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INTELLIGENT SAFETY REGULATION AND WARNING METHOD FOR FISHING BOAT SECURITY

[1] WEI HE, [2]ENJUN WANG, [2]JINYU LEI

[1]Intelligent Transport System Research Center, Wuhan University of Technology, Wuhan 430063, Hubei, China

[2] Transportation Research Center, Wuhan Institute of Technology, Wuhan 430073, Hubei, China

ABSTRACT

The data mining is carried out for the historical data to investigate and analyze crucial factors related to the causes of accidents of fishing boats. The vital factors, especially shipping time, weather and manipulation, etc. are extracted as the input variables of a BP neural network to establish a safety warning model for fishing boats. In addition, the Particle Swarm Optimization (PSO) is employed to develop the generalization ability of neural network and optimize the parameters of safety warning model. Experiments using the historical data have showed high efficiency of the proposed intelligent safety warning model. Hence, it is feasible for the design of waterborne traffic safety and warning system.

Keywords: *Fishing Boats, Safety Regulation and Warning, Neural Network*

1. INTRODUCTION

The coastal area of Fujian is not only a major foundation for the development of fishing industry, but also a significant strategic base of shipbuilding in China. Since reformation and opening of China, we form a structure with variety of economy components in waterway transportation and an enormous power for the waterway transportation. Under the influence of the friendly development of cross-straits relationship and the rise of economy in the west coast of straits in Fujian, the trade between Taiwan and mainland is more and more frequently. For instance, there are more than five thousand ships sailing on the sea every day. The economic prosperity, which represents the rapid growth of fishery and shipping industry, puts forward new requirements and challenges to the work of maritime affairs department whose duty is to ensure the safety of waterway transportation. Although China is the superpower of the world in terms of shipbuilding and shipping industry, many potential safety hazards and traffic accidents still exist in the waterway transportation and threaten the development of shipping industry seriously. According to statistics, there are 109 traffic accidents in coastal area of Fujian during the "Eleven Five-Year" period. Some of them belonged to general level accidents in shipping field. Some are even more serious. Additionally, it directly cause an astonish loss including 37 sunken ships, deaths or disappear of 89 people and approximately 10938 million economic losses [1]. Fig. 1 shows us the ship accident statistics of Fujian coast line from 1994 to 2003. It can be drawn from the investigation and analysis that spontaneous and unordered ship traffic is the major factor of traffic accidents. Moreover, during foggy period, the captains who did not obey the laws and regulations strictly and marine navigators whose enforcement remains patchy are the causes of traffic accidents, especially when they meet poor situation, such as low visibility, bad weather, severe sea condition and high concentration of vessels, etc [2, 3, 4].

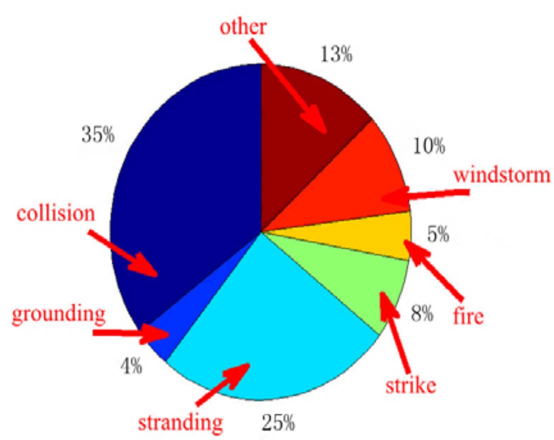

Figure 1: The ship accident statistics of Fujian coast line from 1994 to 2003

In order to reduce the vessel accidents we must take effective safety warning measures. Early-warning theory, which is widely applied in various fields, such as meteorology, environmentology, military, aviation, finance, transportation, enterprise, etc., emerged in the late World War II

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first. Because the early-warning systems' development of waterborne traffic in China is still at the stage of exploratory, mostly we depend on the results of foreign researches and the matured theories of domestic road safety among which there is a book wrote by Yu Lian entitled The Safety Regulation And Warning of Vessel Traffic Disasters. It is one of the few literatures that focus on the research of the regulations of waterways' security in domestic at an earlier time and it has poor timeliness. Therefore, we should pay more attention to monitoring and evaluating the factors leading to waterborne traffic accidents.

