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Automatic Safety Monitoring System of Railway Signal Light Based on Intelligent Learning Algorithm

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Abstract:

Railway transportation is an important part of China's transportation sector. In recent years, with the rapid development of science and technology, the speed of trains has been increased many times, and the density of trains has continued to increase. How to ensure the safety of rail transit has become a concern of people. This paper studies the railway signal light automatic safety monitoring system based on the intelligent learning algorithm, understands the relevant knowledge of the railway signal light automatic safety detection based on the literature data, and then designs the railway signal light automatic safety monitoring system based on the intelligent learning algorithm, and the monitoring algorithm used in the system is tested, and the test results show that the algorithm in this paper has good sensitivity to anomaly detection, and samples with low anomalies have a higher resolution, and the amplitude of anomalies varies greatly, covering non-self-space smaller, it can describe in detail the variation of the abnormality of the sample from its own space.

Keywords*: Intelligent learning, Learning algorithm, Railway operation, Safety monitoring.*

I. INTRODUCTION

A railway bureau in China's country has developed a signal micro-detection device with a single-chip micro-nucleus to replace manual electrical characteristics detection [1-2]. In the process of use, it has continuously evolved and improved year by year, including monitoring range, measurement, statistics, fault alarm, etc. [3-4]. However, in recent years, as China's economy continues to grow, rail transit is facing tremendous pressure. In order to adapt to the evolution of the times, China is actively introducing and adopting new technologies, significantly improving the equipment level of the latest communication and signal equipment, and at the same time, continuous high-speed heavy machinery operation [5-6]. Under the background of this era, the traditional microcomputer signal detector with a microcomputer core can no longer meet the requirements of the new situation. In order to ensure the safety of rail transit, the development of a new type of rail signal monitoring system has become a new research topic [7-8].

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Relevant researchers believe that grasping the status quo of China's high-speed railways as early as possible is an important key to ensuring the safe and stable operation of China's high-speed railways. In spite of the rapid development and construction of China's high-speed railways, China's current high-speed railway safety monitoring and monitoring technologies still generally have disadvantages such as difficult engineering, complex technical systems, high maintenance costs, and the possibility of electromagnetic interference. In extreme weather or accompanied by severe thunderstorms, landslides, landslides and other specific circumstances, telecommunication detectors are extremely vulnerable to damage and cannot effectively respond to line operations, causing serious dangers. In order to ensure the security of line business [9]. According to these problems, the distributed network structure acoustic field monitoring system (DAS) using micro-structured optical fiber is widely used in the safety monitoring field of rail operation. The system will have the advantages of strong anti-equipment operation, long monitoring distance, high resolution, high precision, and the ability to realize distributed monitoring [10]. Some analysts believe that the most important means to detect whether there is space on the rails in the track control system is occupied by vehicles is the track circuit and the device that specifically detects the condition of the electromagnetic sensor well. Its principle is to form a circuit to monitor the track part occupancy. Although the system is simple in structure and low in cost, this method has major drawbacks. The rail or the surface of the rail may rust. Under these conditions, the manufactured circuit may break. At the same time, the manufactured circuit may be short-circuited in a humid environment or when the insulation of the manufactured circuit is damaged. These two kinds of unfavorable environments will cause the crisis signal system to send out wrong judgment signals [11]. In summary, there are many research results on railway safety monitoring, but there are few research on automatic safety monitoring systems for railway signal lights.

This paper studies the railway signal light automatic safety monitoring system based on intelligent learning algorithm and analyzes the purpose of railway signal light automatic safety monitoring and the current situation of railway signal light automatic safety monitoring based on literature data, and then analyzes the railway signal light automatic safety monitoring system based on intelligent learning algorithm. The monitoring system is designed, and the designed system is tested, and relevant conclusions can be drawn through the results.

II. RESEARCH ON AUTOMATIC SAFETY MONITORING OF RAILWAY SIGNAL LIGHTS

2.1 The Purpose of Automatic Safety Monitoring of Railway Signal Lights

2.1.1 Guiding opinions on establishing a safety monitoring system

With the rapid development of railway construction, China's railway construction has achieved leapfrog development. The railway covers a wide area, from north to south and east to west. Many newly built and rebuilt railways, new technologies, and new processes have been widely used in railway systems, and comprehensive technical applications also provide various aspects of railway safety monitoring [12].

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The safety of railway operations is the top priority of the entire railway system. Under these circumstances, it is necessary to conduct an in-depth investigation on the safety of the current railway system and conduct an overall assessment to find out the gaps and weaknesses in the railway safety system and propose effective solutions. This solution needs to integrate other industries or past ideas, such as information fusion, artificial intelligence and integrated information management systems, and establish a corresponding warranty basis based on these technologies to form a technical level suitable for the entire system.

2.1.2 Guiding opinions on establishing a safety monitoring system

Tracking information has improved the accuracy and stability of the supply chain during the entire monitoring. The environmental impact combines various physical and human factors with the problems of the sensor itself. The tracking points are used to ensure the equipment information, but its accuracy and stability is severely restricted. Therefore, the assessment of the overall safe driving situation is not accurate and effective. In response to this situation, the multi-point data collection platform combines in-depth research on information fusion to study the relationship between train safety and information processing, and effective algorithms to improve the accuracy and stability of the data.

