Research and practice on information Technology of landslide early warning, restoration and reinforcement

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Abstract: China is one of the countries with the most serious geological disasters in the world, and landslide is the main geological disaster. China has carried out many years of research in the field of landslide and made a lot of achievements, but the information integration and visualization are not systematic, especially in the data fusion, technology integration, deduction simulation and other aspects. Starting from the framework of the software platform, this paper focuses on the research of key technologies such as multi-data fusion, whole-chain technology integration, deduction simulation; establishes landslide early warning information software platform, and carries out the application practice in the demonstration area, which is of reference significance for the information construction of landslide early warning, repair and reinforcement, to improve the landslide disaster prevention and mitigation capacity in China has a realistic significance.

1. Introduction
China is one of the countries with the most serious geological disasters in the world. During the 12th Five-Year Plan period, a total of 64,521 geological disasters occurred across the country, resulting in 2,008 people dead or missing and a direct economic loss of 27.34 billion yuan. Landslide is a major geological disaster in China. In 2016, there were 148,214 hidden danger points of landslide in China, occupying 49% of the hidden danger points of disaster. 7403 landslides occurred, accounting for 76.2 percent of the total disasters in the year.

Although China has carried out many years of research in the field of landslide and made a lot of achievements, the research on expansive soil bank slope and embankment seepage landslide is not systematic. It is a practical need to improve the disaster prevention and mitigation ability of China to carry out systematic research and technology integration on the disaster mechanism, monitoring and early warning, and reinforcement technology of expansive soil bank slope and embankment seepage landslide.

Focusing on the scientific problems and key technologies that need to be solved in the integration and demonstration of online repair and prevention technology of swelling soil bank slope and dam infiltration failure, the technology of multi-data fusion, whole-chain technology integration and 3D visual expression is studied by using information means. Research and development of multi-data fusion,
monitoring, early warning and evaluation, identification and evaluation of nondestructive testing, flexible prevention and control, trenchless repair and reinforcement technology integration platform based on the whole life of swelling soil bank slope and dam seepage landslide, realizing multidimensional visualization online demonstration. It can improve the disaster prevention and mitigation ability of landslide disaster in China.

2. Platform Design
The platform adopts the five-layer architecture of perception layer, data layer, service layer, function layer and application layer, and the whole process of sensor data acquisition, data fusion, algorithm integration, visual simulation and application to each demonstration site is connected in series, as shown in Figure 1.

![Figure 1. Overall architecture](image)

2.1. Perception layer
Comprehensive use of data collection and information perception means to obtain all kinds of business data and spatial geographic data, including monitoring data, geophysical detection data, laboratory experiments, spatial information, etc.

The monitoring instrument automatically collects the surface deformation, deep deformation, water level, rainfall, seepage pressure, earth pressure, water content and other data, which are collected and transmitted to the integrated platform in real time. The data collected by the geophysical detection instrument, such as cross-section resistance and acoustic cloud map, are connected to the integration platform through file import. Rock and soil mechanical parameters formed by laboratory experiments are connected to the integrated platform by manual input. The digital orthophoto image and digital elevation model data collected and processed by uav aerial photography are imported into the integrated platform by using the support software of 3DGIS-ARK.
2.2. Data layer
Complete the integration of various structured data and geospatial data to form a unified and intelligent data interface. On the one hand, it provides data support for the algorithm model of the service layer; on the other hand, it provides 3D geographic space scenes, models and business data support for the visual expression and simulation of the functional layer.

Structured data mainly include real-time data collected by monitoring instruments, section files formed by geophysical exploration and detection, and parameter information formed by laboratory experiments. Geospatial data mainly include scene data collected by aerial photography of UAV, instrument model data modeled by BIM software, repair and reinforcement model and animation data modeled by 3D animation software.

2.3. Service layer
The algorithm model was published according to the standard service mode, including the whole-life prediction method, the penetration instability evaluation method and the rapid disaster evaluation method. According to the algorithm call conditions, the service layer obtains data input through the data access interface, calculates and analyzes the results, and then provides integrated full-chain technical services through the service interface.

2.4. Function layer
The functional layer realizes the integration of the whole chain technology, visual expression and simulation through data interface and algorithm model. On the one hand, the online service access strategy of the integration platform can be used to combine service links for the algorithm model of the service layer, and the algorithm model can be managed and invoked through a unified integrated environment, including monitoring, early warning and evaluation, identification and evaluation of nondestructive testing, repair and reinforcement. On the other hand, visualization tables and simulation applications, including scene simulation, instrument information simulation and early warning simulation, can be carried out by combining the 3D scene and data access interface after data layer fusion.

2.5. Application layer
The application layer is mainly used for the demonstration of typical demonstration sites, including typical levee, dam and expansive soil bank slope. For different types of demonstration sites, the integration platform will provide different functional modules to realize the integrated application of multi-data fusion, whole-chain technology integration, visual expression and simulation.

