Research on Subway Construction Monitoring and Warning System Based on Internet of Things Technology

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Abstract. Aiming at the problems that the low specification, underinvestment and the low professional level of risk management existed in the subway construction at present, analyzed the construction demand of monitoring and warning system for subway construction, a kind of subway construction monitoring and warning system based on internet of things technology was proposed. Internet of things, wireless communication, cloud computing and other technologies was exploited to comprehensive sense and monitor of the construction site; Researched the personnel positioning system based on Mesh technology to realize wireless self-organizing network of transmit data and improve positioning accuracy and response speed; By combining the video monitoring with wireless sensing technology, real-time monitoring of field operations was realized, ensure the safety of workers' lives and "zero hidden danger" in the field working environment; Data push technology was used to achieve mobile video monitoring, stagewise and classified management, improve the flexibility of safety management.

1. Introduction
Under the reasonable guidance of urban rail transit construction planning, for many years, urban rail transit has developed rapidly with its advantages of energy conservation, speed, safety and large capacity[1]. Underground construction has the characteristics of complex construction technology, bad construction environment, many uncontrollable factors, great influence on the surrounding environment of construction, long construction period and so on. Therefore, underground construction is a high-risk project[2]. At present, there are some problems in underground subway construction, such as low risk management standard, insufficient investment and low degree of specialization. The implementation of safety risk management has become the inevitable trend of rail transit project construction.

Since the 1990s, with the rapid development of industrial computers, the level of automatic monitoring and management of rail transit has been greatly improved. Countries around the world have also carried out research on the problems existing in underground engineering construction and achieved a series of results[3]. In September 2003, the British Tunneling Association and the Institute of Insurers jointly issued the "Joint Code for the Risk Management of Tunnel Construction in the United Kingdom"[4]. The Italian Geodata company has launched the GDMS information management platform for underground engineering construction risk management. The system is composed of five functional modules, such as building risk assessment, shield data management and monitoring data management, to realize the information monitoring of safety risks[5].
Due to the limitations of the current geological survey level and technology, the application of the Internet of Things in China focuses on the intelligent transportation, and is rarely applied in the engineering monitoring. Based on the basic principles and architecture of the Internet of Things, combined with the actual requirements of rail transit construction, this paper proposes a subway construction monitoring information system based on the Internet of Things, which can realize information collection, data analysis and mining, personnel positioning, real-time monitoring and intelligent early warning in the process of subway construction, so as to ensure construction safety and improve construction efficiency.

2. System construction requirement analysis

2.1. Overall demand
In recent years, accidents in underground engineering construction occur frequently, and the construction safety of underground engineering has attracted increasing attention from the society. Therefore, it is urgent to strengthen engineering safety risk management[6]. Aimed at the construction site safety risk early warning and risk control, such as wiring difficulties, unable to realize automatic warning and real-time dynamic monitoring, the system should have construction whole process of risk identification, a visual warning, on-site safety monitoring, personnel positioning, intelligent monitoring, early warning linkage function, such as security risk to implement scientific control of the construction site. In view of the problems of large amount of data transmission and slow transmission rate in subway engineering, the system should have the ability of long-distance, high rate and high reliability transmission, so as to provide accurate and real-time data for safety monitoring[7].

2.2. Safety management needs for people
A variety of cross operations exist in subway construction, and hidden safety hazards are not easy to eliminate, and seriously threaten the personal safety of operators. Therefore, the system personnel need to monitor the location and dynamics of operators in real time to ensure the safety of construction personnel. When an accident occurs, it can provide an important basis for emergency rescue of trapped persons based on information such as the location and behavior trajectory analysis of the system's positioning to prevent the situation from deteriorating and improve rescue efficiency.

2.3. Safety management requirements for machinery
In order to create a safe construction environment, the system should have the function of real-time monitoring and early warning of equipment failure, provide self-inspection and maintenance services, and eliminate the hidden danger of equipment itself.

2.4. Safety management requirements for the environment
In the process of subway construction, engineering geology and hydrogeology conditions are complicated and uncertain under external force operation, and there are safety hidden dangers such as foundation pit engineering risk, structural engineering risk and fire risk[8]. Therefore, real-time monitoring is required. The system should have the linkage function of video monitoring and audio warning, and timely measures should be taken to ensure the feasibility, systematicness and timeliness of risk control.

3. System structure
Based on the Internet of Things technology, this paper builds a subway construction monitoring and early warning system. The system architecture is shown in Figure 1. The system uses wireless Mesh and wired fiber optic network as the transmission media, realizes the sensing and detection of the construction process through wireless sensors, and uses cloud computing technology to store, process and analyze the data, and then transmit the signals and feedback to the audio and video equipment. The organic integration of video linkage, computer management, personnel positioning, sensor
monitoring, mobile Internet and other systems ensures the in-depth mining and utilization of monitoring data, audio and video, image and other multiple parameters, and realizes the integration of "sense, transmission, knowledge and control" of security risks, thus improving work efficiency and early warning ability.

