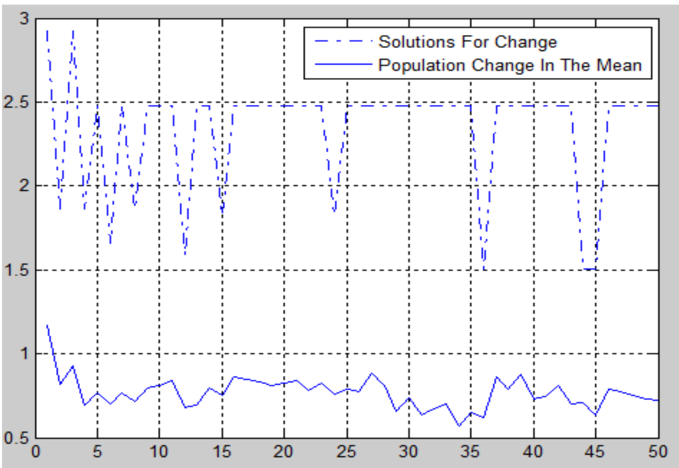

Fig. 2: Predictions: According to the cost mode.

Figure 1 is the application made by Matlab. It is a change tracking map of the total effective value and the mean of the population.

According To the Cost Mode

Passengers who travel at their own expense have low sensitivity for the price, because they do not pay the fees, they will take time or comfort into consideration. So the predictions are more objective. However, the train is less expensive compared with other mode of travel, the passengers who travel at their own expense choosing the direct train is more realistic.

Figure 2 is the application made by Matlab. It is a change tracking map of the total effective value and the mean of the population.

According To Income

In real life, most low-income passengers will choose direct trains as their travel mode for the price is lower, and this is very beneficial to those low-income passengers. However, middle-income passengers will be on a more balanced consideration of all aspects, so the predictions are more realistic. High and higher-income passengers are less sensitivity to the price, what they care about are time, comfort, so the predictions is also close to reality.

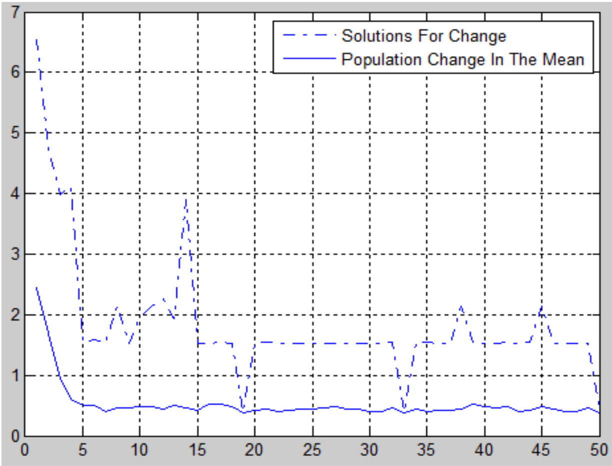

Fig. 3: Predictions: According to income.

Figure 3 is the application made by Matlab. It is a change tracking map of the total effective value and the mean of the population.

4. Study on Railway Passenger Travel Choice Prediction 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:

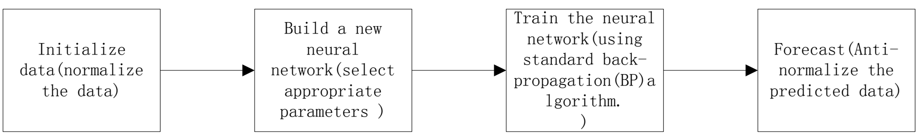

Fig. 4: Algorithm process of the BP neural network forecast model.

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 (Qiu & Wang, 2009), 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 (Ren, Song, &Wu, 2009; Xu & Zhang, 2006), and the result is shown in figure5. Figure 6 represents the forecast error in the training and forecasting process with the neural network.

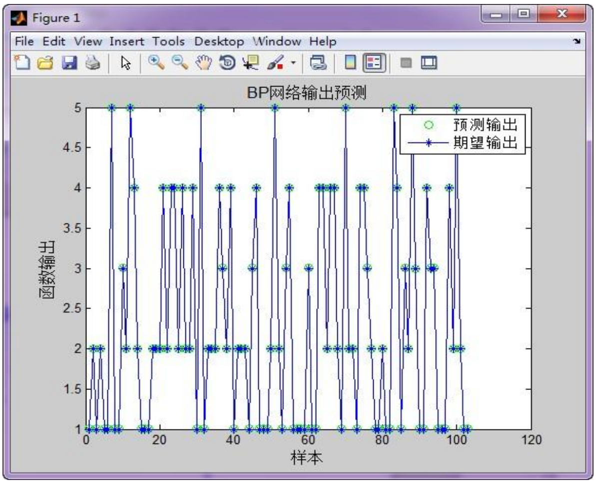

Fig. 5: The BP neural network's forecast result on passengers' travel choices

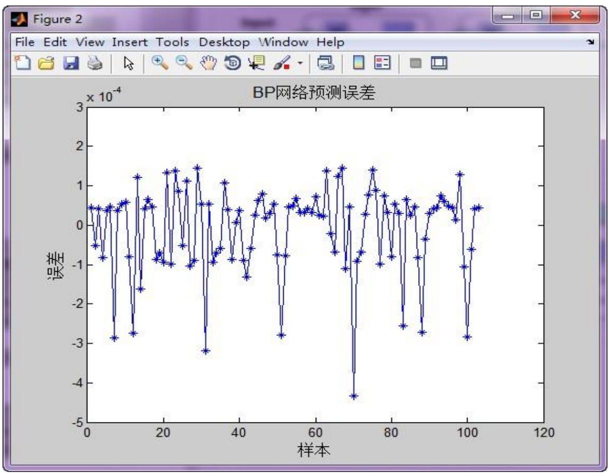

Fig. 6: The forecast error of the BP neural network model

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. Conclusion

We could prove through the empirical study that the soft computing methods applied above are both effective for predicting the railway passenger travel choice. However, the basic idea, the range applicable and the key parameters set in the model are different.

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.

Through the analysis above, the detail from comparative study could be provided for researchers and managers and be applied in the practice according to the actual demand.

Acknowledgement

This paper is supported by the National Natural Science Foundation.

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