GIS+BIM based Management Technology During O&M Period of Water Conservancy Projects

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Abstract. Compared with common engineering projects, water conservancy projects are often larger in scale, more complex in engineering, and longer in construction period. In the whole life cycle of water conservancy project construction, its operation and maintenance stages occupy most of the lifecycle of a project. Constrained by factors such as insufficient application of GIS and BIM data results, inefficient multi-data management, and poor visual analysis capabilities, traditional operation and maintenance management has many disadvantages. In recent years, with the rise of GIS+BIM technology and its wide application in the engineering industry, it provides new and scientific ideas for solving various problems encountered in the O&M management process of water conservancy projects. Combining GIS+BIM technology and its characteristics, this paper conducts an application analysis on the operation and maintenance management of water conservancy projects. It introduces its key technical points in O&M management. Then, it uses the Songgang Wharf of the Danjiangkou Reservoir of the South-to-North Water Diversion Project as an application case. It presents the application of GIS+BIM technology in monitoring analysis, repair and reinforcement in engineering operation and maintenance. The study provides technical reference for the management technology during the O&M period of water conservancy projects.

Keywords: GIS, BIM, Operation and Maintenance, Water Conservancy Projects.

1 Introduction

The construction of water conservancy projects generally has the characteristics of large scale, long period, and complicated technical conditions. From project planning, exploration and design, project implementation, and completion acceptance to operation management, it is a long-term and complicated management process [1-2]. After the construction of the water conservancy project is completed, the later operation and maintenance are also very important. If the management is not done properly, the life

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of the project may be shortened; otherwise, the service life of the project can be effectively extended.

In terms of scheduling and operation, based on big data, cloud computing, Internet of Things, BIM technology, and digital encryption technology, the engineering data resource center, intelligent video surveillance, BIM+GIS engineering visualization system, and automatic control system provide remote control and unattended engineering [3-5]. Few people on duty provide technical support, and a number of water conservancy projects can realize remote scheduling. A new generation of information technology plays an important role in the scheduling and operation of water conservancy projects. At the same time, whether problems can be discovered in time during the operation and management period, whether problems can be warned in time, and whether measures can be taken to repair them the first time are issues that require great attention. The informatization of engineering operation management of a large number of water conservancy projects that have been built has the characteristics of lag. Due to the lack of multi-dimensional, all-factor, large-scale, and automated information collection methods, measures are often taken to repair and solve problems after they occur [6-8]. However, informatization has not been fully implemented in the operation and management of water conservancy projects.

Generally speaking, although the current information development of water conservancy projects has played a huge role in major projects, it is still in its infancy. Many information technologies have been applied, but some are scattered, chaotic, and low-level [9-10]. The application is not mature enough and comprehensive. Aiming at the difficulties of water conservancy project operation and maintenance, this paper expounds on the key technologies of project operation and maintenance based on GIS+BIM. It takes the slope of Songgang Wharf in Danjiangkou Reservoir as an example to build an information system to verify the effectiveness of these technologies.

2 GIS+BIM based key technology during the O&M period

2.1 Integration of BIM model into 3DGIS scene

The water conservancy digital scene includes not only a large-scale GIS model with a large span of time and space but also a BIM model with fine details and a complex structure. When building and integrating the scene, it is necessary to solve the problem of lightweight models to realize the efficient use of massive data resources. In the simulation scene, the City GML standard is followed to divide the model into Levels of Detail (LOD) [11]. The correlation mapping between the GIS+BIM model and the digital scene of different scales is realized, as shown in Figure 1.

City GML expresses 3D scenes through five levels from LOD0 to LOD4. For the BIM building model, in addition to LOD0 describing the terrain, other levels can establish corresponding relationships with City GML. The corresponding component information from the BIM model can be extracted and filtered to realize model association conversion. After the extraction and layering of GIS and BIM model information, the model geometry simplification and texture compression methods are used to simplify the LOD models at all levels. The root node of the scene is further constructed.

The paging logic of the LOD models is generated at all levels, and the water conservancy project GIS+BIM scene lightweight integration is completed.

