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Research on Elevator Safety Management Information Technology in Colleges and Universities: Taking Xi'an University of Technology as an Example

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Abstract: With the increasing use of elevators in Colleges and universities, safety accidents caused by elevators are frequent. In order to strengthen the safety management of elevators in colleges and universities and ensure the safety of personnel in elevators, taking Xi'an University of Technology as an example, combined with advanced technologies such as Internet of Things, cloud computing, data mining, the elevator of campus takes the following technical measures: the elevator engine room equips with standardized construction, the traction machine equips with emergency power supply, the capsule equips with emergency flasher and with "one button" wireless emergency communication system, and the control cabinet equips with elevator safety remote monitoring system，elevator safety early warning and forecasting platform based on data mining. The paper conducts further data mining by using the elevator operation data obtained by the data acquisition terminal, realizing the transmission from the passive alarm of the trapped personnel to the automatically elevator alarming, and even to the early warning and forecast of elevator accidents. It breaks through the "bottleneck" of the "last kilometer" technology for emergency rescue of University elevators and provides a timely, effective, convenient and reliable communication measure for passengers. Thus these measures can protect the safety of teachers and students when they take the elevator and maintain the campus's security and stability.

Keywords: Elevators of Colleges and Universities, Safety Management, Wireless Emergency Communication, Remote Monitoring, Data Mining

1. Introduction

As the fourth largest means of transportation after airplanes, trains and automobiles, elevators are used more widely in universities. Colleges and universities are public gathering places, with high density of people and high accident rate. In the peak hours of classes, libraries, office buildings and dormitory buildings, elevators often run at a high frequency and high load so that accidents such as hurting people, trapping people, and non-flat floors open doors are frequent [1]. The annual accident rate of colleges and universities throughout the country is between 1.56 and 0.15 (per million units). Elevator safety management technology has the following methods: (1) Install cameras inside the elevator to understand the safety conditions through the video surveillance screen; (2) Set a unified 96333 or 12365 alarm phone; (3) Establish an elevator safety supervision platform. In the first way, if the duty room cannot guarantee that people are on duty within 24 hours, the equipment would be useless. The second type is a passive way for help, only when the trapped passengers make an alarm call can they be rescued. At present, the third method on the market mainly adopts a technical solution for installing sensors on elevators, which has the disadvantages of high cost, poor detection accuracy, high false alarm rate, and installation difficulties. As the elevator is an electronic mechanical product, accidents are inevitable in its daily use. However, the losses can be minimized through advanced technology and regulatory levels [2]. College elevator safety managers must ensure the safety of lives, the property of teachers and students, and the effective control of internal safety environment and the order [3]. This paper takes Xi'an University of Technology as an example to discuss the safety management of college elevators from the perspective of information technology

2. Elevator Engine Room Standardization Construction

Elevator is mainly composed of three parts: capsules, traction machine and control cabinet. The traction machine and control cabinets are placed in the engine room, and the engine room environment is directly related to whether the elevator can operate under the best working condition [5]. "People's Republic of China Special Equipment Safety Law", GB 7588-2003 "Elevator Manufacturing and Installation Safety Regulations", GB 24803.1-2009 "Elevator Safety Requirements", TSG T7001-2009 "Rules for elevator supervision and inspection and periodic inspection", TSG T7002-2005 "Tire and forced-drive elevator type test rules" and other standard specifications implemented on January 1, 2014, has specific requirements of the machine room load, temperature, traction wire rope and so on, but there is no unified standard. The school has carried out fine management, formulated the unified standard of the elevator machine room and carried out the bidding construction. The specific content is shown in Table 1:

