

BUILDING A 3D DIGITAL RESERVOIR

L. Yong a,b,* , L. Xiang-guoa

^aInformation Science and Engineering Department of Shandong Agricultural University, 61 Daizong Road, Taian, Shandong Province, China, 271018 -(yongl, xglin) @sdau.edu.cn

^b Chinese Academy of Surveying and Mapping, 16 Beitaiping Road, Beijing, China, 100039

KEY WORDS: 3D model, digital reservoir, spatial analysis, hydrological analysis, digital earth

ABSTRACT:

A 3-d digital reservoir is defined in this paper that is a virtual spatio-temporal model of the real one. The procedure of making it is also presented which is composed of software selected, preparation of data needed, making of the reservoir, and animation effect realization based on real-time hydrologic data. Navigation, zoom in and out, explore and fly, interactive inquiry of spatial information and attributes information, spatial analysis, hydrological analysis, allocations of the material used to rush to deal with an emergency, finding the place where need strengthening when water level is higher than the designed level, interpolating surfaces can be realized on the 3d digital reservoir. Compared to the 2D GIS, 3D GIS has greater advancement than 2D GIS in real-time data acquisition, visualization, simulation analysis and so on those are important in water conservancy. A 3D digital reservoir supplies strong spatial analysis, data management, visualization, combination of real-time attribute data and geographic data, it supports spatial information inquiry, attributes data inquiry and management, and it can monitor and simulate flood submergence and drought conditions, then it also can fast analyse and evaluate loss of the disasters and make schedules against disasters in advance. In a word, it can be a helpful aid decision-making tool for flood control and drought prevention and it is an important means for water conservancy department to realize modernized management of information about water conservancy.

1. INTRODUCTION

With the fast development of science and technology

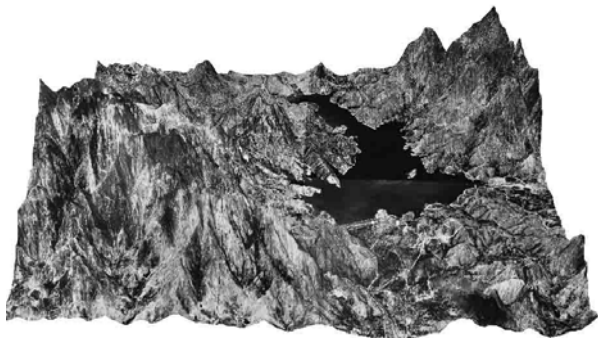


Fig. 1 The ortho photo image is draped over the terrain surface

in RS, GPS and computer, GIS has been being widely utilized in water conservancy. As a result, currently, GIS, especially 3D GIS, has been one of basic tools for work of water conservancy. And 3D GIS has greater advancement than 2D GIS in real-time data acquisition, visualization, simulation analysis and so on those are important in water conservancy. A 3D digital reservoir supplies strong spatial analysis, data management, visualization, combination of real-time attribute data and geographic data, it supports spatial information inquiry, attributes data inquiry and management, and it can monitor and simulate flood submergence and drought conditions, then it also can fast analyse and evaluate loss of the disasters and make schedules against disasters in advance. In a word, it can be a helpful aid decision-making tool for

flood control and drought prevention and it is an important means for water conservancy department to realize modernized management of information about water conservancy.

So far, 3D GIS has been widely employed in water conservancy such as 3D visualization, disaster evaluate, decision-making system and so on. Digital Yangtze, digital Yellow River, and digital valley are proposed and presented, but digital reservoir has not been reported at home and abroad. A whole GIS of water conservancy contains points such as reservoirs, lines such as rivers and surface such as water system. So digital reservoir is a required part of digital water conservancy. Luckily, He Quan reservoir in Qing Hai Province has been armed by RS and GIS, but there is no definition of digital reservoir and no systemic introduction of application of 3S in a reservoir. This paper will make some progress in definition and systemic introduction of application of 3S, especially 3D GIS.

This study is made on Xue Ye Reservoir, as shown in Fig.1, in Shan Dong Province, China, whose Water supplier area being 444 km² and irrigated area being 200 km², total cubage being 2.21×10^8 m³, beneficial cubage being 1.12×10^8 m³, designed water level being 224m, the average multi-year most rainfall being 95mm in 24 hours and 92,000 human living in the downstream. In a word, it is now a flood detention reservoir in flood seasons and water supplier in drought seasons, and digital Xue Ye reservoir is meaningful and helpful for the informization of water conservancy.