Because of the rapid development of computer technology the powerful function of artificial intelligent is able to develop. This study based on the major factors, which affect the safety of vessel traffic, does a number of researches on the safety warning approach for vessels in the coastal area of Fujian. Additional, we establish an intelligent safety warning model, whose accuracy is verified by practical data, on the basis of neural network

2. THE EARLY-WARNING MODEL BASED ON BP ARTIFICIAL NEURAL NETWORKS

2.1 BP Neural Network

BP neural network [5], shown in Fig. 2, is a kind of multilayer feedforward networks that can back propagate errors.

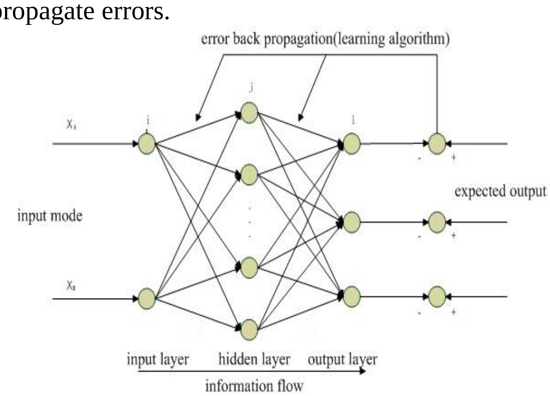

Figure 2: The typical structure of back propagation neural network

Layers are connected by the right coefficient of neurons in the network. Its learning process is divided in two directions: forward propagation and back propagation. The forward propagation calculates the output of current learning network and if the result of calculation is not equal to the expected value it will turn into the backpropagation stage which can revise weight and threshold value to eliminate errors by analyzing errors between the output of network and expected output [6, 7].

2.2 Particle Swarm Optimization Algorithm

Although a single organism is not intelligent usually, the entire group of organisms is smart enough to deal with complicate questions. Particle swarm optimization (PSO), which is a typical optimization algorithm described above, got the attention of scholars for the sake of its efficiency and simplicity.

PSO algorithm [8], which derives from the research focus on the behavior of bird flock when they are preying, is an evolutionary computation based on groups. When a flock of birds is searching for a piece of food in a specific area randomly, the most simple and effective method to find it out is to search the area where exist a bird which is closest to the target. PSO algorithm used to solve the optimization problem is inspired from this method.

The solution corresponds to location of the particle existed in the search area during the PSO calculating process. Every particle has its own location and speed and by using objective function we can calculate the particles' fitness value that corresponds to the problem solution. In the iteration, each particle's speed and location can be evaluated according to

$$v_{i,j}(t+1)=v_{i,j}(t)+c_1r_1(p_{i,j}-x_{i,j}(t))+c_2r_2(p_{g,j}-x_{i,j}(t)),\quad j=1,2,\cdots d \tag{1}$$

$$x_{i,j}(t+1)=x_{i,j}(t)+v_{i,j}(t+1) \tag{2}$$

In (1), $v_{i,j}(t)$ is the $t-dimensional$ speed of particle i in the t bout of iteration. c_1, c_2, which are acceleration factors(or learning factor), can accelerate the rate of PSO convergence and avoid local optimum when their values are appropriate. Usually let $c_1=c_2=2$. r_1,r_2 is a random digit between [0， 1]. $x_{i,j}(t)$ is the $j-dimensional$ location of particle i in the t bout of iteration; $p_{i,j}$ is the j-dimensional location of extreme point of particle i. $p_{g,j}$ is the $F-dimensional$ (F = $fitness$) location of global extreme point in the entire group. Particles' speed v in every dimension must belong to $(v_{\min,i},v_{\max,i})$ to prevent that particles are far away from search space. We assume that the $t-dimensional$ search space is

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defined as interval $(x_{\min,i}, x_{\max,i})$ and so is other dimension. The process of the basic PSO can be described as:

(1) Initialization: Setting the inertia weigh of displacement factors c_1, c_2 and suppose the biggest evolutional generation is $T_{\max}$, then set current evolutional generation to t, and the s particles $\left[x_{1,}x_{2,}x_{3,}\cdots,x_s\right]$, which are produced randomly in the space R, form initial population $X(t)$. The initial displacement variations of particle $\left[v_{1,}v_{2,}v_{3,}\cdots,v_s\right]$, which are produced randomly, constitute the displacement variation matrix $V(t)$;

(2) Evaluating the population $X(t)$;

(3) Using equation(1) and equation(2) to update the displacement direction and step size to produce new population $X(t+1)$;

(4) Ending the optimization if it satisfied the termination criteria such as the biggest evolutional generation is attained by optimization or the value of evaluation is less than the given accuracy. Otherwise, let $t = t+1$ and turn to step 2. And fitness function can be square error and mean value:

$$fitness = E_{AV} \tag{3}$$

$$E_{AV} = \frac{1}{n}\left|\sum_{k=1}^{n}(y_k - f_k)^2\right| \tag{4}$$

In the formula, y_k is target value; f_k is calculated value; n is the sample size of training set.