Table 1. *Elevator room standardization construction content.*

Construction Content	Specific Measure
Civil engineering section	1. The floor is paved with ceramic tile or floor paint, wall latex paint, foot line, stainless steel door (with access control system), aluminum alloy doors and windows; 2. The equipment platform has the same elevation and no steps in the equipment room. If there is a step, install a 70-degree ladder.
Security section	1. Lightning protection: lightning protection facilities are in good condition; 2. Anti-mouse and pest control: There are anti-rat boards, blocking loopholes or hanging nets; 3. Water leakage protection: There are drainage ditch on all sides of the room, doors and windows with canopy, shutter doors, vents with rain-proof devices, bottom pits to make waterproof, no water leakage and hidden dangers. 4. Protection against electric shock: The gate has warning signs, locks, insulated gloves, rubber shoes, rubber flooring, tools that meet insulation safety requirements, and zero-line devices meet requirements; 5. Fire protection: Decorative materials meet fire protection requirements, equipped with adequate and qualified fire extinguishers; 6. Other: no other hidden dangers leading to safety accident.
Environment section	1. Ventilation and cooling: Mechanical ventilation, installation of air conditioning, air temperature in the room maintained at 5°C ~ 40°C, high temperature alarm; 2. Noise: less than 40dB at night and less than 50dB during the day; 3. Dust prevention: High-end equipment has dust prevention facilities.
Affiliated Facilities	1. Emergency lights: install no less than 4 on the walls; 2. Tool Cabinet: Provides cabinets for placing common tools; 3. Telephone: There are five-way telephone room extensions, fire telephones; 4. Intelligent monitoring: install a hemispherical camera; 5. Other: A thermometer.
Identification section	1. Name identification: machine room e name plate; 2. Warning signs: There are safety warning signs (such as high pressure, stop the heavy idlers in the engine room, prohibiting the stacking of objects in front of the door, etc.); 3. The cordon equipment machinery and electronic control part set up a yellow cordon, 8 cm width; Operational warning: identification set value, work steps, etc;

3. The Traction Machine with Emergency Power and the Capsule with Emergency Lighting

In the course of using the elevator, once the power system (external power grid) fails (blackout, phase loss, fire alarm), it will pose a serious threat to the physical and property safety of the trapped passenger. The general treatment method is that the elevator maintenance personnel first cut off the external power grid, loosen the brake of the elevator traction machine, carry out the manual disc brake, lower the elevator car to the nearest landing, and open the car door to rescue the trapped passengers. Such work must be completed by at least two or more professionals, and there is certain potential danger to rescue workers and passengers in the elevator during the rescue process. In addition, the trapped passengers in the elevator may suffer psychological trauma due to nervousness, irritability, fear etc [6].

The composition of traction machine’s emergency power supply device is shown in Figure 1, during normal operation, the 380V three-phase alternating current (AC) power supply is used to provide the AC load of the elevator through the AC connector and charge the battery pack at the same time. In the event of an emergency power outage, the AC connector is disconnected and the emergency power source is automatically activated. Battery assembly supplies power to the elevator via an inverter, allowing the elevator car to run slowly to the nearest landing station door area, and then automatically open the door and the hall door to let passengers get out of the elevator quickly and safely [7].

The composition of the car emergency lighting device is shown in Figure 2. When the commercial power is normal, the 220V AC power is converted into low-voltage direct current through the transformer and rectifier circuit, which supplies power to the light-emitting diode (LED) direct current (DC) load and charges the lithium battery pack at the same time. When the power fails, the transformer loses power, and the lithium battery pack outputs low-voltage direct current, which turns on the LED light [8].