3.1. System functional design
The function design of the subway construction monitoring and early warning system based on the Internet of Things is as follows.

(1) Real-time personnel location monitoring function. The positioning system based on Mesh network can realize the real-time monitoring of the location information of construction personnel and track analysis and management, and can generate the track distribution of construction personnel and screen out abnormal tracks.

(2) Real-time monitoring function of equipment running status. Real-time monitoring of equipment operating conditions and various performance indicators, automatic fault alarm, alarm information will be sent to the command center and the mobile communication terminal of the management personnel, to ensure that the fault can be handled in time.

(3) Audio and video linkage function. The alarm information of the sensor will be transmitted to the camera, which will transmit the monitoring picture of the accident location to the command center and start the recording program; At the same time, the monitoring and early warning system issues alarm information through broadcast and informs management personnel to deal with accidents. The command center can also realize voice communication through the audio and video system to direct
the on-site rescue work. The monitoring system analyzes the monitoring images in real time and extracts effective information. Combined with the sensor monitoring information and cloud computing technology, it can intelligently judge the abnormal situation of the monitoring site and send out early warning information in time.

4. Equipment operation and maintenance function. Monitor the safety and rationality of the equipment operation, record the operation and maintenance records, automatically remind the management personnel to overhaul, maintain and maintain the equipment, improve the efficiency of the equipment operation.

5. Production scheduling function. The personnel and equipment status can be determined through personnel positioning system, video monitoring system and sensor group to facilitate the unified dispatch and command of the command center and improve the work efficiency, work quality and safety management level.

3.2. Key technology of system

3.2.1. Multi-parameter fusion acquisition technology of risk factors. The video monitoring system needs to manage all the construction personnel, machinery and equipment, construction environment, geological conditions, etc., so it needs to design a large-capacity, high-rate multi-source information fusion technology to meet the requirements. The sensor monitoring information is integrated with video monitoring through a variety of data access methods, and the video monitoring information is analyzed with the help of cloud computing technology and the analysis results are stored in the safety production comprehensive database. The data will be displayed on the command center screen in real time to realize the real-time monitoring of the construction site. At the same time, it can judge the abnormal situation of the monitoring location intelligently, and locate the accident location quickly by comparing with the real-time monitoring data of the sensor to reduce the false alarm and missing alarm behavior. At the same time, the management personnel can view the video monitoring through the handheld device to realize the video mobile monitoring of the construction site.

3.2.2. Bidirectional real-time transmission technology based on MESH. The system uses Mesh technology as the wireless communication mode, which has the advantages of high dynamic, multi-hop and easy to build. The sensor sends the monitoring data to the sink node through multi-hop communication module, and then transmits it to the command center and handheld mobile devices through various transmission methods such as mobile communication network and AD hoc network. Mesh technology is a two-way wireless communication technology, and managers can also send management instructions and query historical data to WSN.

3.2.3. Intelligent evaluation and early warning technology of dangerous state. Compared with the monitoring and alarm function of the traditional monitoring and early warning system, this system deploys the APP server of the mobile terminal to the synchronous data server, and sends the alarm and early warning information to the command center and mobile devices in real time through the mobile network, which is convenient to deal with the problem quickly and accurately. At the same time, the monitoring center can send information by classification and classification, which changes from centralized management to distributed management and improves the flexibility of security management.

3.2.4. High precision personnel positioning technology. At present, RFID technology is widely used in personnel positioning system in the field of security monitoring. This technology has the advantages of fast positioning rate, supporting multi-label identification and long-distance identification, but it has the defect of low positioning accuracy and cannot achieve accurate positioning. Based on this, the system adopts the personnel location system based on Mesh technology. The identification card is carried by the construction personnel, which can be regarded as the node of Mesh communication
network. The base station and the identification card form an ad-hoc network, and then the base station detects the information of the identification card to realize accurate personnel positioning.

4. Conclusions
(1) Aiming at the possible safety risks in the current subway construction process, this paper establishes a subway construction monitoring and early warning system based on the Internet of Things technology. By collecting, processing and analyzing the data, the system can realize the information interconnection among the perceptual layer, the network layer, the application layer and the network interface layer, so as to ensure the safety and efficiency of the subway construction. It has good practical significance and application prospect.

(2) The system adopts video monitoring and multi-parameter fusion technology, data push technology, wireless communication technology and personnel positioning technology to realize real-time monitoring of personnel position, real-time monitoring of equipment running status, audio and video linkage, equipment operation and maintenance, production scheduling and other functions, and further improve the functional types of subway construction.

(3) The integration of wireless sensor technology and Internet of Things technology can realize the rapid collection, processing and sharing of information, strengthen the maintenance of network security, realize the normal operation of wireless sensor network, and ensure the security and integrity of the whole system.

Acknowledgments
This work was supported by Key Special Projects of the National Key R&D Plan (2018YFC0808201) and Shaanxi Provincial Natural Science Basic Research Program (2018JM5009, 2018JQ5080).

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