2.2 The Status Quo of Automatic Safety Monitoring of Railway Signal Lights

The central signal monitoring system is a special railway monitoring device and an important auxiliary tool for the maintenance and management of the power sector. It automatically, continuously, and continuously monitors the signal equipment of the station in real time and analyzes the risk of equipment failure and the data collected by the staff.

At the same time, the central monitoring system is also a "black box" for electrical maintenance and repair, allowing maintenance personnel to monitor and record the operating status of the equipment according to existing standards, change rules, and on-site equipment environment. Maintenance personnel at all levels can review and repeat comparisons through the terminal at any time. Real-time monitoring of the status parameters of related equipment is an important tool to realize the transition from "planned maintenance" to "state maintenance".

For the central monitoring system itself, preventive maintenance, fault maintenance, and maintenance of basic equipment are used on site, and with the support of the signal communication department, unified management, hierarchical management, division of labor, and shutdown adjustments. The system has been applied. Please cooperate to ensure stable operation of the system.

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III. DESIGN OF RAILWAY SIGNAL LIGHTS AUTOMATIC SAFETY MONITORING SYSYTEM BASED ON INTELLIGENT LEARNING ALGORITHM

3.1 The Construction Process of the Expert System

The first step of the process of establishing an experienced information system is to obtain the required knowledge and information, design the overall structure of the information system, then establish the knowledge base, and finally establish a certain reasoning system, and then realize the overall information system design. Fig 1. shows the development process of a special system.

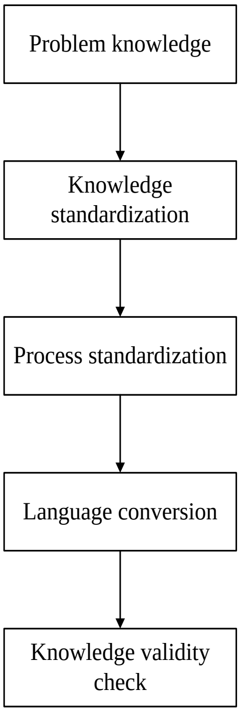

Fig 1: Expert system construction process

3.2 Knowledge Base and Knowledge Base Management Functions

The knowledge base records the points at which failure-related information is collected when a signaling device fails. Error analysis allows analysts to view all relevant information before and after the error occurs based on the relevant collection point information in the knowledge base. This helps to quickly determine the cause of the error.

There are two steps to creating and updating a knowledge base. First, the expert team uses the knowledge base processing platform to compile an analysis process database based on the known failure

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principles and combined with the practical experience of failure processing. The electrical office management staff then distributes the general database to the electrical service departments, and the electrical service management personnel combine the collection systems of the stations within their jurisdiction to issue analysis rules for each station. The stations in the same collection system can be distributed in batches. Knowledge base management tools include analysis process, general library processing, analysis process distribution, equipment combination creation and processing, equipment selection creation and processing, combination processing, zip compression package generation, etc. It consists of 6 modules.

3.3 Graphical Function of the Schematic Diagram of the Malfunctioning Device

Click the diagnosis button on the main interface of the system to start the diagnosis and error analysis process. Display the export error analysis data interface, the analyzer selects the knowledge base unit in the analysis unit, selects the error influence column according to the diagnosis rule area, selects the time when the error occurs, and executes the defect according to the requirements of the related equipment. Select a device, click the load data button on the related device, the system call switch, call the simulation data associated with the machine station according to the rules of the knowledge base, and the data is displayed normally. The "Auxiliary Error Analysis" dialog box displays the change curve of related data. When the analyzer clicks the Replay Failure Schematic Diagram button, the system extracts the simulation data related to the main CAD drawing expansion data from the switch and the station, and the export is completed. The CAD graphics "troubleshooting diagram" interface is displayed, and the parser clicks the "play" button to play the dynamic switching changes and simulation data of the CAD playing interface in chronological order.

3.4 Signal Centralized Monitoring and Alarm Centralized Management Function

Central signal monitoring alarm information system, central management system. If there is an alarm message, it will be sent to the terminal in real time. When the station in the jurisdiction displays an alarm, the real-time terminal alarm light will flash. Click the alarm light to display the real-time alarm dialog box and send out an alarm through the alarm information. The display modes of the levels are different (specifically divided into two categories: first-level and second-level alarms and error levels and third-level alarms and early warning types). According to the number of alarms, the cumulative display and sorting display when alarms occur (display in the first line latest alarm).

3.5 Device Monitoring Method

Equipment failure is a state transition process. As the equipment abnormality (status) changes, the derived characteristic error value will also change. The distance from the sampling point to the center of the hypersphere calculated according to the basic theory of SVDD has also changed. This means that if a sample point moves within the hypersphere, its performance state will not change, or the reliability value

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of the hypersphere (normal state) will be higher than other hyperspheres. That is, when the sampling point moves from a hypersphere to another hypersphere. When the sphere goes out, the state of the sampling point undergoes a qualitative change. In other words, it has entered another extraordinary level. In order to express the degree of equipment abnormality, this article uses the S VDD method to wrap the sample set in a hypersphere, and then uses the contour mapping method to divide the non-self space into various irregular levels, and each contour map represents a detector. The abnormal level represented by this type of hyperloop detector is the abnormal level from the contour map of its own sample set. The super ring detector constructed by the SVDD method can not only detect anomalies, but also monitor the level of anomalies, that is, the degree of anomalies.

