Intelligent monitoring system of elevator Internet of things

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Abstract. The function of traditional elevator monitoring system is relatively simple. It cannot realize on-demand maintenance and fault warning. To solve such problems, this paper builds an intelligent monitoring system of elevator Internet of Things based on multi-sensor information fusion, bus communication and probability and statistical analysis technology. Managers can access the control platform through smart terminals or web browsers to achieve data query, video monitoring, alarm management of the elevator system, health management and other functions, which can help managers detect hidden dangers of elevator safety in time and ensure safe and efficient operation of elevators.

1. Introduction
Elevators are special equipment with high safety performance requirements, the abnormality of any parts may lead to serious consequences[1]. In order to reduce elevator damage to passengers, it is necessary for an intelligent elevator-monitoring system with accident detection and failure warning. Although Hitachi and Otis have kinds of achievements on elevator IOT-monitoring systems[2-4], the application of their elevator-monitoring systems is not common because most elevator manufacturers are unwilling to open data interfaces. It has incomplete system compatibility and openness, which is only suitable for certain elevator brands.

In this paper, the elevator operating data is obtained through independent sensors and data acquisition equipment, which has better compatibility and easy scalability. The elevator maintenance database is established in order to analyze elevator failure data and predict risks. Meanwhile, through the construction of the emergency-management platform, the abnormal state of passengers is identified to reduce the risk of accidents. The elevator IOT intelligent-monitoring system has the characteristics of stable performance and strong compatibility, which has important theoretical and practical significance.

2. System Architecture
The architecture of elevator Internet of the things intelligent monitoring system is shown in Figure 1. The system consists of three parts: data acquisition layer, data transmission and processing layer and network layer. The data acquisition layer is mainly responsible for collecting the elevator operation data, video images and passenger emergency information. It is connected with a series of sensors and webcams installed on the elevator, and is the data source of the whole system. Data transmission and processing layer is mainly realized by field communication protocol and industrial computer, which is responsible for data transmission and processing. The server layer is mainly composed of database and
data analysis algorithm, including fault prediction model based on PHM technology and Bayesian technology, and elevator passenger behavior detection algorithm. The data processed by the algorithm will be published to the Internet terminal via Web page or APP, and the relevant management personnel can realize remote maintenance and dynamic monitoring of the elevator monitoring system according to the authorization.

![System frame diagram](image)

Figure 1. System frame diagram

### 3. System Composition

The intelligent-monitoring system of the elevator is composed of hardware and software. The differences are mainly reflected in the hardware selection and data processing methods.

#### 3.1 Hardware and communication protocols

The hardware part of the system mainly includes data acquisition, on-site monitoring, data transmission and processing equipment. The system uses sensors to collect input data, including load sensors, speed sensors, and vibration sensors. On-site monitoring includes cameras, video capture cards, etc. Part of the equipment list is shown in Table 1.

| Name                  | Model                      |
|-----------------------|----------------------------|
| Temperature sensor    | WRNKL-130/WRNKL-230K       |
| Vibration sensor      | ADIS16445BMLZ              |
| Load cell             | LUDWIG LW-PB               |
| Camera                | HCV iDS-2DF5220s-D4        |
| Video capture card    | HCV DS-40008HS             |
| Data acquisition card | ADVANTECH PCI-1716         |
| IPC                   | IPC 610                    |

In the server configuration, IPC 610 was selected as the host of industrial computer. The industrial computer has large redundancy in computing power, Which can adapt to harsh environment, and is widely used in the field of computer vision. RG-BNBS5710-24GT4SFP-E series is selected as the industrial gateway, which has CAN / RS485 / Ethernet port / USB / IO interface and powerful protocol conversion capability, It can realize remote management of almost all mainstream sensor nodes in the market. It supports the interconnection of Wan and LAN, which can realize SSL and TTL encrypted communication, This further improves the security of the system. In the client configuration, Mainly based on CPU, memory hard disk, graphics card, network card, etc., in the choice of hard disk, you should choose 500 GB or above or 7200 rpm mechanical disk hard disk, and the internal network card
3.2 Software system design

3.2.1 Software environment configuration
The operating environment of the elevator IOT intelligent monitoring system is based on win7/win8/win10 operating systems. The system uses SQL Server 2019 and Tomcat 8.5 as the database and background server respectively. Tomcat server is a free and open source web application server, which are commonly used in small and medium-sized systems. The development and debugging languages are mainly Java, JSP, CSS. In addition, the client browser can be accessed through Firefox. V 51 access to HTML pages.

