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Forecast and Application of GA Optimization BP Neural Network Tourism Demand in High-speed Railway Era

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Abstract. The arrival of the high-speed rail era has profoundly affected China's tourism demand, making it towards uncertainty, and traditional tourism demand forecasting methods need to be innovated. Using Matlab (2014a) to construct a BP neural network model based on genetic algorithm (GA) optimization, taking the number of tourists and tourism income of Sanjiang Dong Autonomous County in Guangxi as sample data, the model is trained repeatedly, and the number of tourists and tourism income are predicted and analyzed, and the model is applied to the forecast of tourism demand in the era of high-speed railway. The example simulation results show that the GA-optimized BP neural network model in the high-speed rail era has better adaptability and prediction accuracy in tourism demand.

1. Introduction

High-speed rail, by international definition, usually refers to railways running at speeds above 250km/h^[1]. By the end of 2017, the mileage of China's high-speed railway had reached 25000 km. According to the "Medium and Long-term Railway Network Planning (2016)", China plans to achieve a high-speed railway operating mileage of 38,000 kilometers by 2025, strengthen the connection between provinces, cities and counties, and build a new pattern of "eight vertical and eight horizontal" high railway network. The forecast of tourism demand has always been a key concern of our country. However, due to the "Pan-industry" of the tourism industry, China's tourism demand forecast has greater uncertainty. With the advent of the high-speed rail era, China's tourism demand forecast will face greater challenges. With the arrival of the high-speed railway era, China's tourism demand forecasting will face greater challenges. The traditional means of tourism demand prediction can no longer meet the precision requirements of the high-speed railway era, so it is urgent to innovate.

BP neural network is a kind of multi-layer feedforward neural network algorithm proposed by Rumelhart, et al. in 1986. It is widely used in artificial neural networks, and its shortcomings are too slow and the network structure is not easy to determine. However, genetic algorithm can optimize the optimal initial weight and threshold of network training, so as to achieve the best effect in the prediction of tourism demand. At present, there are few researches on tourism demand model based on BP neural network model optimized by genetic algorithm, and there are few researches on tourism demand prediction under the background of high-speed railway era. Therefore, this paper constructs a BP neural network tourism demand forecasting model based on genetic algorithm (GA) optimization, which provides a reference for the innovation of tourism demand forecasting model in the era of high-speed



railway.

2. Overview of relevant studies

Previous tourism studies have shown that the main factors influencing tourism demand include tourists' per capita income, leisure time and tourism motivation (Zhang Hua, 2014), travel destination transportation cost (Munoz, 2006), reception service facilities and social consumption level (Yu Qiuyang, Yang Sihan, 2017), etc^[2-3]. In the era of high-speed rail, high-speed rail can reduce the time and space cost of tourism (Wang Degen, 2014), changing the spatial pattern of tourism destinations (Wang Degen, Qian Jia, Niu Yu, 2016, Yin Yi, 2017), the choice of travel modes, travel motives and consumer preferences for tourists (Cui Li, Li Xinjian, Zhang Fangfang, 2014), tourist destinations factors such as choice, service reception level (Zheng Meiyu, Guan Hongyu, Su Wenhui, 2016) and social consumption structure (Albalade D., 2016) all have certain effects^[4-10]. Therefore, the tourism demand has many influencing factors and the data acquisition is difficult. The arrival of the high-speed rail era has deepened the difficulty of China's tourism demand forecasting.

At present, BP neural network, as an intelligent method of machine learning, has been widely recognized by domestic and foreign experts and scholars in the prediction of tourism demand. Jia Peng et al. established a cruise tourism demand forecasting model based on BP neural network by studying the influencing factors of cruise tourism demand, and finally applied the model to the forecast of China's cruise tourism demand scale^[11]. Zhang Jiekuan et al. proposed a gray neural network prediction model optimized by dynamic particle swarm optimization (PSO) based on the standard particle swarm optimization algorithm, and verified the model accuracy of tourism demand^[12]. However, BP neural network still has many limitations. For example, the number of hidden layer nodes in the model is difficult to grasp, the parameter setting in the neural network is not qualitative, and the obtained function does not necessarily match the objective function, thus affecting learning performance and prediction accuracy.

