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Research on Highway Slope Monitoring and Warning System

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Abstract: In order to realize the effective monitoring and warning on road slope disasters and to reduce the economic losses due to road slope disasters, based on analysis of the purpose and structure of road slope monitoring and warning system, this paper proposes the road slope monitoring and warning system that is composed of four functional modules, including slope monitoring, query management, slope management, system management, and the road slope monitoring and warning system is developed from expression layer and service layer. Finally, this paper puts forward the future improvement direction of the system, so that the system can timely and accurately disposal road slope disasters, maximize prevention the disasters and reduce losses.

1. Introduction

The warning system is based on the capture of certain signs and warning of some long-term or sudden disaster events. The warning system has been widely used in flood, meteorology, earthquake, ocean, agriculture and other fields[1-2]. Due to the need of economic development, more and more high-grade highways appear in the mountainous areas of Guangxi. These deep-pitched construction projects make high-slope problems common[3], after the completion of the highway, the slope instability problem is easy to occur, which has serious consequences.

The core of the monitoring and warning system is data acquisition and software design. In recent years, domestic and foreign scholars have made many achievements in data acquisition and software design research. In terms of data collection, Researchers in the United States have developed a distributed dam monitoring and early warning system based on distributed monitoring and collection of dam data for the extremely unstable monitoring of the external environment of the dam monitoring system[4]. Yu Ping designed the ARM-based GPRS early warning monitoring system, and explained the data acquisition link of the system and the software environment of WINCE. In terms of software design, the Geo.slope software developed by Geo.slope and the Slide software designed by Rocscience have a great influence on the international market. Based on mature GPRS network technology and visual VS development platform, Wu Lu and others developed a slope safety remote monitoring system[5].

Based on the analysis of the purpose of highway slope monitoring and warning system, disaster rating, monitoring and warning process, and disaster emergency response process, this paper proposes the structure and function module of highway slope monitoring and early warning, and designs it from the expression layer and the business layer. The system can real-time monitoring, warning and status level determination of the slope state, and timely and accurately transmit the warning information to the manager, timely deal with the problems caused by the slope instability, reduce or even avoid the road slope disaster loss.



2. Analysis of Highway Slope Warning System

The highway slope monitoring and warning system collects, transmits and processes the influencing factors of the specific road slope stability through data acquisition, data transmission, data processing and warning processing, and transmits the processed information to the terminal platform. Before the disaster occurs on the highway slope, assist the manager to detect the danger situation as soon as possible and propose corresponding effective measures to reduce various risks and losses. In addition, the monitoring and warning system operation program accurately evaluates the disaster level of the highway slope problem based on the data collected by multiple sensors and the processing results, combined with the characteristics of the highway slope. The disaster level is divided into four levels (level 1, level 2, level 3, level 4) from low to high. Level 1 (green) is the level of security. The system continues to perform automatic monitoring and analysis, and the corresponding level of operation is taken after the level is upgraded. Level 2 (blue) is the warning level. The system sends warning information to the slope management personnel according to the sensor location information. Level 3 (orange) is the hazard level. The system sends warning information to the slope management personnel based on the sensor location information. Level 4 (red) is a severity level. The system sends a warning message to the slope management personnel according to the sensor location information [6].

The highway slope monitoring and warning process is: the slope acquisition system monitors the road slope and transmits the slope monitoring data to the data acquisition module. The data acquisition module integrates the slope monitoring data to generate integrated slope data. After the data acquisition module performs data encoding on the integrated slope data, the encoded data is transmitted to the GPRS transmission module. The GPRS transmission module uploads data to the GPRS receiving module. After the GPRS receiving module decodes the encoded data according to the slope information database, the slope monitoring data is sent to the civil analysis module. The civil analysis module performs data analysis on the slope monitoring data, and obtains the disaster level of the monitoring slope and sends it to the early warning server [7]. Because the four-level early warning process covers more content and is more practical, the four-level early warning flow chart is drawn as follows:

