Application and Analysis on Geological Hazard Monitoring and Early Warning System Based on Internet of Things

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Abstract. On the basis of reviewing the development of technology at home and abroad, this paper proposes the architecture, functions, and characteristics of a geological disaster monitoring and early warning system based on the Internet of Things (sensor network). The geological disaster monitoring and early warning system based on the Internet of Things (sensor network) includes on-site sensors and data acquisition processors, (wireless, wired) communication modules, and background data processing and information release system software. The system has the characteristics of intelligence, scale, standardization and real-time, reliability and security. Finally, combined with China's national conditions, several key technologies and basic theoretical research directions of the geological disaster monitoring and early warning system based on the Internet of Things (sensor network) in China are proposed.

1. Introduction

In recent years, developed countries have paid more and more attention to real-time monitoring of landslide and debris flow disasters [1-3]. For example, the United States, Switzerland, Germany, South Korea, and Japan have established real-time monitoring systems for landslide and debris flows, and developed corresponding monitoring and early warning systems that combine data collection, transmission, processing, analysis and management.

In the late 1970s, based on the study of the characteristics and mechanism of debris flow, the former Soviet Union set up seismic sensors in the debris flow circulation area, and transmitted the debris flow analog signals to the downstream receiving and dispatching station through wired or wireless channels, and then processed and judged the Residents in the debris flow danger zone issued an alarm signal to reduce losses.

Japan is an international leader in the research and development of early warning systems for debris flows. They mainly develop a debris flow forecast system in a specific area or a small area in an adjacent ditch. Through statistical analysis of rainfall data in the upstream debris flow formation area, they determine the critical rainfall value and critical rainfall warning line, and then collect real-time monitoring data on the upstream rainfall, calculation and comparison, automatically send out an alarm signal, and then use distributed mud level monitoring sensors and video sensors to monitor and alarm the debris flow.

The United States Geological Survey conducted real-time monitoring of some key landslides, using ground telescopes, inclinometers, ground sound monitoring, groundwater pressure sensors, and rain
gauges for real-time monitoring. European countries such as Switzerland, Germany, France, Spain, and Italy have similar geological disaster monitoring and warning technologies and methods to the United States.

South Korea officially launched the real-time landslide monitoring system in 2002. The real-time monitoring system of landslide mainly uses fiber optic sensors, combined sensors of ground telescope and tilt instrument, groundwater pressure sensor and rain gauge to monitor the slope in real time. Slopes, slopes with a height of more than 30 meters, slopes located in important cultural gathering areas and national parks, achieve the purpose of real-time grasping the dynamics of dangerous slopes.

In terms of regional landslide and debris flow monitoring, the United States is one of the earliest countries to carry out related work. In 1985, the United States Geological Survey (USGS) and the United States Meteorological Service (NWS) jointly established a landslide and debris flow early warning system in the San Francisco area. In recent years, the United States has established a relatively complete geological disaster monitoring network based on rainfall monitoring in some geological disaster sensitive areas in Washington State. The monitoring technology mainly uses automatic rain gauge monitoring and radar monitoring. Based on the geological disaster sensitivity (proneness) evaluation, the system determines the critical rainfall value and critical rainfall alarm line of different sections through statistical analysis of regional landslides, debris flow formation and rainfall data, and then collects real-time monitoring data according to rainfall and rainfall forecast, after calculation and comparison.

In addition, a regional forecast and early warning map was built, and an alarm signal was automatically issued according to the danger level. Nowadays, the communication transmission method of the real-time monitoring system of landslide and debris flow in foreign developed countries has used wireless short message, ZIGBEE, GPRS, CDMA and wired communication transmission methods in the early stage. In recent years, most of them have used wireless broadband to transmit monitoring data. After the data is processed by software, it is combined with the early warning information released on the Internet.

2. Three-phase three-level midpoint potential adjustment

The Internet of Things refers to sensors, radio frequency identification, infrared sensors, global positioning systems, laser scanning and other devices, according to the agreed protocol, to exchange information and communicate between people and things, and things to achieve intelligent identification, positioning, one novel network system with tracking, monitoring and management functions. It can be seen that the Internet of Things uses a new generation of IT technology in the prevention and control of geological disasters. Specifically, it embeds sensors and installs equipment in suitable places according to the characteristics of geological disasters, and then integrates the Internet is integrated to realize the integration of human society and physical systems.