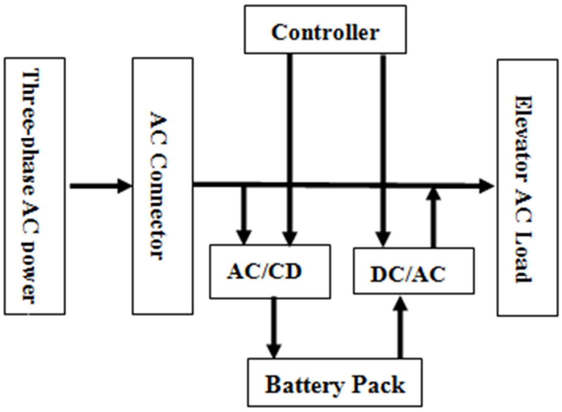

Figure 1. *Traction machine emergency power supply unit.*

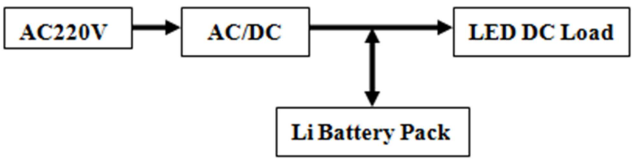

Figure 2. *Car emergency lighting device composition.*

4. Elevator Wireless Emergency Communication System

Shaanxi Province issued the "Shaanxi Province Elevator Safety Supervision and Management Measures" in January 2013: the province's elevators must maintain the elevator emergency alarm device and call device intact to ensure smooth communication. Therefore, colleges and universities in Xi'an area have installed five-way communication systems in elevator cars [9]. The so-called "five-way call" refers to the call between the car, the engine room, the car roof, the car floor, and the extension of the duty room. It is an "emergency channel" for the trapped passengers to get in touch with the outside world [10]. However, the problem with this device is that each elevator cannot have a corresponding duty room. Generally, a total duty room is set up in the whole school, and the wiring to the general duty room is both troublesome and limited. In addition, the duty room must be manned 24 hours, otherwise no one will answer the phone. In view of this, the school installed a "one-button" wireless emergency communication system for each elevator, as is shown in Figure 3, between the elevator capsules extension and handle extensions (the engine room extension, the capsules top extension and the bottom pit extension) through the two cables that are accompanied by the elevator in the hoistway are used to broadcast communication. The car extension and the on-duty telephone use the global system for mobile communication (GSM) network to communicate wirelessly through the host, so that the position of the on-duty telephone can be freely placed without wiring [11]. The device presets four sets of telephone Numbers, "one key" dialing, and automatically transfers to another number when no one is on duty. The device also features specific phone call back and background comfort music playback.

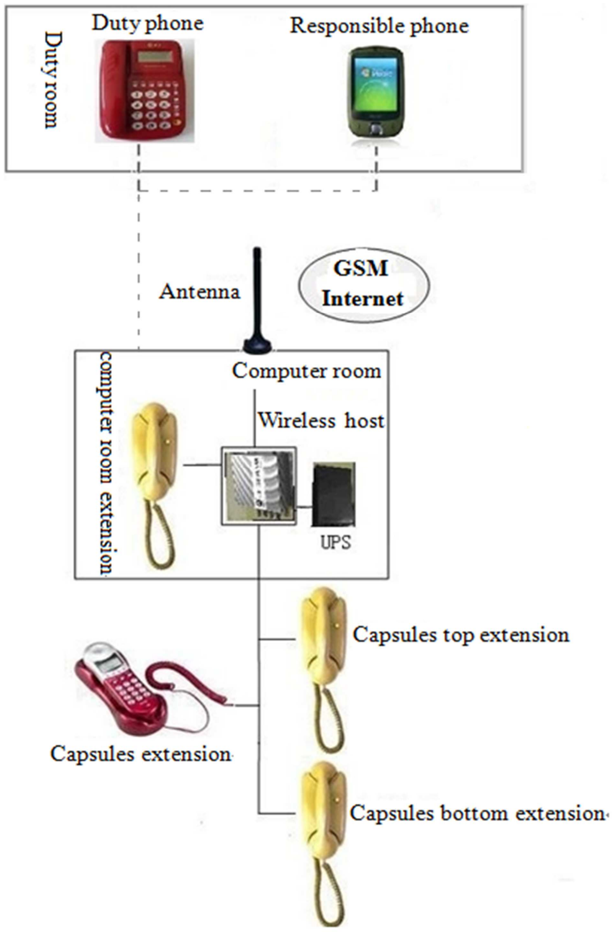

Figure 3. *Elevator wireless emergency communication system diagram.*

5. Elevator Safety Remote Supervisory System

According to statistics, among the numerous elevator accidents in recent years, the accidents caused by failure to maintain elevators on time accounted for more than 60% [12]. How to supervise the quality of elevator maintenance company? How to raise the passive alarm from trapped passengers to the active failure of the elevator? Elevator safety remote supervision system has solved the above problems well. The system consists of hardware and software: the hardware part is installed in the elevator engine room, and the elevator status signal is extracted from the elevator control panel in real time and pushed to the server using the General Packet Radio Service (GPRS) network, as is shown in Figure 4; The software part analyzes the elevator's operating data and displays the elevator's running status in real time [13]. When the fault occurs, information such as faulty elevator position, fault phenomenon, and trapped personnel will be reported to the duty room and maintenance personnel through short messages, Internet personal computer (PC) terminals, and mobile Internet terminals, thereby shortening rescue time.

The adaptive detection technology for elevator wide-voltage (AC/DC12~220V) signals based on circuit automatic shifting principle and installation of sensors makes the system suitable for different countries, different manufacturers, and different types of elevators, as is shown in Figure5. The input signal passes through the rectifier unit (D1~D4), filter unit (C1), step circuit unit (lower resistor R4, high resistor R5, zener diode D5, transistors Q1 and Q2), and signal isolation unit (D6). The signal is output stably by the comparator (U2). The elevator status signal includes eight signals such as operation/inspection mode, ascending and descending, upper and lower flat layer, door lock, safety loop, and power supply [14].