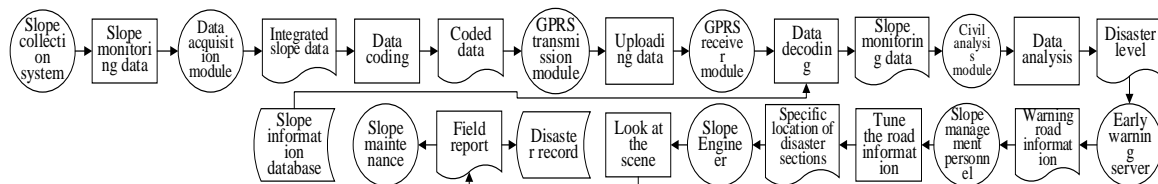


Figure 1 Four-level warning flow chart

3. Construction of Highway Slope Warning System

The function of highway slope monitoring and warning system includes providing direct information on regional rainfall change and soil moisture change on slope, and can accurately locate the grade of road slope disaster, and then formulate corresponding emergency disaster response measures. The regional centres established by the early warning system in each of the cooperative areas have become the main warning centres, and they have close links with disaster prevention and mitigation agencies.

3.1. System purpose

The purpose of establishing a highway slope monitoring and warning system is to provide direct information on regional rainfall changes and soil moisture changes in slopes and assists managers in developing effective measures and taking urgent actions. In order to make the system have multiple functions, the highway slope monitoring and warning system based on rainfall environment is constructed, and the grade evaluation standard of highway slope problem with multi-sensor data fusion is established.

3.2. System structure

The monitoring and warning system software is implemented by C/S. Because C/S programmings realizes more functions than B/S is comparable to B/S programmings, Therefore, monitoring and warning system uses the C/S architecture.

C/S (client/server) architecture, known as the client and server architecture. It is a software system architecture, through which it can effectively exploit the advantages of hardware conditions at both ends, allowing the client and server to jointly and reasonably complete tasks, reducing the communication cost of the system. As distributed web applications are becoming a trend, especially in software application systems, and web and client/server applications can be completed for the same business, different modules share logical components; therefore, new and existing applications It is accessible to both internal and external users, and the logic of existing application systems can be extended to new applications. This is the development direction of the current application system. The two-layer structure of the C/S form is shown in Figure 2. C/S application server has lighter data load and clearer data storage management, but higher initial cost and larger maintenance funds[8].

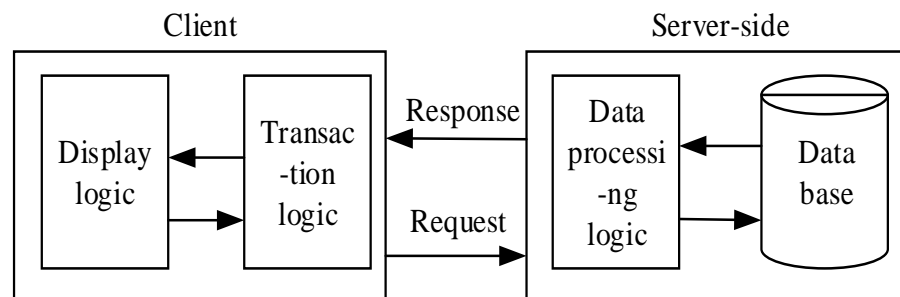


Figure 2 C / S two-layer structure

3.3. Functions of the warning system

In the highway slope monitoring and warning system, the key points of each warning center are:

- (1) System interference: All interference input that affects the regional environmental status balance/steady state.
- (2) System change: The process of the regional environment responding to external disturbances.
- (3) System response: corresponding system status, parameters or structural changes.
- (4) Decision response: The countermeasures should be taken corresponding to the state of the regional slope and the change of parameters.

Highway slope monitoring and early warning system mainly includes four modules: slope monitoring, query management, slope management and system management. The input of highway slope monitoring and early warning system is the geological information of highway slope (soil moisture content, earth pressure, slope shape variable, etc.) and climate information (rainfall, etc.), and the grade of highway slope instability is the basic link. The output is an early warning treatment measure under different disaster levels. This measure is formed based on the data query and information management commands issued by the users of the early warning system, so as to realize the monitoring and early warning of the highway slope (Figure 3).