Genetic algorithm (GA) provides effective support for overcoming the limitations of BP neural networks. The BP neural network prediction related research on GA optimization at home and abroad mainly focuses on the fields of mechanical manufacturing, material chemistry, agricultural planting, etc., focusing on flow prediction, distance prediction, temperature prediction, and diagnostic prediction, and so on. Jahangiri M et al. used a three-amplifier state variable filter as the circuit under test (CART), and proposed a hybrid neural network based slash soft fault diagnosis method^[13]. Chen Zheng et al. provided a low-cost, high-efficiency method for predicting the measurement of spray penetration by establishing a BP neural network model based on GA optimization^[14]. In terms of tourism demand forecasting, Li shao-wen and other attempts to optimize the algorithm, based on Baidu index construction combined with principal component analysis, adaptive difference algorithm and neural network PCA-ADE-BPNN model to predict tourist traffic, but this model is too cumbersome, low universality^[15].

On the whole, the existing tourism prediction models in China are not intelligent, accurate and easy to carry out enough. The BP neural network based on GA optimization has less research and lacks its prediction and application in the field of tourism. Therefore, based on the background of the high-speed railway era, this paper constructs a BP neural network tourism demand forecasting model based on GA optimization, which enriches the related research.

3. Subjects of research and data sources

Sanjiang Dong Autonomous County is located in Liuzhou, Guangxi Zhuang Autonomous region, at the junction of Hunan, Guilin and Guizhou. It is 167 kilometers away from Guilin City and 203 kilometers away from Liuzhou City. It has a good geographical and tourist location. Guangxi is the first start-up train group of ethnic minority autonomous county. With the official opening of the Guiguang high-speed railway in December 2014 and the Liujiang Sanjiang bullet train in May 2016, Sanjiang County has opened a new era of high-speed rail, basically forming a three-hour tourism circle, and its tourism industry has witnessed rapid development. Therefore, the selection of Sanjiang County for empirical research has great reference value.

Considering the maturity of indicators and the accessibility of high-speed rail data, and consulting the opinions of experts and scholars on the basis of literature analysis, this paper adopts four indicators of the number of domestic tourists, the number of foreign tourists, domestic tourism income and foreign tourism income, based on the 1990-2016 related indicators data to build a tourism demand forecast model and carry on an empirical study. The original data are all from Liuzhou Statistical Yearbook and Sanjiang Dong Autonomous County Tourism Bureau website.

4. Modeling of BP Neural Network Based on GA Optimization

4.1. Algorithm flow

The basic idea of this paper is that BP neural network is the core of the whole model. However, because its learning convergence speed is too slow, it can not guarantee the convergence to the global minimum point, and the network structure is not easy to determine effectively, and so on, so in this paper, genetic algorithm is introduced to optimize the BP neural network model. With the initial weights and thresholds of the network represented by the individual, the norm of the prediction error of the BP neural network of the prediction sample is taken as the output of the objective function, and then the value of fitness is calculated, and the optimal individual is searched through selection, crossover and mutation operation. That is, to find the optimal initial weight and threshold of BP neural network.

In the process of establishing the tourism prediction model, the neural network structure is 2-7-2, and the genetic algorithm needs to optimize the parameters to 62. According to figure 1, the samples from 1990 to 2012 were used as training data, and the data from 2013-2016 was used as a prediction sample for model detection. In the process of designing the algorithm, the norm of the test error of the test sample is taken as a generalization ability of the network, and then the fitness value of the individual is calculated by the error norm. The smaller the individual error norm, the larger the individual fitness value, indicating that the individual is superior.

