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THE INDICATOR SYSTEM BASED ON BACK PROPAGATION NEURAL NETWORK FOR MARINE SERVICES

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Abstract. *Marine service has received more attention because of its growing importance to the marine economy. However, there is a lack of an effective indicator system for marine service in China. Therefore, we construct an evaluation indicator system which includes three aspects and 15 subdivision indicators for the marine services. Then we use BP neural network in Matlab2017b for training and simulating. After tenth testing the BP neural network, we can get the error within 10%. And we used the average data from 2012-2015, we had got the final score for the 11 coast provinces, and we also put forward some suggestions about the marine services.*
Keywords: Indicator system, Marine services, BP neutral network

1. **Introduction.** It has been repeatedly mentioned that the goal of building a maritime power and the development strategy for the ocean has received increasing attention in the report of the Chinese government. In recent years, China's marine economy has also developed very rapidly and the proportion of marine production to GDP has reached 9.5% in 2016. At the same time, there are also some changes in the industrial structure of the ocean. In 2003, the proportion of the marine industry was 28:29:43; while in 2016, it was 5.1:40.4:54.5. The proportion of the marine tertiary industry has greatly increased, and the marine service industry has also developed rapidly as an intermediate industry. However, the current domestic research on the marine service industry focuses more on the evaluation of the development of one of the industry fields rather than the overall evaluation of the marine service industry. As a result, it is necessary to carry out the research on the evaluation system of the marine service industry.

All the scholars currently cannot reach consensus in regard to marine services [1]. On the basis of the National Economic Industry Classification (GB/T4754-2017) and the Classification for Marine and Other Related Industries published on the website of the State Oceanic Administration, this paper shows an opinion that the marine services can be interpreted as a collection of the economic sector in marine field with various services and all kinds of marine enterprises, including marine transportation industry, coastal tourist industry, marine cultural industry, marine financial service industry as well as marine public service industry.

The researches on the evaluation of marine service industry conducted by the scholars at home and abroad are still in their infancy with few studies and most of them are about the evaluation on a specific industry in marine service industry. Griffin et al. studied the development of the coast tourism in the Australian port city, and the conclusion is that the current development of comprehensive coastal tourism and leisure sports industry has become the main model [2]. Di and Zhou explored the relationship pattern between the

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urbanization and the development of marine service industry in coastal areas from the perspective of time and space-time coupling coordination, which has created the evaluation and suggestions about marine service industry and the urbanization in coastal areas [3]. Han et al. established the index system of China's marine service industry and conducted gray correlation analysis. As a result, a conclusion has been obtained that the advantageous industries within the economy of China's marine service industry respectively refer to marine science and education management service industry, marine transportation industry and marine tourist industry [4]. Furthermore, Wu and Ye established an evaluation index system for the supply capacity of marine public services, making an evaluation about the supply capacity of marine public services in 11 coastal provinces and cities in China [5].

This paper attempts to establish an evaluation system with multiple indicators, building an index system for evaluating the overall development of China's marine service industry through the training of BP neural network.

2. Evaluation Method.

2.1. Evaluation index system of the marine services. Under the principles of comparability, systemicness, and combination of quantitative and qualitative analysis which are in the system of constructing the evaluation index, this paper designs the evaluation index system of the marine service industry by means of looking up the related document literature from three aspects, including overall condition, development effect and development potential. The whole evaluation index system is composed of three parts, including 3 first-level indicators, 6 second-level indicators, and 15 third-level indicators [6]. The specific index structure level is listed in Table 1.

Table 1. Evaluation index system of the marine services

First-level index	Second-level index	Third-level index
Overall condition	Development scale	The proportion of the gross ocean production to the GDP of the province (city)
		Total output value of the marine tertiary industry
	Industrial structure	The proportion of the total output value of the marine tertiary industry to the gross ocean production
Development results	Social benefit	The number of the marine employed persons
		Freight volume of the marine goods
		The ratio between the students and teachers majored in marine professional in vocational schools and universities
		The number of the coastal observation stations
	Economic benefit	Total volume of import and export trade in coastal regions
		The number of the quay berths used for port production above designated size
		The number of inbound tourists received by the coastal cities in the region
Development potential	Scientific and technological innovation	The number of marine scientific research institutions
		The number of the application for patent authorization of marine scientific research institutions
	External environment	Social fixed asset investment
		The number of the completed marine pollution regulation projects in the same year
		Government investment in the basic construction of the marine scientific research

2.2. **BP neural network.** The concept of BP neural network is proposed by scholars in 1986. The whole process is mainly divided into two stages. The first stage is the forward propagation of input signals through the neural network in order to get the output results. The second stage is the error propagation from output layer to the input layer, and it will adjust weights and thresholds at the same time [7]. According to the theory, we can know that a nonlinear function can be achieved by BP neural network with only one hidden layer [8]. In Figure 1, it shows a simple 2-layer (input layer not included) BP neural network.