![Figure 1. Architecture of geological disaster monitoring and glancing system](image_url)
The geological disaster monitoring and early warning system seamlessly integrates modern communication technology, computer network technology, and spatial information technology [4]. Combined with the business requirements of disaster monitoring and early warning, adopts the world's leading GIS geographic information processing technology, remote sensing technology, and large-capacity data collection technology and large-capacity data storage and other computer network communication and data processing technologies, establish a user-friendly, multi-terminal, customizable, integrated data collection, storage, analysis and integrated geographic information platform. Therefore, the geological disaster monitoring and early warning system based on the Internet of Things mainly includes four modules: intelligent monitoring [5], reliable transmission [6], application support [7] and business application, which were shown in Figure 1.

2.1. Intelligent monitoring module
On the basis of full on-site investigation and comprehensive analysis, use professional Internet of things sensor monitoring equipment (rain gauge, water level gauge, crack gauge, etc.), video surveillance cameras and manual monitoring stations to monitor the hidden danger points of geological disasters, And storage, mining, fusion, calculation, analysis and sharing of monitoring data.

2.2. Reliable transmission module
The method based on mobile communication technology is preferred, including the existing optical fiber sensor, 3G network, etc. However, due to the poor field signal in remote mountain areas, BeiDou Navigation Satellite System communication module should be deployed to supplement to ensure real-time and complete monitoring data to the monitoring center.

2.3. Application support module
It includes the IoT network support platform, machine to machine management platform, data mining, and middleware support platform. It supports the application layer, and requires a public support platform to support the standardization, security, and privacy of the IoT network.

2.4. Business application module
It is the interface between the Internet of Things and the user. It can realize the intelligent application of various types of geological disaster monitoring and early warning results, including provincial level applications and demonstration area applications, and the government service network.

3. Technical framework

3.1. Front-end monitoring system design
This part mainly uses real-time monitoring sensor equipment and video frequency monitoring system to carry out real-time monitoring of land quality disasters (including collapse, landslide, debris flow, ground collapse, ground subsidence, etc.).

(1) Professional monitoring sensor equipment: such as rain gauge, water level meter, inclinometer, etc., use special monitoring equipment to realize the sensing information collection and transmit the monitoring information to the wireless sensing network node device, the node transmits the data information to the wireless sensing according to the prescribed protocol Network gateway equipment.

(2) Video monitoring system: such as intelligent video monitoring equipment, which is composed of front-end video acquisition equipment and back-end video processing equipment. The front-end camera collects the real-time disaster site conditions in real time, and completes the coding work, and transmits the data to the backstage video server through the Beidou or wired communication equipment the improved algorithm, a comparative experiment was conducted on the experimental platform. Except for the selection of 1.4mH for the filter inductance during the test, the remaining parameters are communicated.
3.2. Transmission network design
Transmission networks include wired transmission networks, wireless transmission networks, satellite transmission networks, and other emergency communication networks. Mainly realize the data transmission from the monitoring system to the demonstration area, the demonstration area to the provincial (city) level Internet of Things platform, and the national monitoring center through the Ministry of Provincial Interface Road, so as to achieve network management and information security management of data access points, to ensure efficient, reliable, real-time and safe transmission of information.

3.3. Sensor design
Aiming at the characteristics of landslides, debris flow and other ground disasters, the sensors on the ground and underground are studied. Sensors should be adapted to real-time monitoring requirements. In terms of intelligent acquisition, distributed networking, energy saving and long-term stability, they have higher requirements for sensor development, material selection, and production processes. To cope with the requirements of a large number of sensor networks in the region, it is also necessary to do further research on the light weight and economy of the sensors.

(1) sensor technology for ground-based disaster monitoring and early warning
Relative to the usual sensor network, a sensor network facing landslides and debris flows has its own special requirements. The monitoring environment is complicated, and various communication facilities will be destroyed after landslides and other disasters. Therefore, a sudden situation will be developed.

Sensors that can be stored urgently, meanwhile it is necessary to develop low-cost and low-power sensor network terminals, video monitoring terminals and gateway equipment, develop wireless broadband emergency communication systems, develop network sensors for landslide debris flow monitoring, and establish a landslide debris flow monitoring and early warning system based on the sensor network, and Choose geological disaster-prone areas with different geological environments, different types of geological disasters, and different climatic conditions for application demonstration to improve the overall technical level of geological disaster monitoring and early warning .

(2) fiber optic sensing technology for monitoring ground disasters
The optical fiber grating monitoring demodulator and distributed optical fiber sensor monitoring system with the main intellectual property rights can reach the level of similar technical products in the world, which lays the foundation for the research of optical fiber sensing technology for monitoring of land quality disasters.

