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Disaster emergency response technology based on digitization of reservoir dam

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Abstract: With the help of GIS, Terra Vista and MultiGen Creator platform, this paper achieves the digitalization of high precision dam, reservoir area and flood. Using DEM technology to simulate flood evolution, it analyzes flood inundation process and possible disaster area, and combines material reserve, traffic situation, and possible refuge path, and uses GIS geographic information to seek the best withdrawal. The path provides a scientific analysis way for the scientific decision of dam disaster response.

1. Introduction

With the increase of extreme weather, how to control flood of the dam and how to make correct and timely response measures in the face of the risk of dam break are important contents of dam safety management. The dam break will cause serious loss of life and property in the downstream reservoir area, which brings great disaster to the society and the environment, and the correct response in the disaster disposal is the key. However, due to the complexity of the environmental, social, terrain, and flood evolution processes involved in emergency treatment, it is very difficult to make scientific and timely treatment.

The Reliability of Traditional disaster emergency response way by experts’ decision rely on the experience of decision-makers and the understanding of flood disaster. So in recent years, a lot of studies have been carried out to help the decision-makers. Shi-Chen Zhang's dam evacuation and Practice Research[1], Cong-Bing Ge and others have carried out the design and implementation of the small reservoir dam break prediction expert system[2], Chong-Hui Fang carries out the new general formula of the calculation and verification of the maximum flow rate of instantaneous dam break[3], which provide the theory and technical support to the decision making of dam break. However, in the flood emergency, only the theory is far from enough. It needs a complete and accurate information of "environment - terrain - crowd". In the evolution of the flood, the three types of information change coupling relationship and the timely verification after decision making can help the decision better.

In this paper, the dam, reservoir area, flood and corresponding environmental factors are digitized with the help of GIS, Terra Vista and MultiGen Creator platform. The calculation and Simulation of flood evolution, disaster area and retreat path are achieved with DEM and evacuation model, and the scheme is verified according to the thinking of decision making, which provides a scientific decision for the response of the dam disaster.
2. Digital realization of reservoir dam

Terra Vista software is used in the terrain modeling in the development of the system. MultiGen Creator 3 is used in the main building of the hub, the model adopts OpenFlight format, the database adopts Sql sever, and the 3D virtual platform adopts ArcGIS.

2.1. 3D terrain generation

The terrain is stored in the digital elevation model DEM (Digital Elevation Model) format. DEM is a solid ground model that expresses the ground elevation with an ordered numerical array. It is a branch of the digital terrain model (Digital Terrain Model, abbreviated DTM), and all the other terrain features can be derived from it. DTM is the spatial distribution of linear and nonlinear combination of various geomorphic factors including elevation, such as slope, slope direction, slope change rate, etc., in which DEM is a simple single digital geomorphic model of zero order, and other geomorphic characteristics such as slope, slope direction and slope change rate can be derived from DEM.

In order to simulate the comprehensive information of terrain, only the landform is not enough, the image data such as vegetation and river are needed, the image quality is downloaded through the Google map, and the resolution accuracy is 90m. Remote sensing images are saved in TIFF format. The terrain model has the contradiction between the model precision and the computer rendering ability. The terrain needs to be partitioned, the far area can be larger LOD. LOD determines the generating precision of Terra Vista. The reservoir area can be used as a smaller LOD. The topographic map established by the above method is shown in Figure 1.

![Figure 1. D terrain simulation of rockfill dam junction](image1)

2.2. Digitization of pivot building

MultiGen Creator software is used in the modeling of the hub building. The file OpenFlight generated by it is the mainstream scene data file, and the OpenFlight uses tree structures to save the three-dimensional image. The tree structure consists of many different types of nodes. This kind of representation makes the interactive programming of the later building change easier. The model structure is shown in Figure 2.

![Figure 2. Schematic diagram of OpenFlight structure](image2)
The process of modeling is to extract the drawing information and establish a three-dimensional model. There are three steps to establish the model: Firstly, Extract the drawing information. Then establish a three-dimensional model. Finally, map with texture, which can improve the fidelity of the model. When establish the model, make the number of faces as less as possible under the premise of satisfying the display effect. The dam hub model is shown in Figure 3.

![Figure 3. A schematic diagram of the model of the rockfill dam of the Shiziping core wall rockfill dam](image)

2.3. Establishment of calculation model

In order to achieve planar or three-dimensional computation, we need to digitize the corresponding structure first, including structure partition, region parameter assignment and boundary information. When used, the corresponding calculation method and digital structure are called for calculation. Figure 4 is a digital structural model for stress and strain calculation of the rock core dam.

![Figure 4. Digital structure model of stress and strain for rockfill dam of the Shiziping core wall rockfill dam](image)
2.4. Storage of digital data
SQL sever 2008 is responsible for saving all digital information. The method to achieve is imported and directly established from other platforms. Direct importing is to aim the data that need not be converted, such as the properties of hub building, monitoring instrument information, monitoring data and physical and mechanical parameters. The digital preservation format of engineering features is shown in Table 1, and the digital preservation format of measured values is shown in Table 2.

| Field name           | Field identification | data type | Remarks                        |
|----------------------|----------------------|-----------|--------------------------------|
| Serial number        | number               | Int       | Unique identification of information |
| Project category     | Category             | VcHar (30)|                                |
| Content              | content              | VcHar (30)|                                |
| Numerical value      | value                | float     |                                |

**Table 1. Digital storage format for engineering features**

| Field name           | Field identification | data type | Remarks                        |
|----------------------|----------------------|-----------|--------------------------------|
| Serial number        | number               | Int       | Unique identification of information |
| Measuring point name | name                 | VcHar (20)|                                |
| Reading (1-15)       | Mid Value            | float     |                                |
| Result value (1-15)  | value                | float     |                                |

2.5. Digital integration of GIS
Geographic Information System (GIS) is a technological system which integrates computer, geography and informatics in 1960s. Compared with the traditional visualization engine, GIS has more advantages in spatial query, spatial analysis and spatial computation. GIS is mainly responsible for integrating the terrain and building images, and combining the C# language, using the digital elevation model (DEM, Digital Elevation Model) to realize the intercommunication between the spatial information and the database information.