2.3 The Neural Network of Particle Swarm Optimization

Combining PSO and neural network and optimizing the connection weights of the neural network by PSO can not only give full play to the generalization ability of neural networks but also improve its convergence rate and learning ability [9, 10]. The process of the neural network optimized by PSO is shown in Figure 3.

The neural network optimized by PSO eliminates the impact of structure parameters on the results of early-warning system. Therefore, we are able to implement a reliable early-warning measure to ensure the safety of fishing boats if we can figure out the appropriate input variable, which is the major factor affecting the safety of fishing boats.

3. ANALYSIS OF FACTOR AFFECTING THE SAFETY OF FISHING BOATS

At first, we need to discover more practical monitoring data for the purpose of analyzing the main factors which affect the safety of fishing boats. This paper takes the Coastal Area of Fujian as a study case. According to the analysis of historical data in the coastal area of Fujian we find that operating time of vessels, traffic flow, climate, operator's fatigue, etc. have direct tie with the accidents.

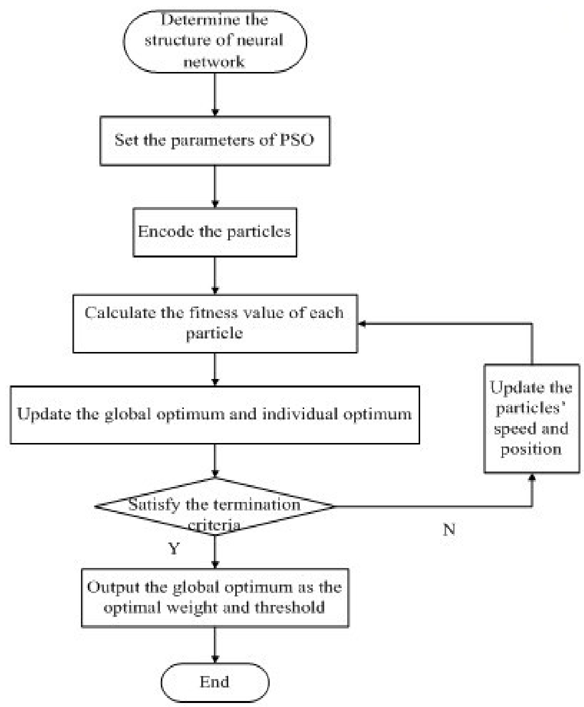

Figure 3: The calculating process of neural network optimized by PSO

Figure 4 shows the safety incidents' statistical relationship with vessels' operating time of 57 accidents in a specific period of time. It can be drawn from the picture that the accidents occurred mainly in 04:00~07:00, 12:00~14:00, 17:00~18:00 and 22:00~24:00. We can make a conclusion from Fig. 5, which shows the statistical relationship of traffic flow with time, and Fig. 4 that 12:00~14:00 and 17:00~18:00 are the peak period of traffic flow which means that the probability of traffic accidents in this period will increase. Fig. 6 shows the statistical relationship between operator's fatigue and safety incidents. Fig. 7 tells us the impact of weather on the accidents of fishing vessels. So operating time of vessels, traffic flow, climate and operator's fatigue have a direct connection with the

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safety of fishing boats according to the analysis of the 57 accidents. Therefore, a reasonable early-warning message can be achieved when we input these elements, which are considered as the vital factors to the safety warning, to the early-warning model of neural network.