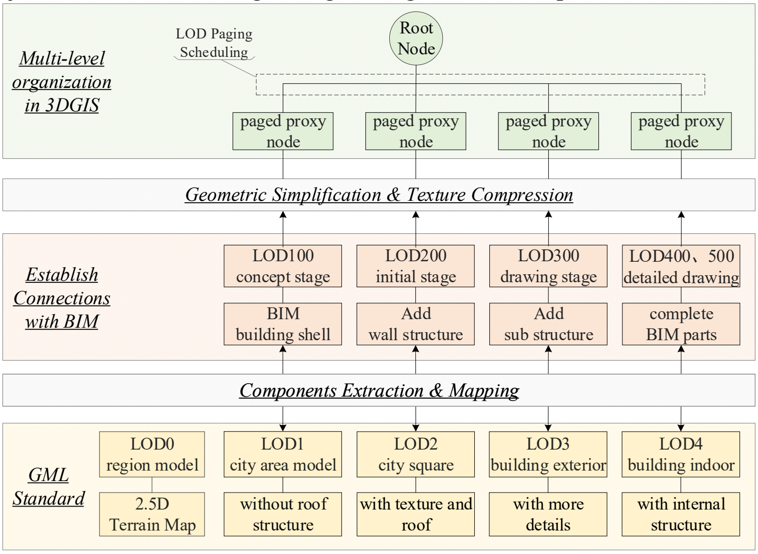


Fig. 1. Integration of BIM model into 3DGIS scene

2.2 Multivariate engineering data fusion based on GIS+BIM

Based on the built GIS+BIM scene, data fusion can be carried out at three levels: pixel level, feature level, and decision-making level, as shown in Figure 2.

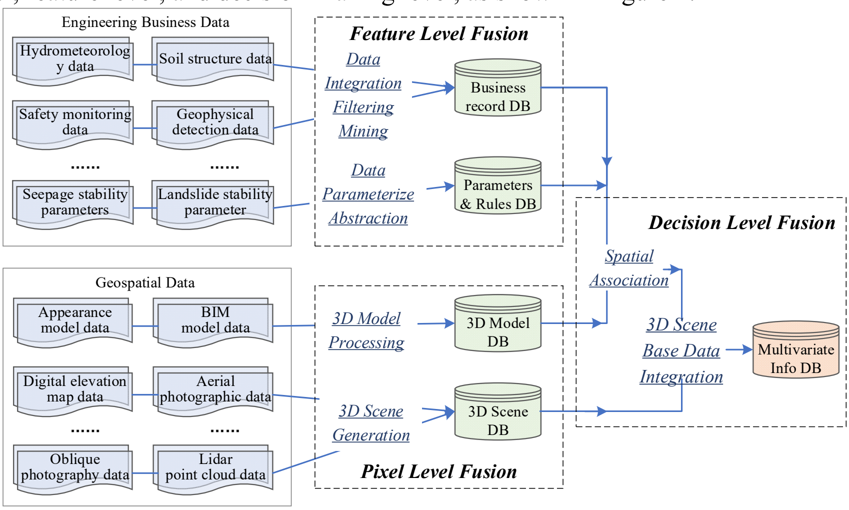


Fig. 2. Multivariate engineering data fusion based on GIS+BIM

Spatial data is fused at the pixel level. Information extraction and fusion are carried out based on the collected spatial pixel features of appearance models, BIM models, DEM, DOM, oblique photography, point clouds, etc., to form a 3D model database and a 3D basic scene library. The business data adopts feature-level fusion. It carries out correlation transformation on stability parameter information such as hydrometeorology, safety monitoring, geophysical monitoring, seepage and landslide, and screening and analysis operations such as information aggregation to form a business record database and a parameter rule database. Based on the completed pixel-level fusion of spatial data and feature-level fusion of business data, the theoretical method of decision-level fusion is adopted. It establishes a unified set of multi-dimensional information based on 3DGIS through 3D model spatial association and 3D scene data integration. The data is collected and stored as a fused multivariate information library, providing integrated support for subsequent analysis and decision-making.