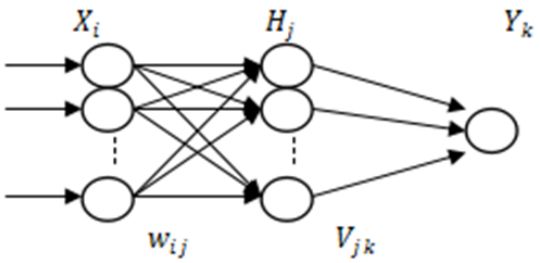

FIGURE 1. A simple BP neural network

X_i means the input date, via the hidden layer to act on the output layer, and after the nonlinear function's action, we can get the result Y_k. The weight value between the input layer and the hidden layer is named w_{ij}, and V_{jk} shows the weight between the hidden layer neuron j and the output layer neuron k. And there is a threshold, θ, between the neurons in the hidden layer and the output layer, which regulates the excited level of the neurons. And the output for the hidden layer:

$$y_H = f\left(\sum_{i=1}^{n} w_{ij}x_i - \theta_j\right), \quad j = 1, 2, 3, \ldots, h \tag{1}$$

The output of output layer neuron k is:

$$y_k = f\left(\sum_{j=1}^{h} V_{jk}y_H - \theta_k\right) \tag{2}$$

The error (δ) adjustment of the BP neural network is reversed propagation and started by the the output layer, at the same time, to correct the weights between each layer. For the output layer:

$$\delta_k = -Y_k\left(E_k - Y_k\right)\left(1 - Y_k\right) \tag{3}$$

E_k is expected output.

For the hidden layer:

$$\delta_j = y_H\left(1 - y_H\right) \bullet \sum_k \delta_k V_{jk} \tag{4}$$

$\sum_k \delta_k V_{jk}$ indicates the error of the weight when the error back propagation from output layer to the hidden layer. The formulae of weight and threshold to correct are:

$$w_{ij}\left(d+1\right) = w_{ij}\left(d\right) + \xi\delta_j + \alpha\left(w_{ij}\left(d\right) - w_{ij}\left(d-1\right)\right) \tag{5}$$

$$V_{jk}\left(d+1\right) = V_{jk}(d) + \eta\delta_k y_H + \alpha(V_{jk}(d) - V_{jk}(d+1)) \tag{6}$$

$$\theta_j(d+1) = \theta_j(d) + \xi\delta_j + \alpha(\theta_j(d) - \theta_j(d-1)) \tag{7}$$

$$\theta_k(d+1) = \theta_k(d) + \eta\delta_k + \alpha(\theta_k(d) - \theta_k(d-1)) \tag{8}$$

In the formula, d means the number of iterations, η, ξ is the learning efficiency of the BP neural network, α is a proportional constant.

The accuracy of errors could be calculated as follows:

$$e = \frac{1}{2}\sum (E_k - Y_k)^2 \tag{9}$$

where E_k is a network output we predefined, and Y_k is the output that we get in actually. The goal is to minimize e, in order to satisfy the accuracy which we setted. If satisfied, we can end; if not, the iterate times add one and continue [9].

3. **Simulation.** By querying the "*China Marine Statistical Yearbook*" and "*China Marine Economic Statistics Bulletin*" from 2013 to 2016, and other official statistics data of coastal areas, this paper collected 11 coastal provinces' data from 2012 to 2015 as the input, and the 11 coastal provinces include two municipalities – Tianjin, Shanghai; nine provinces – Liaoning, Hebei, Zhejiang, Shandong, Fujian, Jiangsu, Guangdong, Guangxi, Hainan.

3.1. **The training and verification of BP neural network.** Before using the Nerual Network Toolbox in Matlab 2017b, the data was needed standardized, and the method we used is z-score. And the data of the past four years is subjected to repeated sampling operations to expand the sample data as data for training the BP neural network.

Enter nntool at the command line to open the Neural Network Toolbox and select the input and output data. Select feed-forward backprop. The number of neurons in the hidden layer is determined by empirical formula $h = \sqrt{m+n} + a$; h is the number of neurons in the hidden layer, m is the number of neurons in the input layer, n is the neuron in the output layer, and a is an arbitrary constant between 1-10. In this paper, we have determined that the number of neurons in the hidden layer is 10. The training function selects trainlm, adjusts the learning function to select the leanngd function, selecting the 2-layer neural network and the number of 10 hidden layer neurons. For the hidden layer and the output layer, we selected the tansig function. Select data for training and verification, the training epochs set 2000 times, the best validation performance we got is 0.00105. Figure 2 below shows the distribution of the 10th error mean of the verification set. It can be seen from the figure that error mean of the 10th verifications of 11 samples is within 10%.