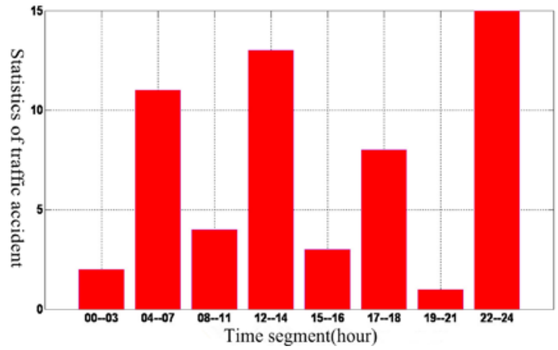

Figure 4: The statistical relationship of accidents with operating time of vessels

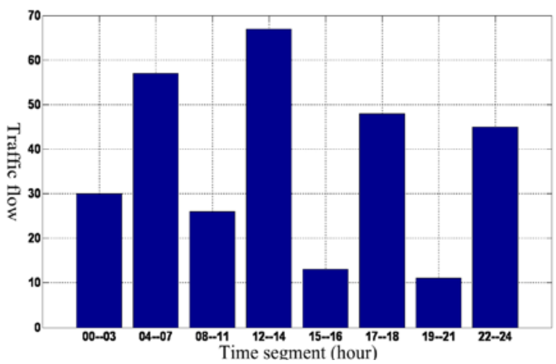

Figure 5: The statistical relationship of traffic flow with operating time of vessels

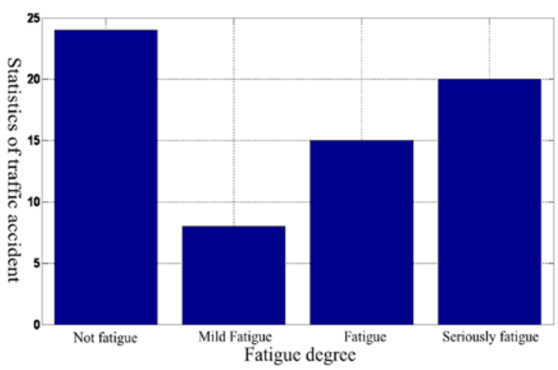

Fig. 6. The statistical relationship of accidents with operator's fatigue

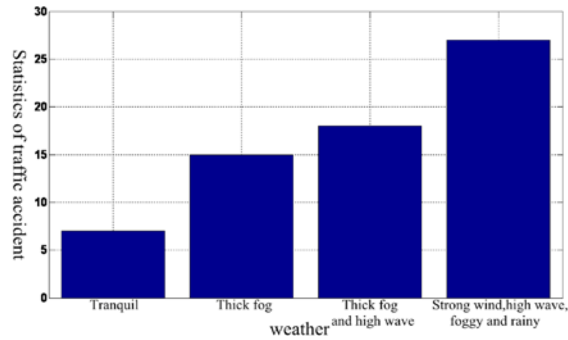

Figure 7: The statistical relationship of accidents with weather

4. EARLY-WARNING TEST FOR THE SAFETY OF FISHING VESSELS

We select 500 samples among which there are 421 samples without accidents and 79 accidents sample, from the historical monitoring data in the coastal area of Fujian to conduct an experiment in order to verify the performance of the early-warning model. Firstly, by data preprocessing, we can extract the quantitative values of operating time, traffic flow, climate and operator's fatigue as the input variables of neural network. Then we need to take advantage of the 300 samples to train the neural network, and the remaining 200 samples were used to test.

The neural network with 4-25-3 structure has three neurons in the output layer. Encoding the meaning of the output as below: [0 0 1] means navigation normal; [0 10] means that vessels can sail but need an early-warning message; [1 0 0] means that vessels must stop navigation because it is seriously threatened. The results are shown in table 1.

Table I
The performance of early-warning model

PSO-BP neural network	BP neural network
false alarm rate	false alarm rate
4.8%	6.1%

In table 1, false alarm rate means that system send a seriously early-warning message to the samples without accidents. The results turn out that the safety early-warning model for fishing boats, which is put forward by this study based on neural network, can forecast risks and send the security messages to fishing boats correctly. Additionally, it has a good application value to the world. At the

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same time, the accuracy of BP network optimized by PSO is better than the one without optimization.

5. CONCLUSION

In the coastal area of Fujian, fishery is the major source of income and carrying out the safety warning for fishing boats is a significant strategic to control and prevent accidents effectively. Although we had tremendous achievement at the aspect of early-warning theory and safety regulation for vessel traffic, the literature remind us that we still need more deeply research at the aspect of safety warning system for fishing boats. In order to realize the intelligent safety warning method for fishing boats, this paper has introduced a neural network optimized by PSO to regulate the early-warning. In addition, by extracting the crucial factors that affected the safety of fishing boats I have established an early-warning model and its effect is good. In the next step, I will spend more time on finding the factors leading to the accidents and improving the early-warning model. And I will come up with corresponding measures on the basis of hazard assessment and promote the process of making early-warning system practical.

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