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Railway Signal Electronic Control System Based on BP Neural Network

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Abstract: - Railway signal system is the core system of railway command train operation. After the installation of the system equipment is completed, a comprehensive test shall be carried out through joint debugging and joint testing, and the applicability of the system to the design requirements shall be generally evaluated according to the test results. This paper focuses on the research of railway signal electronic control system. Based on BP neural network, fault information can be quickly and accurately identified in a relatively short time, and accurate electronic signal control can be realized in a complex system environment. The final result of the study shows that the difference in delay error of railway signal transmission under BP neural network technology is small, there are some subtle differences in 5 different modes, but the impact is small, in mode 1, the target time value is 0.236s, The actual reflection time is 0.322s, it can be seen that the error is controlled within 0.2s, which is feasible. Through the analysis of delay error of railway signal electronic control system, BP neural network has certain advantages in railway signal transmission.

Keywords: Railway Signal, Control System, Bp Neural Network, System Delay.

I. INTRODUCTION

Railway transportation has the characteristics that other land transportation modes are difficult to replace. Therefore, railway transportation has great advantages in terms of cost, carrying capacity and regularity, and is an indispensable backbone in land transportation [1]. With the rapid development of China's economy and the country's high emphasis on infrastructure construction, the state's investment in railway transportation has also increased year by year, and the role of railway transportation in the development of the national economy has become more and more important. Therefore, it has certain research significance to analyze the railway signal electronic control system by BP neural network technology.

In recent years, many researchers have studied the analysis of railway signal electronic control system based on BP neural network, and achieved good results. For example, Thendral R believes that railway signal equipment, as the control terminal of railway signal interlocking system, is a high-frequency fault area due to its harsh working environment and complex and diverse structure [2]. Milne D believes that neural network technology is a popular technology in the development of modern fault diagnosis technology, and its application to the field of railway signal system fault diagnosis meets the needs of modern railway development [3]. At present, domestic and foreign scholars have done a lot of research on the analysis of railway signal electronic control system. These previous theoretical and experimental results provide a theoretical basis for the research in this paper.

Based on the theoretical basis of BP neural network, combined with the analysis of railway signal electronic control system, this paper studies the dynamic assessment of information security risk status of railway signal security data network, and proposes an extended Bayesian attack graph model. Firstly, based on the interconnection between multi-step attacks and the uncertainty of attack initiation and success, an extended Bayesian attack graph model for signal safety data network is established to obtain the probability of system accident, and then the static risk of the system is obtained by combining the impact of accident in functional safety domain. Finally, the alarm data of the detection equipment is used as evidence to update the confidence level of the network nodes to obtain the dynamic risk analysis results.

II. RELATED THEORETICAL OVERVIEW AND RESEARCH

A. Failure Mechanism Analysis of Railway Signal Interlocking System

1) Hierarchical Analysis of Signal Interlocking System Structure: The railway signal interlocking system is a high-security and high-reliability system designed to ensure the safety of railway operation. It is responsible for ensuring the shunting operation and train operation of the train in the station. At present, the station signal interlocking system in my country has been from the first The generation of mechanical interlocking and the

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second generation of relay interlocking have developed to the third generation of computer interlocking system. Computer software is used to replace relay logic operations, reducing relay combinations and occupying less space [4-5]. Compared with the previous two generations of signal interlocking systems, the computer interlocking system has faster logic operation speed, higher logic operation security and reliability, and is currently the main system used in the signal control of railway stations in my country.

2) Structural Analysis of Computer Interlocking System: Computer interlocking system From the perspective of the composition and structure of the system, the computer interlocking system mainly includes four parts: indoor control part, console, power supply part and outdoor equipment. The console is the operation terminal of the on-site staff. It mainly realizes the staff issue operation commands to control the terminal equipment to perform actions, and at the same time displays the current status information of the signal equipment for the staff to grasp. The indoor control part is the core part of the computer interlocking system, including the software layer, the hardware layer and the equipment control circuit. By performing logical operations on the operation commands issued by the console, it checks whether the action conditions of the signal equipment are satisfied, and controls the safe operation of the outdoor equipment. At the same time, the current state of the signal equipment is collected and fed back to the operator [6]. The power supply part mainly supplies power to each part of the system and provides energy guarantee, mainly including AC and DC power supply panels, dynamic power supply and conversion panels, etc. The outdoor equipment part is the control terminal of the computer interlocking system, mainly including various outdoor signal basic equipment such as signal machines, switch machines and track circuits.