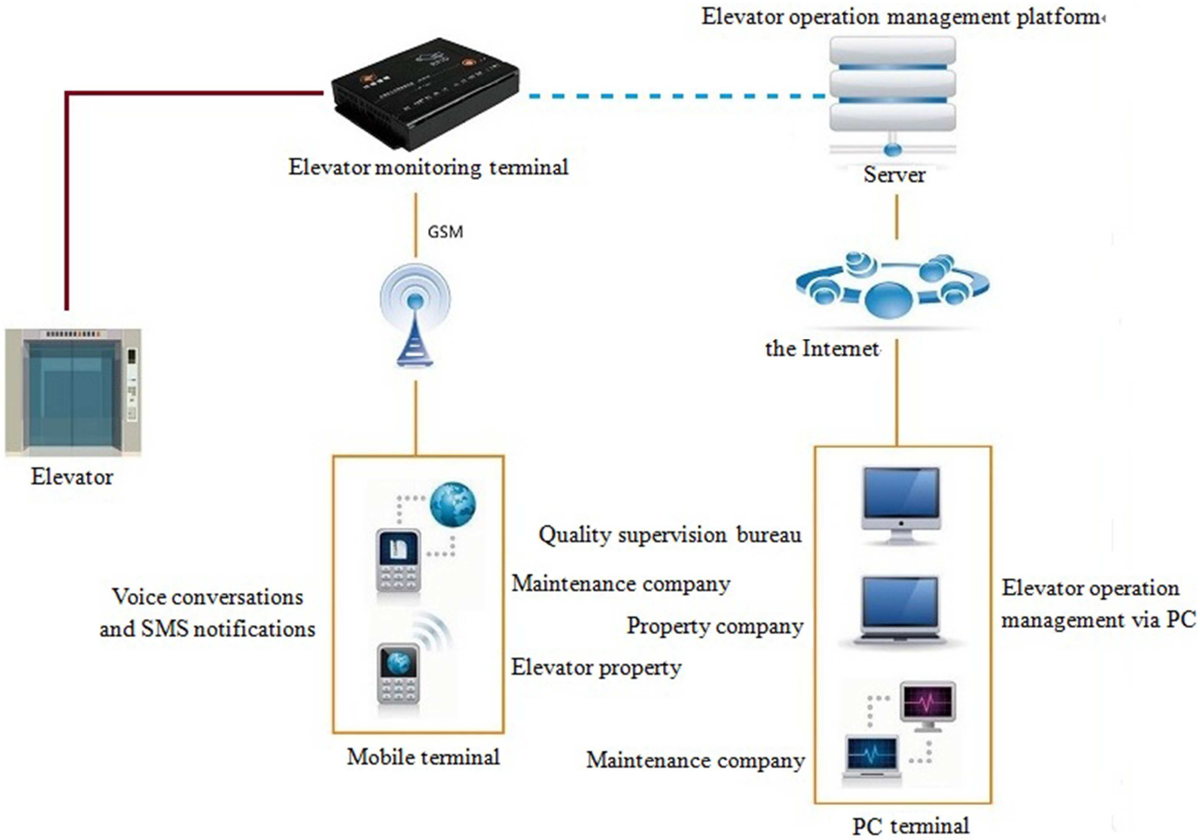

Figure 4. *Elevator safety remote monitoring system diagram.*

According to the criteria and basis for elevator fault determination, a number of mathematical models were established. Through the background service procedures, the fault criteria was applied to the mathematical model identification and the criteria of the constraints to determine the elevator fault. The application software includes eight modules: data management, real-time monitoring, fault management, maintenance management, violation management, announcement notification, report management, and system management.

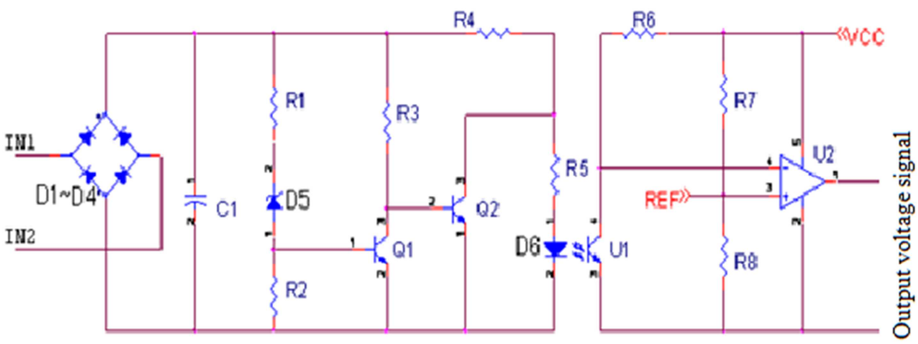

Figure 5. *Schematic diagram of adaptive detection of wide-voltage signals for elevator sensors.*

6. Elevator Safety Early Warning and Forecasting Platform Based on Data Mining

The data in the database of elevator safety remote monitoring system is used as a data source for data mining, which constitutes an elevator safety warning and forecasting platform. Its architecture is shown in Figure 6. The data mining management engine provides an application program interface (API) for data mining and is responsible for scheduling and managing the entire data mining task at the same time: Manage multiple computing tasks running at the same time and coordinate resource allocation. The excavator independently runs a data mining program, and takes responsibility for the processing of the segmented minimum unit tasks. The data mining algorithm library provides commonly used basic mining algorithms [15].