The center of the smallest characteristic hypersphere A_0 in the normal state of the device is a_0, and the radius is R. If VZ∈R”, the distance from Z to center a_0 is:

$$R' = \|Z - a_0\| \tag{1}$$

Then the anomaly degree of Z in the state space position is:

$$\eta = \begin{cases} 0 \\ 1 - \dfrac{1}{\exp(R'/R)^2 - 1)} \end{cases} \tag{2}$$

Among them, η=0, which means that the device is in a normal state;

IV. DETECTION OF ANOMALY MONITORING METHODS

Iris reference data is used for evaluation and testing to verify the effectiveness of the S VDD method in generating generalized hyperloop detectors. Set 25 Virginia data in your own space as your own samples and perform SVDD training. The experimental results are shown in Table I.

TABLE I. Anomaly detection method detection

	Setosa	Versicolour	Virginica
5	0.25	1.4	2.7
10	0.25	0.6	2.3
15	0.25	0.4	2.5
20	0.25	0.8	2.4
25	0.25	1	2.6
30	0.25	1.5	2.3
35	0.25	0.6	2.4

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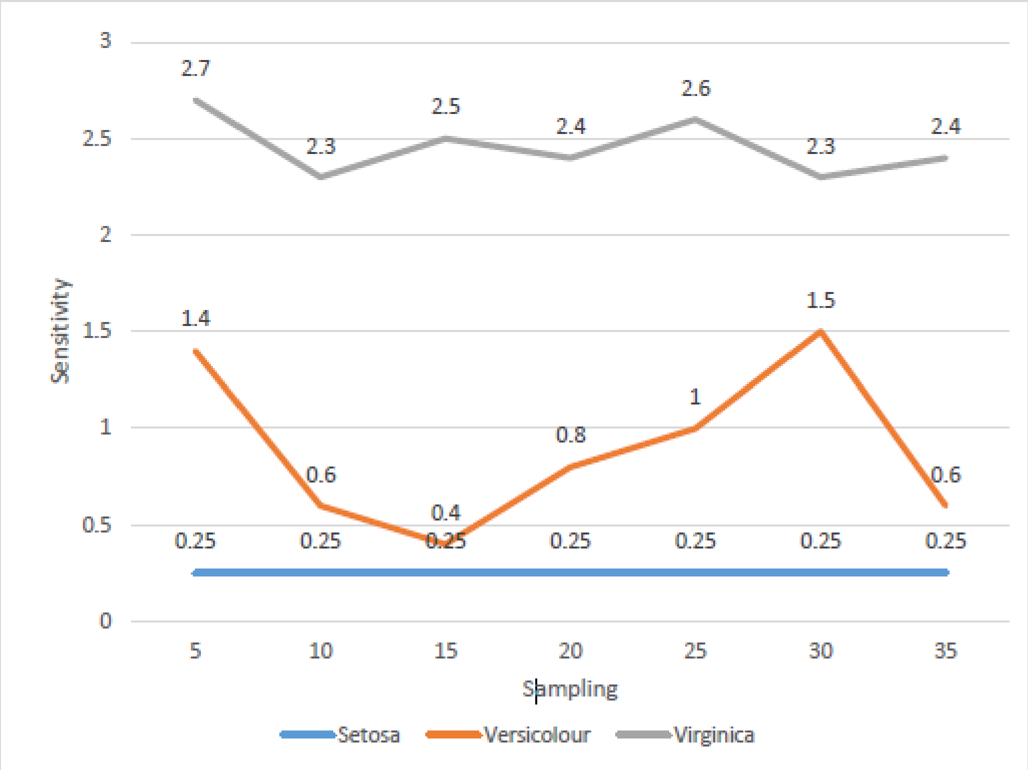

Fig 2: Anomaly detection method detection

It can be seen from Fig 2. that the outliers of Setosa and Versicolor are both greater than zero, and the outliers of Setosa samples are greater than those of Versicolor. This also truly shows the abnormal multiple analysis features of the proposed method: highly abnormal sample resolution Low, the abnormal amplitude changes very little, so it can cover a larger non-autonomous space. The abnormal low-level samples have high resolution, large changes in the magnitude of the abnormality, and small amount of space not covered by themselves, so it can accurately represent the deviation from the sample itself.

V. CONCLUSION

This paper studies the railway signal light automatic safety monitoring system based on the intelligent learning algorithm. After analyzing the relevant knowledge on the basis of literature data, the railway signal light automatic safety monitoring system based on the intelligent learning algorithm is designed and the applied algorithm is tested. The test results show that the proposed method has a high degree of abnormality sample resolution is lower, the amplitude of the abnormal degree changes less, and can cover a larger non-self space.

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