3. Research on key technologies

3.1. Multivariate data fusion
Compared with the international research on multi-source heterogeneous big data fusion, China started relatively late. The early monographs《Data Fusion Theory and Application》[1] and 《Multi-sensor Fusion and Its Application》[2] provide support for the construction of related theories. Hua Bailin and Li Guangjian et al from Peking University studied data fusion for competitive intelligence in the context of big data, and reconstructed the processing process and algorithm system of multi-source heterogeneous fusion[3]. Yu Yonghong combined relevant recommendation algorithms such as network and interest points to build a Poisson matrix decomposition interest point recommendation algorithm based on project attributes[4]. Application research from simple data integration to deep learning has been carried out.

In view of the characteristics of structured and unstructured data involved in bank slope dam landslide warning, repair and reinforcement, this paper utilizes big data technologies such as data integration, data screening and data mining, combined with database technologies such as spatial database and distributed file storage database, and developed a three-dimensional database for multiple and heterogeneous data. The resource catalogue of multiple data such as safety monitoring, geophysical...
detection, model threshold, hydrometeorology and BIM model is established. In the unified multi-fusion database, multi-cloud data storage and fusion are realized.

Among them, spatial data adopts pixel-level fusion method. The DOM, DEM, BIM model, tilt photography, point cloud and other data are extracted and integrated based on spatial pixel features to form a 3D model database and a 3D basic scene library.

The service data adopts the feature level fusion, and the stability parameter information of hydrometeorology, soil structure, safety monitoring, geophysical monitoring, seepage landslide and other stability parameters is associated with transformation, information aggregation and other screening and analysis operations to form the service record database and parameter rule database.

On the basis of pixel-level integration of spatial data and feature-level integration of business data, combined with decision-level fusion method, three-dimensional model spatial association, three-dimensional platform data integration and other means are used to form a unified multivariate data set to provide integrated support for analysis and decision.

3.2. Full chain technology integration

Integrating multiple fusion data sets and algorithm services, designing an integrated application architecture for registration, access and monitoring, integrating full-life behavior prediction, monitoring, early warning and evaluation, identification and evaluation of nondestructive testing, flexible prevention and control, trenchless repair and reinforcement, and other technical algorithms to build a technology integration framework, as shown in Figure 2.

On this basis, the extension design of service verification, service composition, service chain, service publishing and other technologies is carried out, and the technology integration framework is established to meet the requirements of the packaging and access of the research results of each subject.

3.3. Deduction simulation

On the basis of multivariate data fusion and full chain technology integration, the 3d model is supplemented and beautified by 3DGIS-ARK support software, and the optimized 3D scene is formed to carry out monitoring visualization, repair and reinforcement visualization, time series simulation, etc.

In the three-dimensional geographical space scene, the monitoring section and monitoring instrument model can be expressed visually and stereoscopic, and the model information can be inquired
interactively. Based on the embedded monitoring sensors, automation, geophysical detection data acquisition of data, the uav aerial data, etc., combining with the monitoring and early warning and assessment algorithm, detection, identification and evaluation algorithm, real-time calculated the risk of the pilot sites as a result, and the results of risk analysis shall be carried out in accordance with the risk classification, in the heart of the integration platform, according to the corresponding space range to the risk of partition is shown in figure 3.

![Figure 3. Risk partition simulation](image)

4. Conclusions
By selecting a typical region, multi-data fusion, whole-chain technology integration and THREE-DIMENSIONAL visualization technology means are utilized to integrate multi-data fusion, monitoring, early warning and evaluation, identification and evaluation of nondestructive testing, flexible prevention and control, trenchless repair and reinforcement, etc., to achieve a multi-dimensional visualization online demonstration, as shown in Figure 4.

![Figure 4. Application system](image)

A total of two monitoring sections are set up in the demonstration area, with one monitoring section in the repaired and strengthened area and one monitoring section in the non-repaired and strengthened area respectively. Through the introduction of surface crack map, deep water content map, configuration of field parameters, laboratory parameters, analysis and evaluation algorithm to calculate the vital signs of expansive soil bank embankment, judge its health, health, ill and disease. By configuring historical risk data and experimental parameters, the monitoring, warning and evaluation algorithm model automatically analyzes and calculates the real-time monitoring data collected, calculates the risk status
and grade of the swelling soil bank embankment, and realizes automatic alarm for high-risk bank embankment, as shown in Figure 5.

![Figure 5. Monitoring and warning visual](image)

Using multivariate data fusion, the whole chain technology integration and the 3D visualization technology, this paper developed based on the expansive soil bank slope and dam osmotic landslide whole lifetime behavior prediction model of multivariate data fusion, monitoring and early warning and evaluation, nondestructive testing and evaluation, such as the prevention and control of flexible trenchless repair reinforcement technology integration platform, has realized the multidimensional visual demonstration online. The research on key technologies and the establishment of system platform have reference significance for the information construction of landslide early warning, restoration and reinforcement.

With the rapid iteration and deepening application of the new generation of information technology, such as cloud computing, Internet of things, big data, artificial intelligence, mobile computing, digital twin, the landslide warning and strengthening information construction is accelerating to develop intelligence, wisdom, accelerate the transformation and upgrading of the information capacity, better for the landslide early warning management more scientific and more effective service.

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