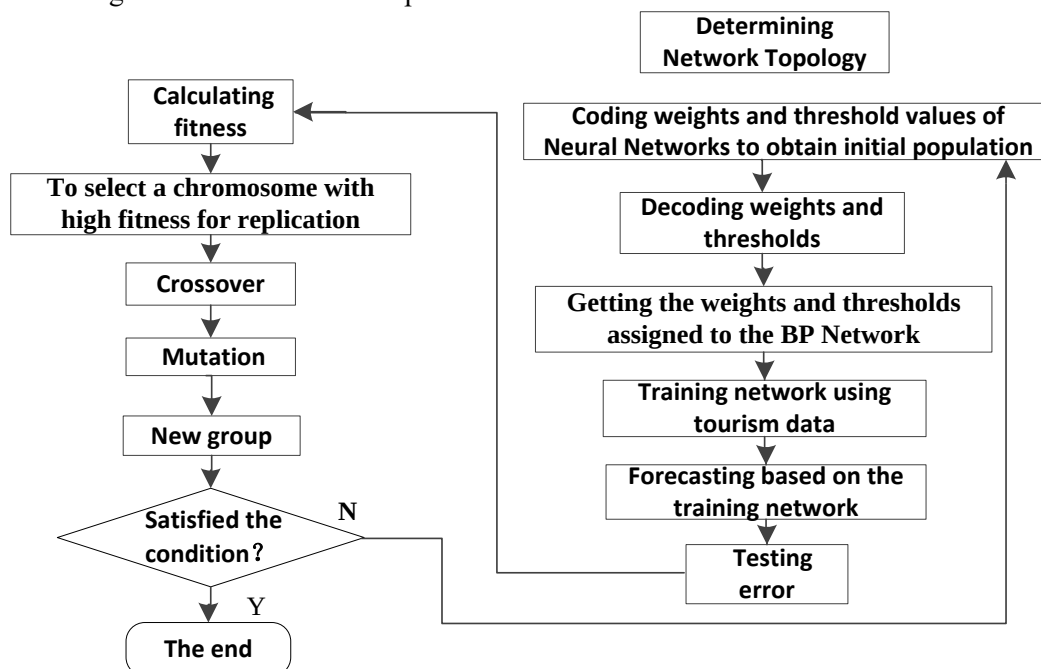


Figure 1. The algorithm flow chart

4.2. Model structure

The basic elements of genetic algorithms are chromosome coding methods, fitness functions, genetic operations, and operational parameters. Genetic algorithm optimization BP neural network is mainly divided into: BP neural network structure determination, genetic algorithm optimization weight and

threshold and BP neural network training and prediction. Usually, the weight and threshold of the neural network are obtained by randomly initializing the random number between $[-0.5, 0.5]$. This initialization result has a great influence on the network training, but it cannot be accurately obtained. Based on this, the transfer function of the hidden layer neurons of the neural network of this model uses the S-type tangent function $\text{Tansig}()$, and the transfer function of the output layer neurons uses the S-type logarithmic function $\text{Logsig}()$. At this time, the output mode is 0-1. To achieve the optimization of the weight and threshold of the neural network. The neural network model is shown in Figure 2.

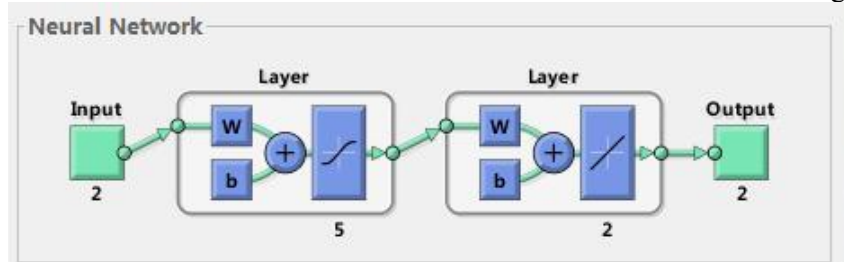


Figure 2. Structure diagram of neural network model

4.3. Model Training and Forecasting

Based on the time series, this model uses Matlab (2014a) to forecast the tourist volume and economic growth of Sanjiang County. The samples from 1990 to 2014 are used as training data, and the data of 2015 and 2016 are used as prediction samples for model detection. A genetic forecasting model for BP neural network optimized by genetic algorithm is constructed. Figures 3 and 4 show the changes in the number of domestic and foreign tourists and tourism income from 1990 to 2016, respectively.