3) Analysis of the Working Mechanism of the Computer Interlocking System: From the perspective of working mechanism, the computer interlocking system can be divided into four layers, namely human-computer interaction layer, interlocking control layer, acquisition driving layer and outdoor equipment layer. The interlocking control layer is mainly responsible for realizing the interlocking logic operation in the computer interlocking system. By receiving the operation commands of the human-computer interaction layer and collecting the equipment status information of the driving layer, it comprehensively analyzes and makes safe and reliable equipment control commands; The layer is mainly responsible for the state acquisition and action driving of the outdoor equipment, and is the connection bridge between the outdoor equipment and the indoor control; the outdoor equipment layer is the control terminal of the system. The high frequency region where faults occur in the system [7-8]. When a fault occurs, the on-site staff needs to locate the fault point in a timely and accurate manner and carry out troubleshooting, which brings greater work pressure to the staff. Therefore, combining advanced scientific and technological theories, realizing intelligent fault diagnosis of signal equipment is an important basis for promoting intelligent fault handling of interlocking systems.

B. Theoretical Introduction of Bp Neural Network

Artificial neural network mainly imitates the human brain through a large number of simulated neurons, and can undertake intelligent work such as image and signal processing, pattern recognition, etc. The artificial neural network can realize the nonlinear correspondence between the input signal and the output signal, and this behavior is the learning process [9-10]. The neural network model has obvious advantages in learning, so it has been further researched and promoted in the context of the current big data. The most widely used error back propagation network model, referred to as BP neural network, is a A multi-layer feed forward network trained according to the error backpropagation algorithm, where "feedforward" means that there is feedback between neurons in the network, which can be represented by an undirected complete graph.

The BP network model was proposed by American scientists headed by Rumelhart and McClelland in the mid-1980s. After decades of development, the BP neural network has now been generally recognized by the academic community, and has been widely used in information, medicine, psychology, engineering, Its learning process is mainly divided into the following two stages. First, determine the input and output vectors, which can generally reflect certain characteristics of the target parameters, and then determine the hidden The number of layers containing layers and the number of neurons (nodes) in each layer of input layer, hidden layer and output layer are the topological structure of the network, and then the threshold and weight of each layer of the network are defined at the same time [11]. Secondly, calculate according to the above-built network framework, according to the output error squared sum and the pre-set error comparison result, if the error is relatively small, then activate the neuron, and the information will be propagated to the For the neurons corresponding to the next layer, if there is a missed work, the parameters will be adjusted in reverse, that is, the thresholds and weights between the neurons in each layer are repeatedly corrected until the learning process of the network is completed [12].

This process is consistent with the cognitive process law in the human learning process, that is, the human brain is simulated from the following three links:

(1) Using neural networks to acquire knowledge from the outside through the learning process;

(2) Internal neurons (ie thresholds and weights) store the acquired knowledge;

(3) The acquired knowledge is used for transfer to solve similar problems encountered next time.

III. EXPERIMENT AND RESEARCH

A. Experimental Method

The BP neural network learning algorithm is mainly based on the gradient descent algorithm, also known as the steepest descent algorithm. The solution process is to first assign a random or conditionally specified initial position on the error surface. The gradient descent method runs along the direction of negative gradient and requires the transfer function to be differentiable. The typical commonly used function is the sigmoid function：

$$S_j = \sum_{i=1}^{n} \omega_{ij} X_i - \theta_j \tag{1}$$

$$L_k = \sum_{j=1}^{n} \gamma_{jh} B_j - \theta_h \tag{2}$$

Among them, the transfer function f is an s-shaped function, S is the input of all l+e parts mapped from the input layer to the hidden layer, and B; is the total output value of each unit of the hidden layer to the output layer. Use the output value B of the hidden layer; the connection weight Yjh and the OR value 0n to calculate the output value Lk of each unit, and then calculate the output Y of each unit of the output layer through the transfer function.