* Corresponding author. L. Yong, doctor, professor, majored in digital water conservancy and digital agriculture. E-mai: yongl@sdau.edu.cn

2. DEFINITION AND FUNCTIONS OF 3D DIGITAL RESERVOIR

A digital reservoir, based on the theory and technology of digital earth, is a virtual spatio-temporal model of the real one that can make best of spatial information for managing the reservoir. It has many functions as following.

2.1 Navigation, zoom in and out, explore and fly

Simulated 3D terrain model, as Fig.2 and Fig. 3 shows, is built for navigation, zoom in and out, explore and fly. Points such as hydrologic stations, rain condition stations, lines such as road, streams, railroad, polygons such as water surface, entity such as houses, buildings, trees can be represented and displayed in electronic sand table of circumjacent area of Xue Ye Reservoir.

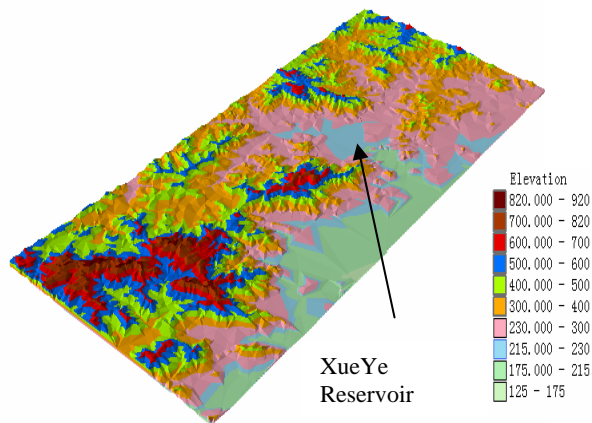


Fig. 2 The TIN model of circumjacent area of Xue Ye Reservoir

2.2 Interactive inquiry of spatial information and attributes information

Interactive inquiry is very easy for a3D digital reservoir if data warehouse is perfect built. The user can click the features to get the related attributes data while can inquire the attributes tables to locate the features in 3D models. As Fig. 6 shows, submergence analysis also can be used to locate the area where will be submerged in case of collapse of the dam and where is safe and can be used to retreat for human being.

2.3 Spatial analysis

Slope, aspect, hillshade, viewshed analysis, submergence analysis, curvature analysis, geometric measurement such length, area, volume and so on can be made on 3D reservoir.

2.4 Hydrological analysis

DEM of the circumjacent area supply a platform for hydrologic analysis such as derive sinks, flow direction, filling sinks, flat area detection, DEM correction, flow length, flow accumulation, flow

change, flow maxim, contributing area, snap pour points, stream designation and so on.

2.5 Computation

2.5.1 Conversion between water level and water volume

Thanks to the volume computation function, the conversion between water level and water volume can be easily realized if the DEM of the reservoir is prepared, as Fig. 5 shows.

2.5.2 Calculating the added volume of bedload of the reservoir

The difference of volumes of the upstream system between current time and datum time, subtracting the earthwork volume made by human, is approximately equal to the added volume of bedload of the reservoir that is a basis to water regulation.

2.5.3 Calculating the volume of earthworks

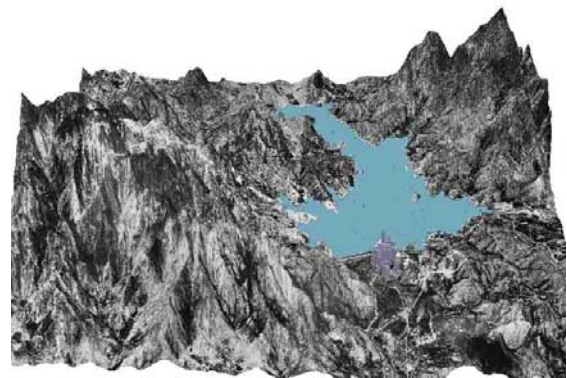


Fig. 3 Electronic sand table of circumjacent area of Xue Ye Reservoir

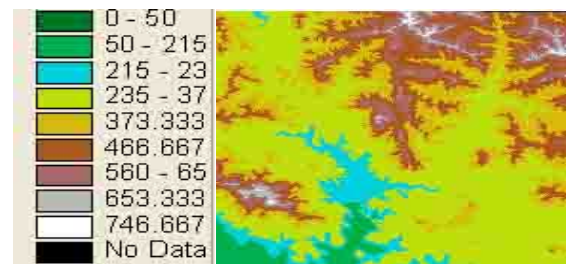


Fig. 4 DEM of circumjacent area of Xue Ye

The difference of volumes of DEM between before and after of the engineering is approximately equal to the earthworks of the work.