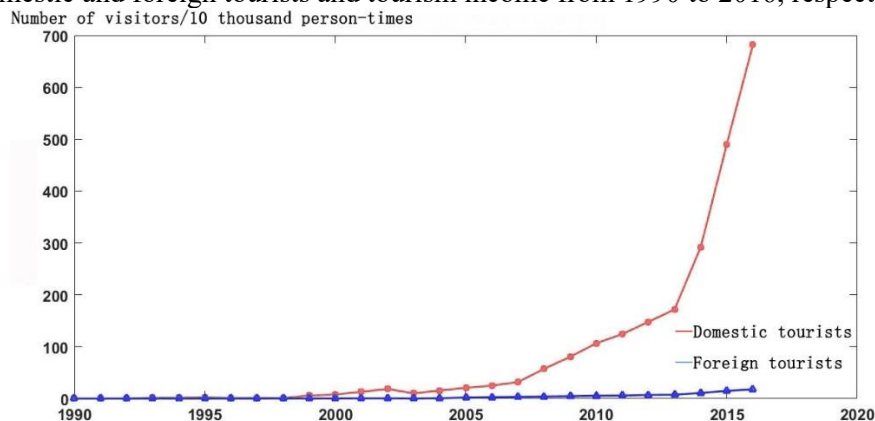


Figure 3. Changes in the number of domestic and foreign tourists from 1990 to 2016

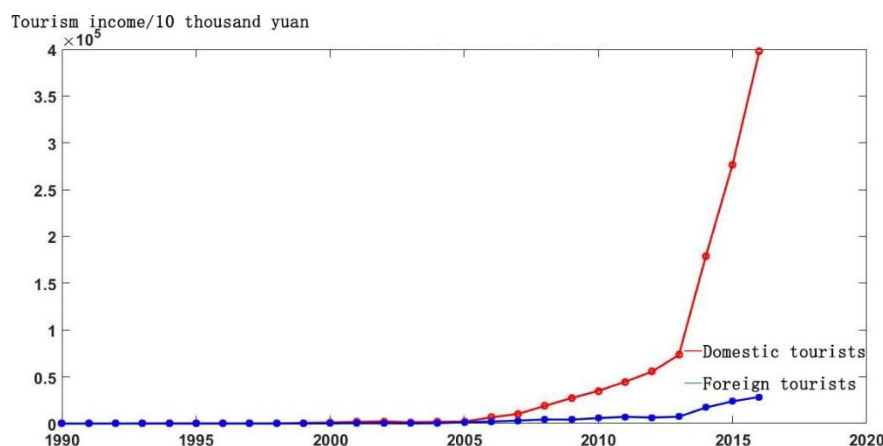


Figure 4. Changes in domestic and foreign tourism income from 1990 to 2016

According to the data of the relevant indicators of the domestic and foreign tourist population and tourism income, the tourism demand model is established for training and prediction, and the forecast curve of domestic and foreign tourism income and tourists is obtained, as shown in Figure 5 and Figure 6. The results show that the number of domestic and foreign tourists and income forecasts are in good agreement with the original data, and the model has good accuracy.

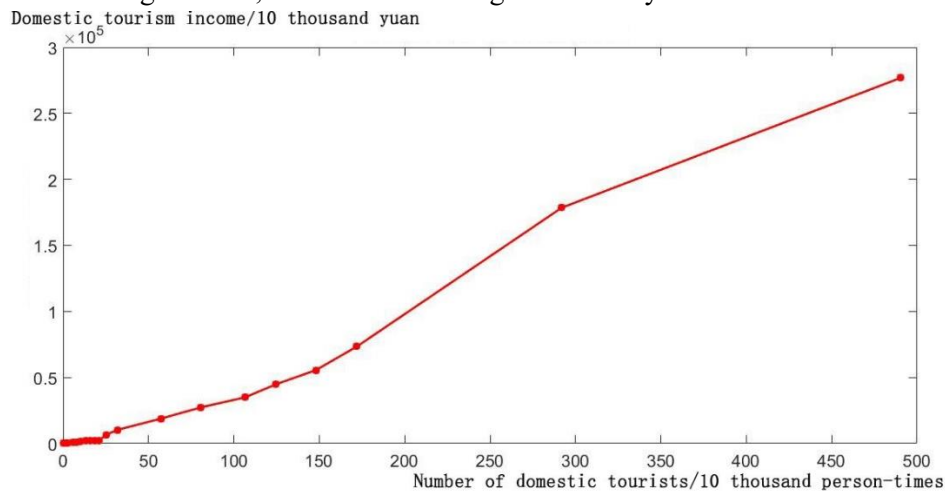


Figure 5. Relationship between domestic tourism income and number of tourists from 1990 to 2016