2.3 Monitoring and detection algorithm model construction and visualization

In the process of project operation and maintenance, it is necessary to use algorithmic models to analyze multivariate data, including algorithmic models such as life-cycle behavior prediction, monitoring, early warning and evaluation, non-destructive testing identification and evaluation, repair and reinforcement. They can detect sudden project risks in a timely manner and take countermeasures. To access these algorithm models, it is necessary to analyze the dependencies and application modes of the algorithms and build a technology integration framework. On this basis, technologies such as service verification, service composition, service chain, and service release can be expanded and designed to form a full-chain technology integration. The framework satisfies the encapsulation and access of various algorithms. On the basis of model algorithm integration, GIS+BIM technology is used to carry out visual simulation, including 3D scene simulation, monitoring and detection information simulation, monitoring and early warning simulation, and repair and reinforcement technology simulation. The specific process is shown in Figure 3.

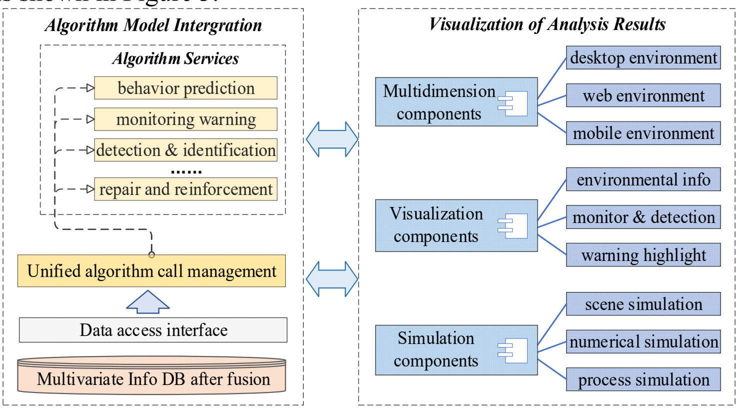
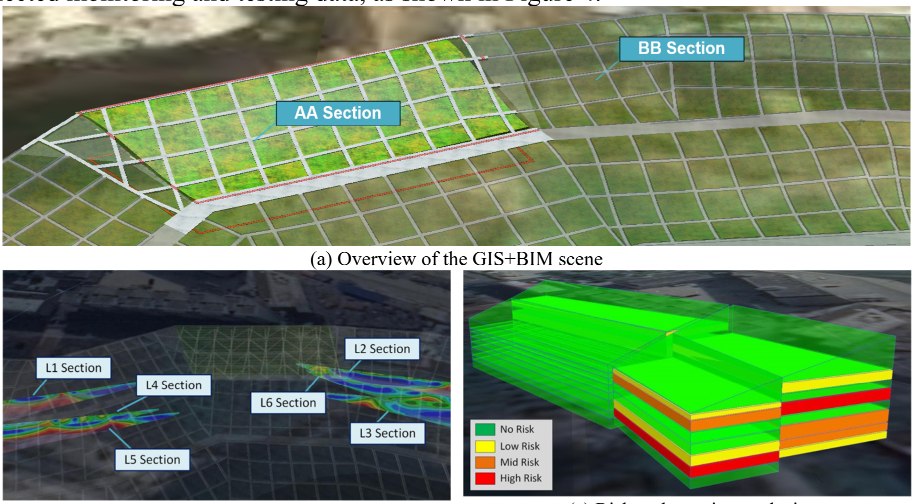


Fig. 3. Monitoring and detection algorithm model construction and visualization

3 System application

3.1 GIS+BIM scene construction and monitoring analysis

Based on the above-mentioned key technologies in the project operation and maintenance period, the system example selects the bank slope of Songgang Wharf in the Danjiangkou Reservoir of the South-to-North Water Diversion Project as an application case. The engineering operation and maintenance information system built by GIS+BIM technology can intuitively present the operating status of the project. It can calculate and analyze the health status of the project through real-time or regularly collected monitoring and testing data, as shown in Figure 4.



