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Health Monitoring Method of Elevator Door Machine Based on Multi-Source Sensor Data

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Abstract. With the rapid urbanization of China's social economy, high-rise buildings can be seen everywhere Elevator has also become the main tool in the field of vertical transportation, and its application is becoming more and more extensive, which provides great convenience for people's lives But the safety of the elevator is also a hot topic. In recent years, the elevator door crane operation failure will occur from time to time in various places, which leads to accidents caused by the impermanent opening and closing of the elevator door. Therefore, it is very important to study the door crane In view of this phenomenon, sensors for safety monitoring can be installed to monitor and judge whether the elevator is in a dangerous state through the data transmitted by the sensors, and repair the elevator in time before the danger occurs With the development of modern technology, the research direction of elevator door crane turns to the health monitoring of door crane, from the maintenance after failure to the prediction and timely maintenance before failure The maintenance cost, time and energy are greatly increased, the service life of elevators is prolonged, accidents are avoided, and the safety and reliability of equipment operation are improved.

Keywords. Sensor, elevator, safety monitoring, door operator health

1. Introduction

With the rapid development of China's social economy and the acceleration of urbanization, the application of elevators in the field of vertical transportation has gradually increased, bringing great convenience to people's lives.

However, the safety of the elevator is also a hot topic, and there are often some accidents due to failures. The elevator faults mainly include crush accident, fall accident, collision accident, electric shock accident, earthquake accident and other concentrated situations. Among them, there are many former residences. Take Jiangsu Province as an example. In 2021, Jiangsu Province will deal with an average of 137 people in distress every day. From the perspective of the reasons for people trapped, among the three main types of reasons, elevator door system failures account for 12.40%. Among the door system reasons, the hall door lock failure accounted for 34.61%, the car door lock failure accounted for 22.95%, and the door machine failure

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accounted for 22.69%. It can be seen that the research on the elevator door machine is very important.

Therefore, a new health monitoring method based on visual sensor and optical fiber sensor is proposed to monitor and identify the operation status and fault information of elevator door machine.

2. Research Status at Home and Abroad

2.1. Research Status Abroad

At present, there have been researches on health monitoring of metal parts or mechanic al equipment at home and abroad.

Steven [1] started the research on the fault diagnosis system of elevator door machine. However, due to the limitations of the technical conditions and theoretical concepts at that time, the idea of intelligent maintenance was not involved.

Jay Lee [2] was responsible for the research and development of intelligent maintenance system with elevator door machine as the research object. A device capable of performing performance degradation analysis, life prediction, fault diagnosis and maintenance services for the elevator door machine system under the experimental environment has been developed. The acceleration sensor is installed on the door leaf of the door machine test bench to measure the three-dimensional vibration signal during the door opening and closing cycle, and extract the door opening and closing command and pulse encoder signal in the door controller. The experiment simulates the fault and normal state of the door machine, and processes and analyzes the collected signals.

2.2. Domestic Research Status

Compared with foreign countries, the research on elevator door crane in China started late. Lu Shihai [3] completed the development of health monitoring management system based on Android. Liu Jianxiu [4] used the finite element simulation calculation to carry out the system simulation and mechanical analysis of the arch space steel pipe in the elevated station building of the station, and carried out real-time monitoring of its key parts. Wang Xiaoyong [5] adopted the damage early warning method to carry out the research of damage early warning based on the similarity distance function index of time series based on the domain transformation feature representation.

Based on the shortcomings of the above research, a method of combining optical fiber sensor and visual sensor is proposed to detect whether the elevator door machine is faulty through the data transmitted by the two sensors. Through the visual sensor, it can intuitively and conveniently observe whether the elevator door can not be opened normally, whether it can not be closed, and whether the door leaf keeps opening and closing. The optical fiber sensor can detect whether the door leaf has abnormal vibration.

3. Elevator Door Monitoring Scheme

The health monitoring technology of elevator door machine based on vibration signal mainly includes: collecting and analyzing the vibration signal to identify the vibration source; Vibration signals are used to identify operating state parameters; Determine the fault location and realize fault diagnosis [6].

The elevator door is divided into car door and landing door. In the car door monitoring, a visual sensor is added to the camera inside the car door, two or more optical fiber sensors are installed on the side of the car door, and discrete infrared light is selected to perform horizontal detection of the entire door width. The combination of the two can monitor the car door status. In the monitoring of landing door, the same way is used as the car door. A camera with built-in visual sensor is installed on the outside of the elevator, and an optical fiber sensor is installed on the side of the landing door. The combination of the two is used to monitor the status of the landing door. As is shown in figure1, figure 2 and figure 3 [7].

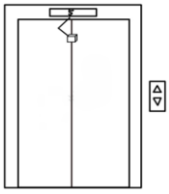

Figure 1. Visual sensor placement structure diagram (landing door).

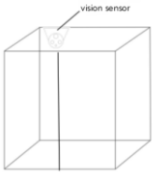

Figure 2. Visual sensor placement diagram (car door) variable.

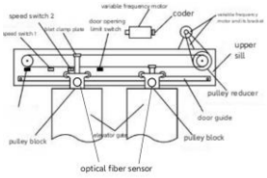

Figure 3. Mechanical diagram of frequency door crane.