B. Experimental Requirements

Based on the BP network technology, this experiment analyzes and studies the railway signal electronic control system, and judges the feasibility of the system through the delay error analysis of the railway signal electronic control system and the railway signal fault detection accuracy analysis. To detect the error standard, refer to the test case, the function of the train control system, and the system equipment and its circuit characteristics, and compile a set of standardized and rigorous test sequences dedicated to the function of the train control system.

C. Experimental Environment

The overall design of the signal control system adopts the regional computer interlocking system (RClS). RClS is a remote interlocking control for multiple stations within an effective distance. It is a new type of computer interlocking technology that integrates computer interlocking, network, safe transmission and other technologies, and enables one central station to manage several stations. The computer responsible for interlocking operation is located in each controlled station, and the central station sends out control commands to the operator station of the controlled station through the channel. The operator transmits it to the interlocking machine of the controlled station through the local area network of the station. The interlocking operation is completed by the interlocking machine of the controlled station to control the field equipment. The accused station does not usually participate in the handling of traffic operations, and can only operate at the local operator station under the authorization of the central station.

IV. ANALYSIS AND DISCUSSION

A. Delay Error Analysis of Railway Signal Electronic Control System

In order to test the delay error analysis of railway signal transmission under BP neural network technology, and judge the feasibility of the system according to the error time, the experimental data is shown in the following figure.

Table 1. Delay Error Analysis Table of Railway Signal Electronic Control System

Mode category	Target time value(s)	Actual reflection time(s)
M one	0.236	0.322
M two	0.335	0.411
M three	0.136	0.135
M four	0.128	0.188
M five	0.441	0.532

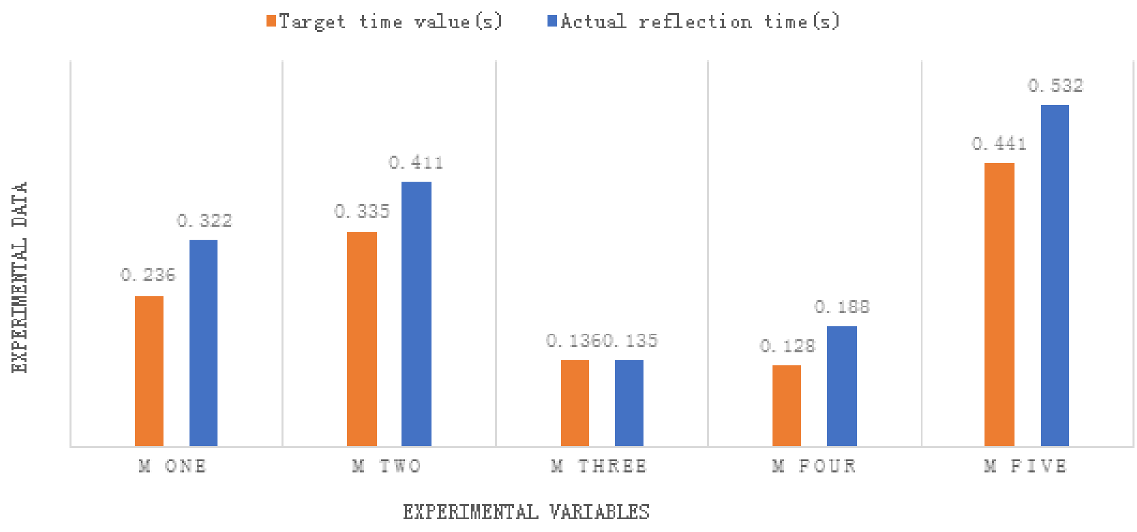

Figure 1. Analysis of Delay Error of Railway Signal Electronic Control System

From Figure 1 and Table 1, it can be seen from the above results that the difference in delay error of railway signal transmission under BP neural network technology is small, and there are some subtle differences in the five different modes, but the impact is small. In mode 1, the target time value is 0.236s and the actual reflection time is 0.322s. In mode 2, the target time value is 0.325s and the actual reflection time is 0.411s. In mode 3, the target time value is 0.136s and the actual reflection time is 0.136s. 0.135s. In mode 4, the target time value is 0.128s and the actual reflection time is 0.188s. In mode 5, the target time value is 0.441s and the actual reflection time is 0.532s. It can be seen that the error is controlled within 0.2s, which is feasible. In addition to selecting high-reliability electronic components in the field of railway transportation, Ramadan EA usually adopts multi-mode redundancy to improve the reliability and security of the computer platform. Two by two out of two and three out of two structures, Netto M studies Alcatel interlocking devices by using two computers to work according to two different design programs, one of which is used to run and check safety In the case of , the other one is used to check whether the previous computer is wrong, and if it is correct, it will output the command.