(a) Overview of the GIS+BIM scene

(b) Geophysical detection

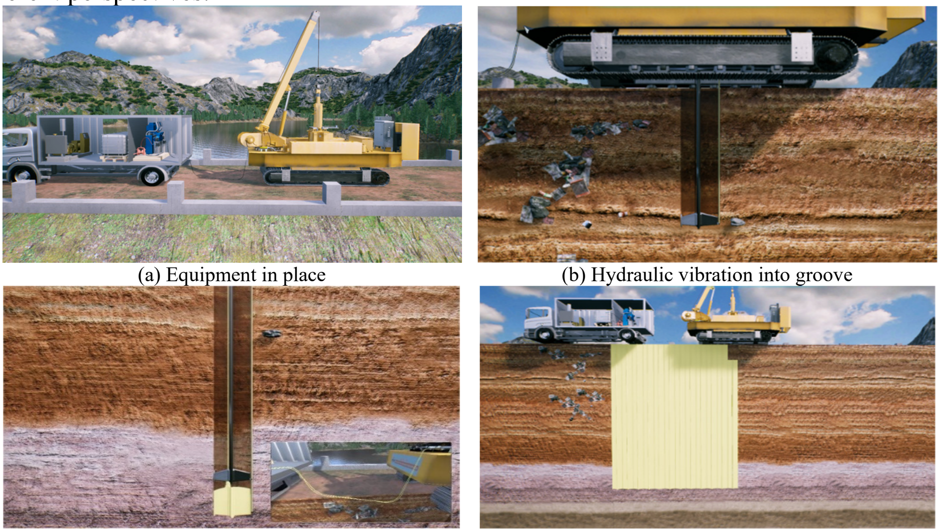
(c) Risk and warning analysis

Fig. 4. Integration of BIM model into 3DGIS scene

Figure 4(a) shows the three-dimensional visualization effect of the bank slope selected by the system application in the GIS+BIM scene. The bank slope is divided into two parts, namely, the AA area that has been reinforced and the BB area that has not been reinforced. The engineering health status of the two is compared through monitoring and testing data. Figure 4(b) is a view of the geophysical monitoring information, showing the delayed electrical detection results of geophysical instruments in layered and colored sections. Figure 4(c) is the risk warning simulation view. In the comprehensive platform, according to the monitoring section of the demonstration area, 3D blocks are used to display the health status of the project on the bank slope at different depths. In addition, the warning information is marked with different colors. Green means no risk, yellow indicates low risk, orange indicates medium risk, and red indicates high risk.

3.2 Simulation of risk repair and reinforcement process

After analyzing and calculating the monitoring data and discovering potential engineering health risks, appropriate disposal measures can be selected according to the internal risk status of the project. When the risk factor is large and needs to be repaired and reinforced, it can be simulated through the 3D scene of GIS+BIM. The repair and reinforcement process takes polymer grouting flexible reinforcement technology as an example, as shown in Figure 5. The figure shows the whole process of the repair and reinforcement of simulated polymer grouting in the system. The animation embedding and automatic calling are used for dynamic simulation. The repair and reinforcement process is simulated in an all-round, multi-angle, and multi-level manner through different perspectives.



(a) Equipment in place (b) Hydraulic vibration into groove

(c) Simultaneous lifting grouting (d) Repair and reinforcement effect

Fig. 5. Simulation of risk repair and reinforcement process

Figure 5(a) shows that the repair and reinforcement equipment arrive at the position to be operated and prepares for repair. Figure 5(b) shows the process of forming grooves through hydraulic vibration of the equipment. Figure 5(c) shows the process of synchronous lifting and grouting. Figure 5(d) shows the effect of the reinforced cut-off wall formed by repeating the steps in Figures 5(b) and (c).

4 Conclusions

In order to improve the O&M management capabilities, this paper conducts an application analysis on the operation and maintenance management of water conservancy projects. It introduces its key technical points in O&M management. It uses the Song-gang Wharf of the Danjiangkou Reservoir of the South-to-North Water Diversion Project as an application case. It presents the application of GIS+BIM technology in monitoring analysis, repair, and reinforcement in engineering operation and maintenance.

The study provides technical reference for the management technology during the O&M period of water conservancy projects.

In the follow-up research process, the ability of multivariate data fusion and the effect of 3D visualization can be further improved. Hence, auxiliary support can be provided for the refined and efficient operation and maintenance of water conservancy projects.

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