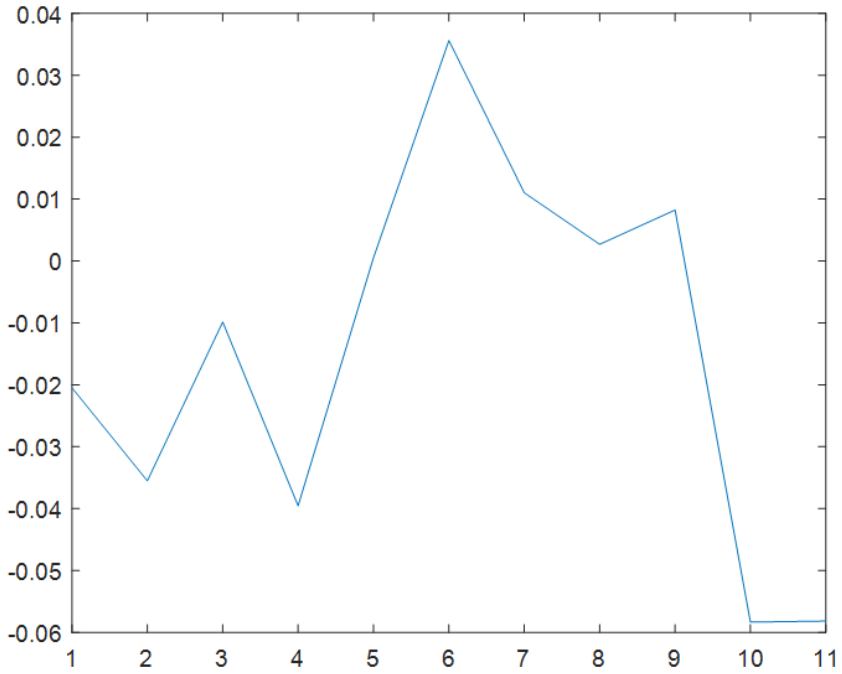

FIGURE 2. The mean of 10th verification's error

3.2. **Result and analysis.** According to the neural network we had trained, the average data from 11 coastal provinces are used as input [10]. And the final results we get are shown in Table 2.

Based on the data from 2012 to 2015, about the final score, Guangdong province has the highest score and the marine service industry has achieved excellent results in the past four years; Shandong province and Shanghai rank second and third, Zhejiang, Liaoning, Fujian, Jiangsu, Tianjin and Hainan are between 0.5 and 0.7. And the development is relatively good. The development of marine service industry in Guangxi and Hebei province are poor in the development of marine services, with a score below 0.5. From the score of the overall condition indicators, it can be seen that the scale of development is similar to the ranking of the composite score, and only Hebei province has a better score in it than the final score. Among the indicators of development effectiveness, Guangdong scored the highest. It is far better than other provinces and cities. Among the scores of development potential indicators, Shanghai scored the highest according to its scientific research advantages and its socio-economic development. Through the final score, each province and city should formulate a suitable development strategy according to its own situation in the future development of the marine service industry. Guangdong, Shandong and Shanghai are developing in a balanced manner. They must actively use their existing advantages and actively explore new development models. Hainan and Guangxi can promote the development of their marine service industry by developing coastal tourism. Hebei should pay more attention to the technological innovation and attach importance to higher education for the development in the future. Tianjin, Zhejiang, Liaoning, Jiangsu and Fujian should make good use of scientific research institutions and universities in the province to promote the marine service industry through technological innovation.

Table 2. The result of evaluation score

Province	**Overall condition's score**	**Development results' score**	**Development potential's score**	**Final score**
Guangdong	0.5118	0.9094	0.4786	0.8623
Shandong	0.5116	0.7422	0.4699	0.8049
Shanghai	0.5092	0.7210	0.5201	0.7572
Zhejiang	0.5037	0.7760	0.4715	0.6945
Liaoning	0.5012	0.5904	0.4739	0.6629
Fujian	0.5051	0.6582	0.4590	0.6444
Jiangsu	0.4960	0.7374	0.4539	0.6356
Tianjin	0.4904	0.5203	0.4637	0.5368
Hainan	0.4910	0.4921	0.4608	0.5216
Guangxi	0.4957	0.4869	0.4566	0.4976
Hebei	0.4973	0.4879	0.4513	0.4837

4. **Conclusion.** This paper constructs a marine service industry evaluation index system consisting of 15 three-level indicators including overall scale, development effectiveness and development potential, and validates the model through BP neural network. An empirical analysis of 11 coastal provinces and cities in China was conducted through data from 2012 to 2015. The development of marine service industry has a positive effect on the growth of the marine economy. The index system constructed in this paper can provide some guidance for the development of the marine service industry through the evaluation of the development of the marine service industry. However, this is the neural network toolkit for data processing. After that, we use the algorithm-optimized neural network to carry

out the work later. At the same time, how to obtain more accurate data is also the key direction in the future.

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