B. Accuracy Analysis of Railway Signal Fault Detection

Through the analysis of the delay error of the railway signal electronic control system, the BP neural network has certain advantages in railway signal transmission. This experiment continues to analyze the accuracy of railway signal fault detection. The experimental data is shown in the figure below.

As shown in Figure 2, when the number of detections is 48, the accuracy is 99.93%, when the number of detections is 78, the accuracy is 99.77%, and when the number of detections is 125, the accuracy is 99.68%. When the number of times is 156, the accuracy rate is 99.45%, and when the number of detections is 189 times, the accuracy rate is 99.23%. To ensure the fault detection rate when the number of faults is large, it is necessary to further improve the technical ability to improve the accuracy rate. Relevant scholars took the wireless occlusion center as an example to use this model for risk assessment, and verified the rationality and effectiveness of the model. It can be seen from the fault detection in the five modes that the accuracy rate has reached below 90%. , and with the increase in the number of detections, there will be some slight drops in the accuracy.Mitzner K studies Ansaldo's computer interlocking system using software redundancy voting. Two processors use different versions of software with dissimilarity for comparison. One processor obtains data through communication, and the other processor uses The program status data is compared with its own status, and finally a voting judgment is made.

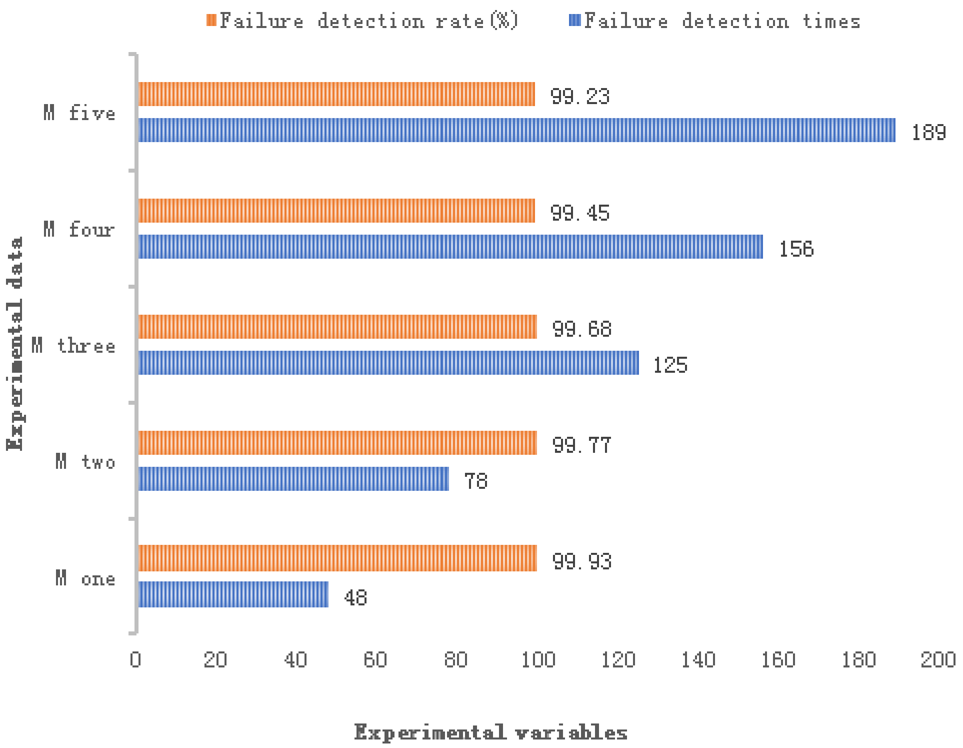

Figure 2. Analysis of the Accuracy of Railway Signal Fault Detection

C. Comparative Analysis Of Cost Budgeting Process Complexity

Through the analysis of the railway signal fault detection accuracy, it can be seen that the railway signal fault detection accuracy is relatively high. The experiment continues to analyze the complexity of the cost budget process by comparing with different models. The experimental data are as follows.