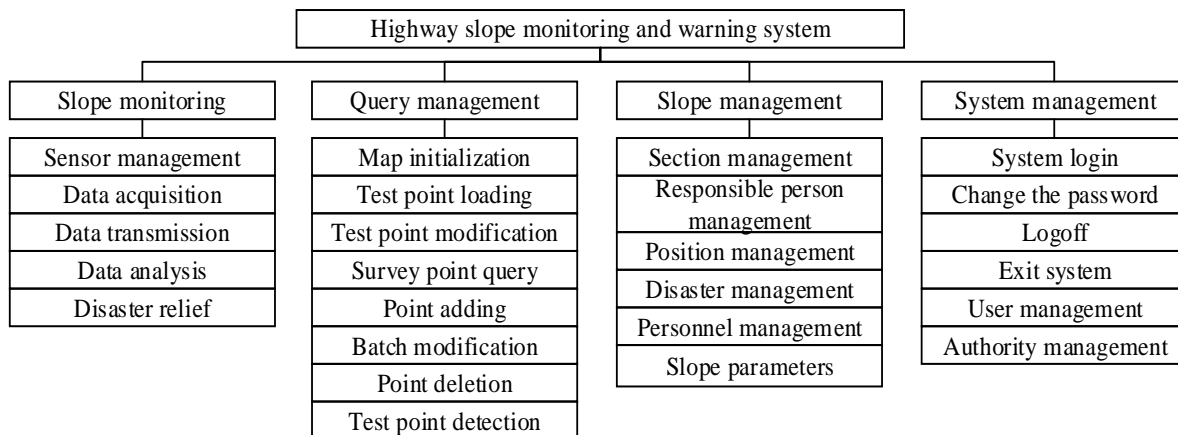


Figure 3 The function of highway slope monitoring and warning system

The functions of each component of the highway slope monitoring and early warning system are as follows:

(1) Slope monitoring function module

This module is the basic part of the early warning system, but it does not appear in the user interface of the system. The system should place the monitoring sensor at the appropriate location according to the information characteristics obtained by the highway slope monitoring, and collect and transmit the information obtained by the monitoring sensor, and then analyze the obtained information to perform disaster judgment. The functions include: sensor Management, data collection, transmission, analysis, and disaster recovery.

(2) Query management function module

After the system user enters the early warning system, the user interface of the early warning system is displayed. Anyone using the system can search the map for the current disaster level of the road monitoring point, but only the management personnel can manage the monitoring points, including map initialization, point loading, modification, addition, deletion, monitoring, and Batch editing and other functions.

(3) Slope management function module

This module includes road segment management, responsible management, location management, disaster management, personnel management, and slope parameters. When the disaster level is above the second level, this module can be used to query the slope data, and delete, add, modify and search the corresponding road sections, personnel, disaster level, location and corresponding slope geological parameters of the problem slope.

(4) System management function module

This function module includes: system login, password change, logout user, logout system, user management and rights management system configuration.

4. Development of Highway Slope Monitoring Waring System

The development of highway slope monitoring and early warning system mainly includes two levels: expression layer and business layer.

4.1. Expression layer development

The development of the expression layer of the highway slope monitoring and early warning system: users should log in first when using the early warning system, and the system will detect whether the user is designated. If the system is not specified by the system, the user is prohibited from using the system. If the system is designated by the system, then the system is detected. Is it a manager? If it is not a manager, it is allowed to use the system's information viewing function, such as monitoring point location, sensor data, slope problem level, etc. If it is a manager, it has the authority to perform related

operations on the information of the early warning system, such as viewing Slope monitoring point, sensor data, slope problem level information, material transportation and personnel scheduling for problem slopes with high disaster level, complete maintenance of problem slope[9]. The development process of the expression layer of the highway slope monitoring and early warning system is shown in Figure 4.