3.2.2 Software architecture
The intelligent monitoring system of elevator Internet of things adopts browser server (B/S) architecture. Users can access the operation and maintenance system through the specified browser software installed on the client side. In the hierarchical framework, the standard MVC design pattern (model view controller model view controller) is adopted. The whole system is divided into four layers from bottom to top, which are Dao layer, service layer, controller layer and view layer. In the framework design, the function and data processing are separated relatively independently, which can make the system structure clear and enhance the system scalability. Practicability and maintainability. The software framework of elevator IOT intelligent monitoring system based on MVC mode is shown in Figure 2.

![Software system framework](image-url)
The intelligent monitoring system of elevator Internet of things takes SQL Server database as the data storage platform, tomcat 8.5 as the web server, and uses JSP technology to program. On this basis, the system operation development and system function interface can be improved at the same time. The code update is convenient, and the system has good portability and scalability in the actual development. Database is interconnected with web server through JDBC (Java Data Base Connectivity). JDBC is a Java API used to execute SQL statements. It provides unified access for a variety of relational databases and consists of a group of classes and interfaces written in Java language. JDBC provides a benchmark through which more advanced tools and interfaces can be built so that database developers can write more database applications.

The intelligent-monitoring system of elevator IOT choose SQL Server database as the data storage platform, Tomcat 8.5 as the Web server, and adopts JSP technology to program. The database interconnects with Web server through JDBC (Java), which provides API interface for database developers to write database application programs. In the B/S system development model, the user first sends an HTTP request instruction to the Web server through the browser, the Web server passes the request to the JSP engine, and executes the Servlet program to produce an HTML output, and finally the Web server returns the HTML output to the user in the form of static Web page. This system is based on this way to connect to the database, so as to connect to the Web server by loading SQL Server.

3.2.3 Platform interface design

The intelligent-monitoring system of the elevator is based on Hbuilder and VS2010 to develop the front-end and back-end, which is convenient to interact with the background data. The main interface of the platform is divided into three parts: title bar, navigation bar and menu bar, which display login information, current tab and function menu respectively. Each function module is displayed as a hierarchical tree menu. Each function module has an independent form interface, and the related forms can be called each other. The platform interface design structure is simple and has good human-computer interaction performance. The main interface of the system is shown in Figure 3.

![Figure 3. Main interface rendering of elevator management system](image)

The intelligent monitoring system of elevator Internet of things has the following functions:

1) User login registration. Users can log in to the system by inputting account number and password through specified browser on any client server connected to the Internet. At the same time, new users can query user information according to authorization.
2) Elevator operation data. When the user clicks the operation data module in the left menu bar, a new elevator operation data tab will be added in the navigation bar. In the right area of the main interface, the elevator operation speed, load distribution, infrared switch status, limit switch status and other elevator mechanical and electrical data will be displayed in real time in the form of chart.

3) Passenger management. The passenger management module includes three main sub functions: passenger number statistics, passenger fall detection and elevator reservation. Through the analysis of the number of passengers, the time of taking the elevator and the behavior state of passengers, the optimal operation configuration of the elevator can be realized, the waiting time of passengers can be reduced, and the personnel fall accident in the car can be found in time, so as to reduce the injury of elevator failure to the middle-aged and elderly people.

4) Elevator health management. Using PHM technology and Bayesian theory statistical analysis method, analyze the equipment data and historical maintenance work orders that are still in normal working condition, and establish a system health monitoring system based on Bayesian network and grass-roots data. It can realize on-demand maintenance and fault early warning of elevator.

5) Emergency treatment. The system automatically collects emergency events such as elevator trapped and falling reported by multiple elevator terminal collectors, manages each elevator fault alarm in the form of form, and pushes the emergency information to the elevator production department, supervision department and user department in real time. Real time record the disposal process, including the elevator operation parameters, maintenance information, fault types, rescue station information, etc., to improve the safety performance of the elevator.

4. Conclusion
In this paper, the intelligent-monitoring system of the elevator designed comprehensively uses sensor data fusion, network communication, java web development and other technologies. It can obtain the operation status of the elevator without relying on the data interface of the traditional elevator manufacturer. In case of an accident, the elevator can be rescued at the first time to ensure the safety of the elevator passengers to the greatest extent, it improves the intelligent monitoring level of the elevator. The test shows that the elevator IOT intelligent monitoring system has low cost and strong compatibility, and has good practical value.

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