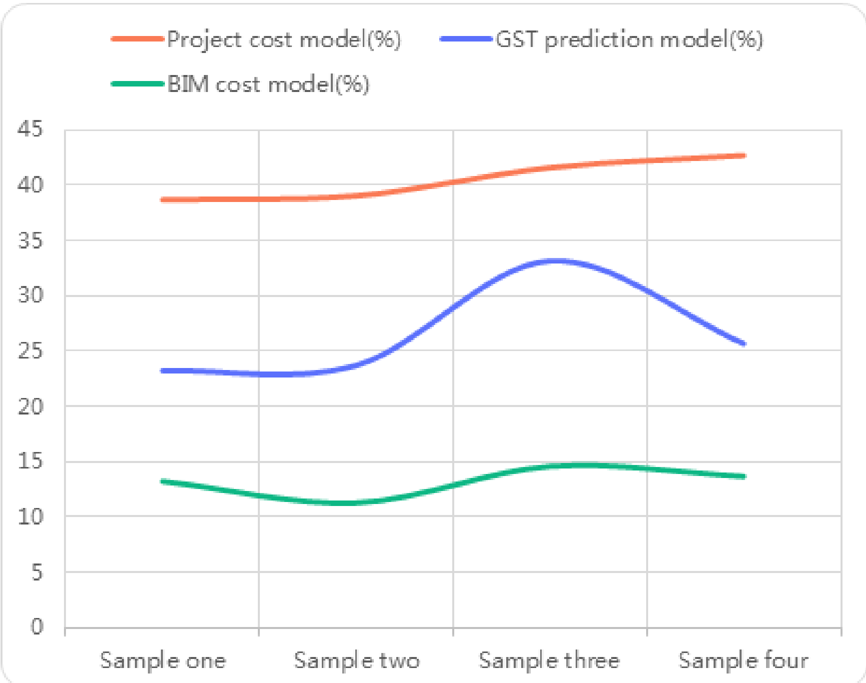

Figure 3. Comparative Analysis of Cost Budgeting Process Complexity

It can be seen from the data in Figure 3 that the complexity of the project cost budget model, the GST cost prediction model and the BP neural network model in sample 1 are 38.66%, 23.21% and 13.21% respectively, and the complexity in sample 2 is 39.02% respectively. , 23.69% and 11.26%, the complexity of sample 3 is 41.56%, 33.13% and 14.56%, and the complexity of sample 4 is 42.66%, 25.65% and 13.65%, respectively. In 2016, Zhang Youpeng conducted research on uncertainties such as ambiguity and randomness in the evaluation process, and used the cloud model to model expert comment information. The BP neural network model in this paper has a low budget complexity and a relatively simple budget process. It can be seen that BP neural network model budget is better than the other two model algorithms.Zhou Runjing studies the main control module of the existing domestic interlocking safety computer system platform, mainly based on DSP chips for development, the system is basically a single-core architecture, because the main control module needs to analyze the RSSP-I security protocol

V. CONCLUSIONS

This paper firstly studies the railway signal electronic control system based on the BP neural network technology, and through a series of experiments to prove that the machine BP neural network technology has a certain feasibility in the railway signal electronic control system. From the experimental data of error analysis and railway signal fault detection accuracy analysis, it can be seen that the delay error difference of railway signal transmission under BP neural network technology is small, and there are some subtle differences in 5 different modes, but the impact is small. The error is controlled within 0.2s, which is feasible to a certain extent. It can be seen from the fault detection in the five modes that the accuracy rate has reached below 90%. At the same time, with the increase of the number of detections, the accuracy rate will be slightly small. In order to ensure the failure detection rate when the number of failures is large, it is necessary to further improve the technical ability to improve the accuracy. In the future, with the continuous increase and improvement of the knowledge base and case base, a platform for comprehensive analysis and sharing of big data will gradually be formed. The railway signal electronic control system will provide strong support for the development of intelligent monitoring technology for railway signal systems in China and the world.

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