3.1. Data Acquisition

The terminal data acquisition part is mainly collected by optical fiber sensors and visual sensors, including the torque current, displacement, speed, acceleration and door system friction of the door motor.

The optical fiber sensor is installed on the landing door and car door operator. The output voltage signal of the vibration photoelectric sensor generated by the door operator is approximately proportional to the measured vibration signal, so as to reflect the vibration of the measured object.

According to the experimental results, the measured value of the accelerometer is relatively stable and has little fluctuation during the normal operation of the elevator door system.

Install visual sensors inside the elevator car and outside the landing door. Through the camera, after capturing the image, the visual sensor converts the optical image into a digital image and compares it with the reference image stored in the memory for analysis.

LabVIEW Photoelectric Vibration Test System. The main functions of LabVIEW vibration analysis include vibration signal waveform display time domain analysis, frequency domain analysis 10, data storage, etc; The process is shown in the figure 4.

The LabVIEW program panel of the photoelectric vibration test system is shown in figure 5.

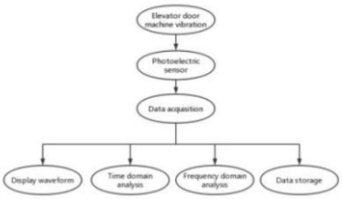

Figure 4. Flow chart of vibration detection.

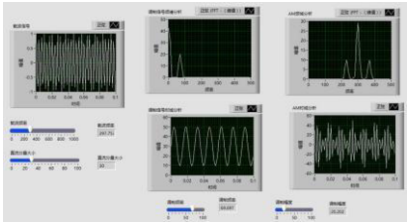

Figure 5. LabVIEW panel.

3.2. Data Transmission

The Arduino Mega 2560 control board is used to connect the esp8266 wireless module to the network server, upload it to the cloud platform, and monitor the elevator operation data information. The wireless terminal mode is adopted. The module is used as wireless WIFI STA. The ESP8266 module is connected to the Internet through a router to realize wireless data conversion and mutual transmission between the serial port and other devices. Under the WIFI STA mode, according to different application scenarios, three sub-modes can be set: TCP server, TCP client and UDP. The process is shown in figure 6.

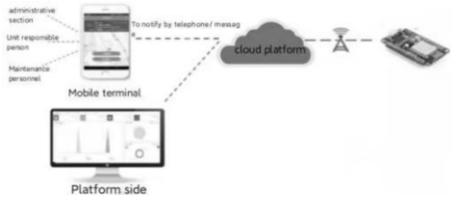

Figure 6. Wireless terminal mode.

3.3. Data Processing

The elevator monitoring system based on cloud platform is composed of Internet of Things gateway, cloud server and user end. The system is divided into perception layer, transmission layer and platform layer, which respectively play the role of information collection, transmission and application. The operation information of the elevator door machine is collected and transmitted by the sensor to the Internet of Things gateway. The Internet of Things gateway uploads the information to the cloud server. The user end then uses the data of the cloud server to carry out relevant application development. It can enable the user to access the cloud server through the web terminal or mobile terminal to view real-time data, and realize the elevator operation status monitoring, fault alarm and other functions. Through the cloud platform, store the elevator operation data transmitted by the Internet of Things gateway, process the data, and provide users with visualization, create the elevator door operator data monitoring platform, and add the elevator door operator operation data [8].

4. Experimental Test

4.1. Elevator Door Closing Test

First, detect the data of the elevator during normal operation through the sensor, including the opening, closing and vibration of the elevator door; Store these data in the database. Then put a box between the two door leaves of the elevator to act as the foreign matter in the elevator door. Through the visual sensor placed in the elevator monitoring, the foreign matter in the elevator door can be visually observed and detected. Compare the data at this time with the data in the normal state. If there is a difference, that is, determine that the elevator door is faulty and send an alarm in time.

4.2. Elevator Door Opening Test

Press and hold the elevator door by hand to prevent the closing of the elevator door, and simulate the scene that the elevator door fails and cannot be closed. Through the visual sensor placed in the elevator monitoring, it can be visually observed and detected that the elevator door cannot be closed. Compare the data at this time with the data under the normal state, and there is a difference, that is, determine that the elevator door has a fault, and send an alarm in time.

4.3. Vibration Test of Elevator Door Leaf

Push the elevator door leaf by hand to make the elevator door leaf vibrate and simulate the vibration of the elevator door leaf. Through the optical fiber sensor installed in the elevator door machine, the vibration of the door leaf can be detected. Compare the data at this time and place with the data under the normal state. If there is a difference, that is, determine that the elevator door has a fault and send an alarm in time.Whether the elevator is running or not is as shown in the figure 7 and figure 8.

Figure 7. Elevator that cannot be normally closed or opened.

Figure 8. Elevator that can be normally closed or opened.

5. Conclusion

In this paper, the status of elevator door system is monitored by combining visual sensor and optical fiber sensor. In this way, the door is monitored by the combination of visual sensor and optical fiber sensor, and Fourier transform is used to identify the fault information of the collected signal, so as to realize the monitoring and early warning of the door machine switch and vibration status, and provide data basis for the subsequent door machine maintenance. Compared with the traditional elevator door

machine maintenance after failure, this method can predict and maintain in time before failure, greatly reduce the maintenance cost, time and energy, extend the service life of the elevator, and avoid accidents and casualties.

Acknowledgments

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