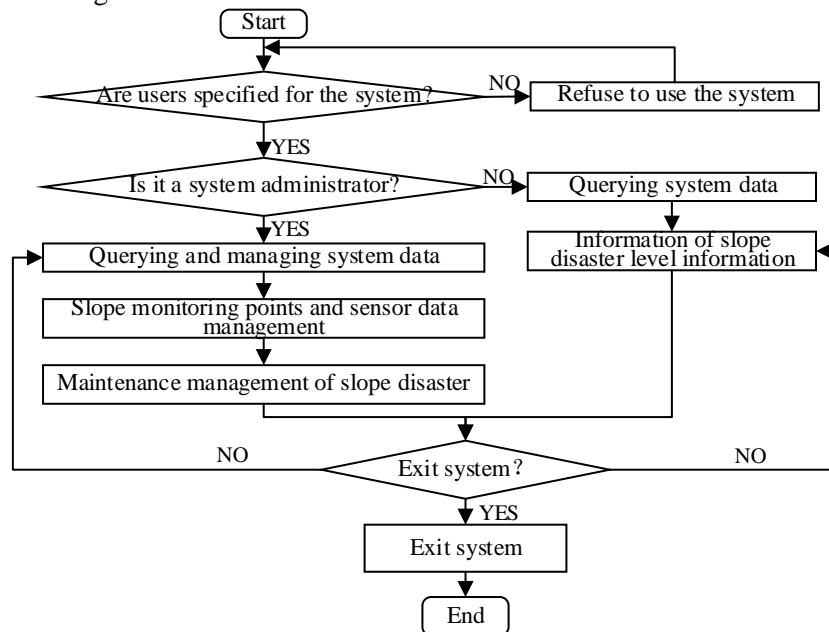


Figure 4 Expression layer development flow chart

4.2. Business layer development

The development of the business layer of the highway slope monitoring and early warning system: When the user uses the early warning system, the user first receives the unconsolidated monitoring data of various types of highway slopes sent back by the data collection system, and the scattered slope monitoring data passes through the civil package module. Analyze and integrate, divide into data types that meet the requirements of monitoring data, and then process the mathematical model of data processing through the moon to judge the grade of road slope disaster[10].

After the establishment of the early warning system business, it is necessary to construct a highway slope monitoring database, so that the road slope section, sensor type, and primary response monitoring data can be stored in the database. After obtaining the grade of the highway slope problem, search for the matching slope data, display the warning information at a specific position of the expression layer, and fill in the slope problem schedule. The business layer development process of the highway slope monitoring and early warning system is shown in Figure 5.

The highway slope monitoring and early warning system allows users to query, alarm and emergency the slope problem level, and allows the system users to implement auxiliary functions such as early warning system loading and adding, user management and authority management. The main functions of the system such as query, alarm, dispatch management and system debugging use of the disaster situation of the system.

5. Improvement Direction of The Warning System

The design process of the system is not only complicated, but also should be considered from the overall perspective. Based on the design of the highway slope monitoring and early warning system, the future improvement direction can be considered from the following aspects:

(1) further optimize and calculate the weight value of the safety level of the slope to make it more realistic; improve the accuracy of the main warning information such as the safety factor, critical

deformation value and displacement rate of the slope and the accuracy of the warning level. Improve the accuracy of monitoring and analysis processing.

(2) Realizing the informationization and intelligence of material transportation, vehicle and personnel dispatch in the emergency response section of the highway slope monitoring and early warning system.

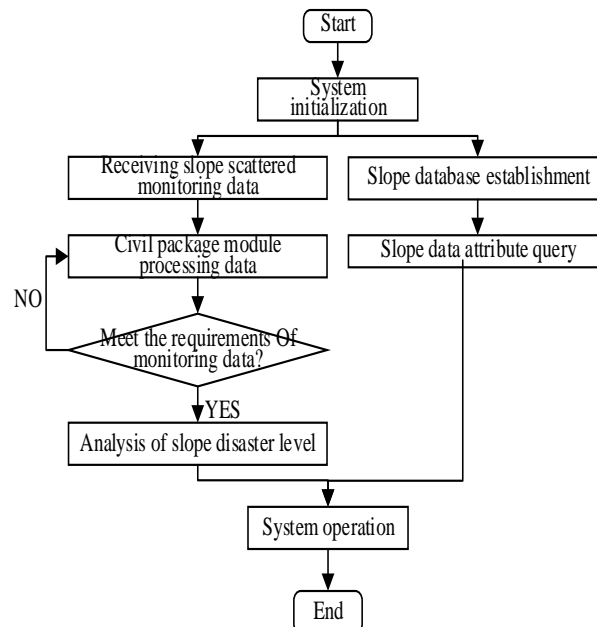


Figure 5 Business layer development flow chart

6. Conclusion

The instability of highway slopes often jeopardizes the safety of highway traffic. In order to reduce the losses caused by slope disasters, effective monitoring and early warning of highway slope disasters is needed. Based on the analysis of the purpose of the highway slope monitoring and early warning system and the monitoring and early warning process, this paper proposes to construct the highway slope monitoring and early warning system from the aspects of structure and function modules, and to carry out the highway slope monitoring and early warning system from the expression layer and the business layer. Development and Design. Finally, the upgrade direction of the system is proposed, so that the system can be further improved on the basis of timely and accurate early warning and disposal of highway slope disasters.

Acknowledgments

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