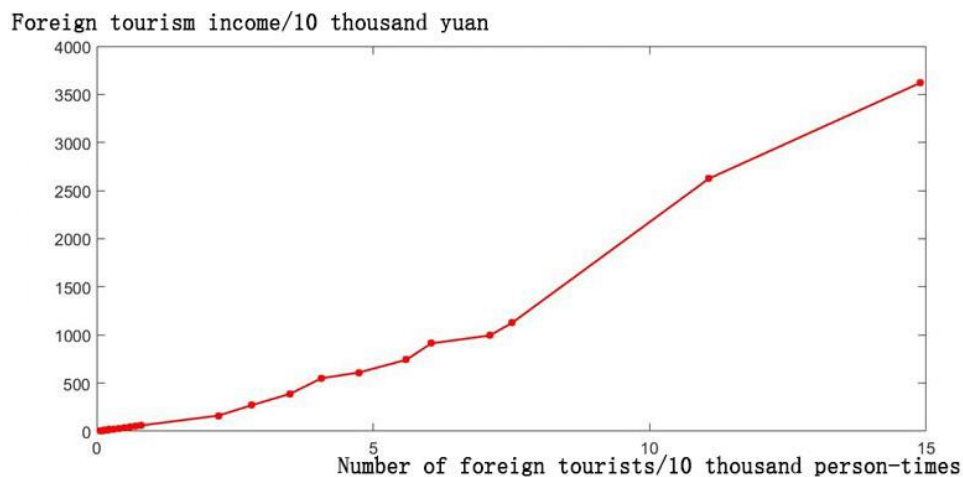


Figure 6. Relationship between foreign tourism income and number of tourists from 1990 to 2016

Through iteration, the relative error of domestic tourist population is finally stabilized at around 12.23%, the relative error of foreign tourist population forecast is stable at around 4.95%, the relative error of domestic tourism income is stable at around 1.84%, and the relative error of foreign tourism income is stable at around 1.82% (see Figure 7).

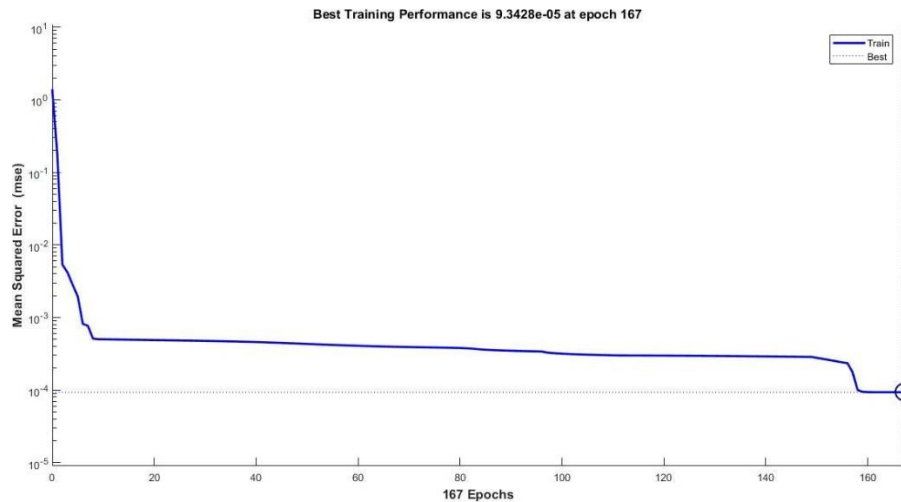


Figure 7. Error evolution curve

Figures 8 and 9 are graphs showing the changes in the number of tourists and income at home and abroad from 1990 to 2020, respectively. According to the model, the reasonable and effective prediction in time series can further provide effective technical support and guarantee for the planning of tourism resources. It is predicted that the domestic population will reach 9.136 million in 2018, and the foreign population will reach 244,100. It is predicted that domestic income will reach 660 million yuan in 2018, and foreign income is forecast to be 134.5 million dollars.