(3) multi-sensor data fusion technology
Data fusion technology, also known as multi-sensor data fusion or distributed sensor technology, is a new information processing method for the specific problem of using multiple sensors in a system. Its core is coordinated optimization and integrated processing of information. Data fusion technology is to imitate the comprehensive processing capabilities of experts from the data information from multiple types of multi-source and multi-platform sensors, and perform intelligent processing, which leads to a more accurate and credible conclusion.

4. Application in geological disaster monitoring and early warning system
Landslide disasters often occur under various synthetic factors and natural factors. Landslide disasters mostly occur in mountainous areas. Although their hazards are not as great as earthquakes, their frequency and breadth are much greater than earthquake events. Therefore, landslide disasters are the most extensive, severely damaged, and longest geological disasters facing humanity [9]. The monitoring of geological disasters in the past is usually based on manual or semi-automatic monitoring. However, when the range is relatively large, the conventional monitoring methods cannot meet the requirements. Among many emerging automatic monitoring systems, sensor network applications based on the Internet of Things technology are the most widely used. Optical fiber sensors use light as a carrier of information, and use optical fiber as a medium to transmit information. It has anti-
electromagnetic interference, corrosion resistance, high sensitivity, fast response, light weight, small size, variable shape, large transmission width, and can be reused for distribution. Outstanding advantages such as measurement. Among them, the optical fiber Bragg grating sensing technology is the most representative two types of distributed optical fiber sensing technology.

Fiber Bragg grating (FBG) is a kind of quasi-distributed optical fiber sensor. Its sensing signal is wavelength modulated. The measurement signal overcomes the interference of light intensity fluctuation, fiber bending loss, and aging of the measuring instrument. The need for a fixed reference point shows that it has good application value in a geological hazard monitoring system. When this fiber with Bragg grating is stretched or compressed and its temperature changes, its period changes, so that the wavelength of the reflected light also changes, and the strain on the fiber can be known by measuring the change in the reflected wavelength or the temperature value. When FBG is used for strain monitoring, it only needs to be used for strain monitoring of structures whose deformation position has been roughly determined and the deformation is relatively large. Based on the special features of FBG, when it is used for landslide monitoring, it is mainly used to monitor the real-time change of the trailing edge of the landslide or the known cracks.

Brillouin optical time-domain reflectometer (BOTDR) mainly uses the characteristics of the frequency spectrum and power characteristics of the backward Brillouin scattered light generated when the light wave propagates in the optical fiber and the outer environment (temperature, strain, etc.). When used for landslide monitoring, the optical fiber is implanted into the landslide body in the form of a neural network, and real-time monitoring of the landslide from line to surface can be implemented.

Therefore, through in-depth analysis of various typical landslides and distributed optical fiber sensing technologies, a system architecture based on distributed optical fiber sensing Internet of Things, big data and cloud computing is proposed to deal with physical changes such as temperature and stress during landslides. Carrying out monitoring and uploading continuous monitoring data to the cloud computing platform, and then through deep data mining and analysis to study the occurrence mechanism and subsidence law, the landslide can be predicted timely and widely. This kind of monitoring and early warning system that adopts remote geological disaster awareness, monitoring, early warning, and scheduling processing can avoid personnel from approaching dangerous areas and casualties, and realize the informationization and intelligentization of disaster monitoring and early warning.

5. Conclusion and future work
The geological disaster monitoring and early warning system based on the Internet of Things technology has the characteristics of intelligent sensors, diversified transmission channels and technical standardization, and the overall architecture is based on the Internet, combined with cloud storage and cloud computing, provides a new geological disaster service mode from the monitoring site to the multi-level monitoring and early warning center in one province, one city and county in the country.

Adopting the Internet of Things technology can quickly obtain the precursor information of geological disasters, timely warning and emergency risk avoidance, and play a greater role in geological disaster mitigation and prevention, while using the Internet of Things technology for monitoring and early warning is currently the most economic and effective means of disaster reduction.

The geological disaster monitoring and early warning system fully distributes the advantages of various technologies of the Internet of Things, and realizes the intelligentization of disaster prediction, pre-reporting, pre-alarm and emergency command. With the continuous development and improvement of data transmission technology, the application of the Internet of Things technology in the field of geological disasters continues to be deep, and the real-time transmission of geological disaster monitoring data and information sharing will be safer, more reliable, and smoother. Disaster
events will be more scientific and effective, and have strong use value in guiding the prevention and reduction of landslides.

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