The data mining algorithm consists of data specification, data transformation, and data analysis algorithms. It processes massive amounts of data from elevator monitoring terminal equipment through mathematical models, empirical formulas, fuzzy algorithms, and genetic algorithms to obtain useful information from data warehouses, and integrate the information for the use of forecasting and warning platforms.

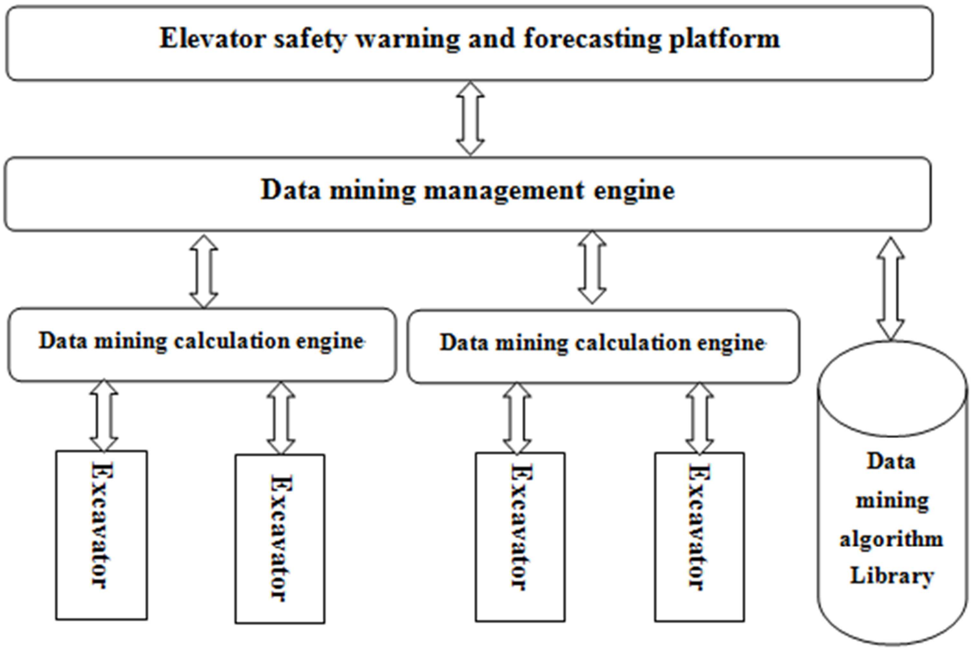

Figure 6. *Schema diagram of the elevator safety forecasting and warning platform based on data mining.*

The early-warning forecast analysis consists of HADOOP analysis system, expert forecast warning model, and simulation model [16]. Based on HADOOP MAP/REDUCE algorithm to realize the efficient parallel data analysis, the simulation model for further analysis and deduction likely scenario, and the existing early warning and forecasting templates are adaptively matched and added, so as to achieve an autonomous analysis of elevator fault accidents and achieve the release of warning and forecast results.

7. Conclusion

Xi'an University of Technology has 26 straight ladders in the teaching area and 21 straight ladders in the family area. The school logistics office has introduced advanced technologies such as Internet of Things, wireless communication, cloud computing, intelligent expert systems, and data mining to closely integrate with elevator safety, it broke through the "last mile" technology "bottleneck" of real-time monitoring of elevator status, fault alarm, and emergency call-out for passengers in the event of an accident, providing the occupants with a timely, effective, convenient and reliable communication guarantee; 24 hours of continuous monitoring, timely detection of signs of failure, to avoid major accidents. The emergency plan can be automatically generated according to the type and level of the accident, and can save the rescue time. During the implementation, the poor coverage of wireless signals in the hoistway was encountered, and the signal strength was increased by adding signal amplifiers. The implementation results in the past three years indicate that the standardized construction of elevator engine rooms, the installation of emergency power supplies, emergency lights, and other technical measures such as the installation of wireless emergency communication systems and elevator safety remote monitoring systems have strengthened the supervision capabilities of schools for elevator equipment and maintenance personnel, improved the fault handling rate of more than 60%, reduced the elevator failure rate of 80%, provided a strong technical guarantee for the safe operation of elevators and reduced the occurrence of elevator accidents.

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