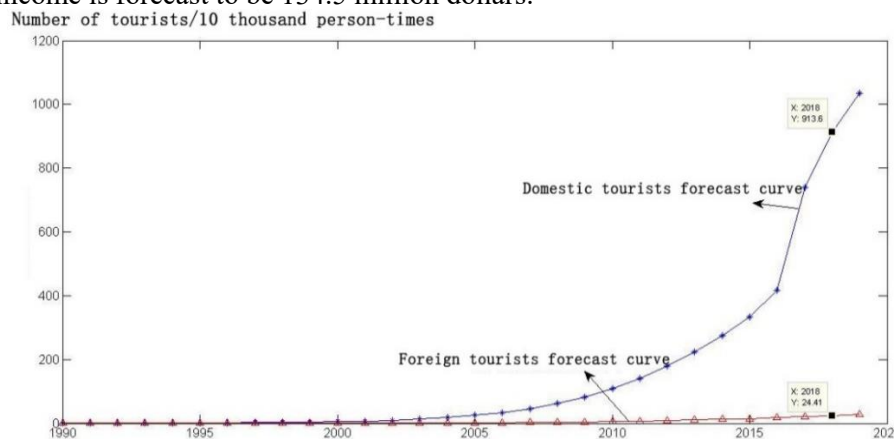


Figure 8. 1990-2020 number of domestic and foreign tourists forecast change curve

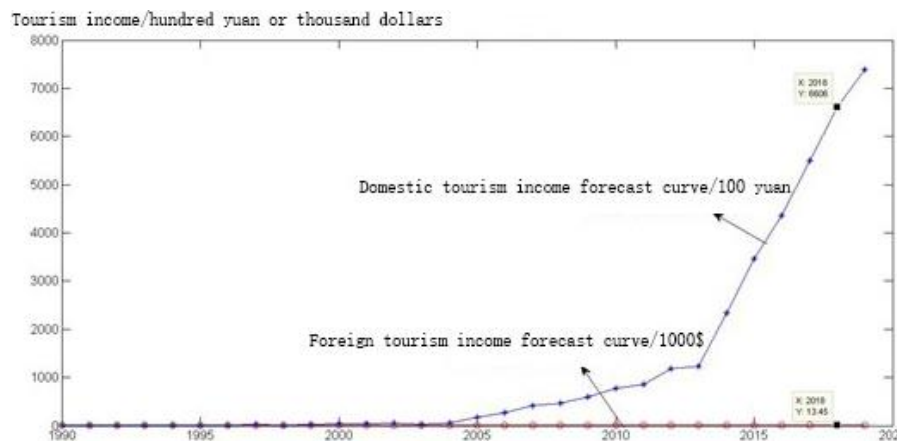


Figure 9. 1990-2020 domestic and foreign income forecast curve

5. Conclusion and discussion

This paper constructs a BP neural network tourism demand forecasting model based on genetic algorithm optimization, and finally stabilizes the relative error of domestic and foreign tourist population and tourism income at 12.23%, 4.95%, 1.84%, and 1.82%, respectively. The empirical results show that the BP neural network tourism demand forecasting model based on genetic algorithm optimization has good adaptability and precision in scenario application, and provides intelligent and efficient means and simple and convenient way for the high-speed rail era to accurately predict regional tourism demand.

The vigorous development of the high-speed railway industry has brought a new opportunity for China's tourism industry. It has not only expanded the domestic and international tourism market, but also promoted the emergence of new formats such as "high-speed rail tourism". It is also one of the new four major inventions in the new era. Therefore, the future high-speed rail is bound to become the preferred mode of transportation for people to travel. As a high-speed railway originating county, Sanjiang County should speed up the transformation and upgrading of its tourism industry to cope with a series of tourism services, ecological environment and economic development issues arising from the rapid development of high-speed rail.

However, in order to facilitate research, this paper only considers the high-speed rail era as a background factor, and does not consider the uniqueness of high-speed rail tourism itself. As the statistical methods of high-speed rail data are becoming more and more perfect, in the future, large-sample data and multi-case model empirical research should be considered, and models with strong universality, simple operation and less error should be obtained as much as possible. At the same time, how to distinguish between high-speed rail tourists and high-speed rail travelers? How to better count the number of tourists and tourism income? How to enhance the effectiveness of tourism destination statistics? These issues are also worth studying in the future.

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