The digital elevation model is the surface of using the regular or irregular polygons to fit the surface space object, mainly for the description of the digital elevation surface. According to the shape of polygons, the DEM can be divided into two types, the network model and the irregular triangulation network model. Similar to raster models, spatial objects are directly represented by surface or spatial enumeration. In general, the center points of each pixel or pixel of a grid model represent the geometric and geometric features of the spatial objects or entities within a certain area, and the grid model usually represents the spatial geometric and attribute geometry of the space objects or entities near the intersection with the intersection point characteristics of the row and column. It is mainly applied to automatic generation of contour lines, analysis of slope and slope direction.

The GIS visual integration diagram is shown in Figure 5.
3. Module of visual analysis
The visual analysis module is mainly based on the GIS platform. It has the functions of spatial data acquisition, storage, display, editing, processing, analysis, output, display and application. At present, the system has used its functions to realize flood routing simulation, watershed visual query and emergency plan verification.

3.1. Visualization of flood evolution
There are two ways to simulate floods that caused the dam break, namely instantaneous dam break and gradual dam break. The earth dam is a gradual dam break. The numerical simulation of dam break flood is calculated by Mike21 software, and the result data can be visualized by using GIS that technology is provided by DTM. DTM technology can add regional water depth, flood arrival time, flood inundation duration and other information to GIS, and simulation diagram is shown in Figure 6.

![Reservoir water level rise (a)](image1)
![Reservoir water level rise (b)](image2)

Figure 6. Simulated flood evolution process

3.2. Query of information visualization
In GIS model, information and visual query can be realized through intensification of points and regions. First, set up the point space that corresponding to information, and then set up the triggering event of the space. When the event occurs, the information is associated with the database, thus the visual query of the information is realized. The 3-dimensional query is shown in Figure 7.
3.3. Verification of emergency plan
An important factor in the effectiveness of emergency plans is whether the proposed scheme can protect downstream personnel from evacuating to safe locations before flood arrival. In the selection of the scheme, the selection of the safety point and the evacuation route and the distribution of the emergency facilities are complex. The traditional method is judged by the experience of the experts and engineers. Once the fault is judged, or the neglect of some details will cause immeasurable loss. In this regard, the use of GIS spatial analysis function can achieve the best emergency route selection.

First, according to the simulation of flood evolution, mark the submergence time in the downstream area, and then calculate the evacuation time of the downstream personnel from the emergency instructions to the safe area, as is shown in formula (3.3-1) - (3.3-2).

\[
t(i, j) = L(i, j) / V(i, j) \quad (3.3-1)
\]
\[
V(i, j) = v_0 / 2 \pm \sqrt{(v_0 / 2)^2 - B(i, j) \times v_0 / J_m} \quad (3.3-2)
\]

In the formula, \( L(i, j) \) is the length of the section \( i \) to \( j \); \( V(i, j) \) is the actual driving speed; \( v_0 \) is the possible speed of the vehicle and walking when no traffic is blocked in the section; \( B(i, j) \) is the traffic on the section of the section; \( J_m \) is road congestion and congestion density; When the road is not congested, the positive sign is taken before the root; when the road is in a crowded state, the negative number is taken before the root.

Traffic volume \( v_0 \) can be corrected according to the actual speed of \( v_s \), considering mixed traffic and road traffic capacity.

\[
v_0 = \gamma \cdot \rho \cdot v_s \quad (3.3-3)
\]

The \( \gamma \) in the formula is the reduction factor of mixed traffic condition, and \( \rho \) is the influence coefficient of lane width.

The calculation formula for road congestion and congestion density \( J_m \) is as follows:

\[
J_m = \gamma \cdot \alpha \cdot 1000 \cdot n / (L + L_0) \quad (3.3-4)
\]

In the formula, \( \alpha \) is the influential correct factor of the influence of intersection; \( n \) is the number of one-way vehicle lanes; \( L \) is the average vehicle body length; \( L_0 \) is the average clear distance of traffic jam.

Input information of personnel in each area in GIS system, and input the speed of each section according to material resource information. GIS can calculate the time to reach the security area. If the evacuation time is less than the flood arrival time, the plan is feasible, otherwise the effective path should be searched again.
The ARC/INFO module in GIS can provide the best path choice. It can search the shortest way to reach the destination according to the starting punctuation and the path conditions, as shown in Figure 8.

Figure 8. Interface of retreat scheme verification

4. Conclusions
(1) With the help of GIS, Terra Vista and MultiGen Creator platform, the high precision dam, reservoir area and flood are digitized, and the information needed for flood response of dam deformation, reservoir area and materials is provided by space integration of SQL sever database, which can provide complete and intuitionistic analysis information for decision-makers.

(2) High precision flood routing simulation can be realized by GIS, which can calculate flood loss and submergence analysis over time more accurately.

(3) Based on the digital reservoir dam model system, consider the comprehensive analysis of Flood-flow-path system and the statistics of life loss, in combination with the interaction of three elements information between environment, objects and people, to search for the best exit path. At the same time, the scheme can be verified according to the improvement of decision-making, which provides a scientific analysis way for the scientific decision of dam disaster response.

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