2.6 Allocations of the material used to rush to deal with an emergency

Proximity mapping is useful to fix the optimized position and allocations of the material used to rush to deal with an emergency.

2.7 Finding the place where need strengthening when water level is higher than the designed level

The reservoir needs containing more water in emergency situations, but how to know the risk of overloading. Convert the bearing capacity of the dam body of each part to corresponding wide line and covert pressure of the water to corresponding distance, then make buffer analysis can find whether the level is risky and the place where need strengthening.

2.8 Interpolating surfaces

Accurate water surface (curved) can be drawn by interpolating the hydrologic data measured by some hydrologic stations to estimate and rectify the water volume. And rainfall isolines can also be drawn by interpolating.

2.9 A monitored dam by GPS

GPS devices are installed on the dam to monitor the deformation and to make alert in advance if the deformation is larger than tolerance.

3. PROCEDURE OF MAKING 3D RESERVOIR

3.1 Data collection and preparation

DEM data, DLG data, DOM data are required to build 3-d reservoir. And real-time hydrological data are used to build a dynamic virtual 3-d water surface. ArcGIS 9.0 is employed due to its advanced functions and open interface and easy master secondary development environment, and ENVI is used to masic photos.

Image data are 4 pieces of ortho photos scaled 1:10000, DLG is digitalized based on the terrain map scaled 1:5000, and DEM is also made based on the contour on the terrain map. Note that the DEM of ther reservoir used to convert water level and volume is made on the terrain map before the construction of the reservoir, as Fig. 5 shows. And attributes such as elevation of houses is estimated while the hydrologic data is supplied by the water conservancy department.



Fig. 5 DEM of Xue Ye Reservoir

3.2 Processing of data

4 ortho photos are mosaiced into one by ENVI, and grid maps and DLG are registered, TIN or GRID is generated form counters, and attributes are filled into tables.

3.3 3D scene generation

In ArcScene, the ortho photo image is draped over the terrain surface, the features such as houses are extruded based on their height, and points and lines such trees, roads are symbolized in 3D style, and all the features' base height is the terrain surface. As Fig.3 shows, a 3-d digital reservoir is built to simulate the real one.

3.4 Animation effect of the water surface

Water surface is drawn in ArcMap and is given a height, then be added into ArcScene, and create at least two keyframes, and modify the Z transition value based on different water level, and the animation is played once the animation control button is clicked.

Flooded area when the dam is broken

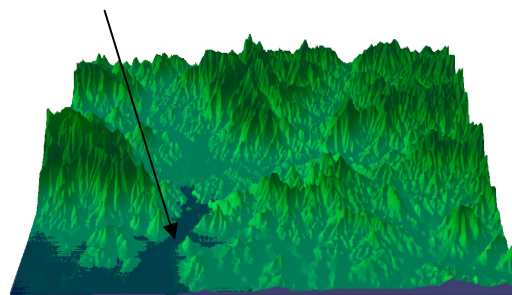


Fig. 6 Flooded area when the dam is broken

4. CONCLUSION AND DISCUSSION

Flood and drought severely threats the human beings' lives and safety of treasures, and jeopardizes the sustainability of economy. The reservoir can block and store the flood, decrease the flood peaks and save water to supply in drought seasons, which increases the comprehensive use of the water resources. Based on the theory and technology of digital earth, we make a definition of 'digital reservoir', and illustrate the functions and making it. But the how to realize the functions need more research and more functions need developing. We expect this paper has a far-reaching affect to informationization of water conservancy in China, which can promote the construction of digital reservoirs.

REFERENCE:

AL Gore. The Digital Earth: Understanding our planet in the 21st Century. Given at the California Science Center, Los Angeles, California, on January 31, 1998. <http://www.Digitalearth.net.cn/> (accessed 12 Sep. 2001)

Liang Yong, 2004. Study on digital reservoir. Journal of Shandong Agricultural University (natural science edition),20(1):35-39.

ZHU Qing, 2003. Design of 3D Models for 3D GIS. Geomatics and Information Science of Wuhan University, 28(3):283-287.

LIANG Yong, 2002. The Main content, Technical Support and Enforcement Strategy of Digital Agriculture] GEO-SPATIAL INFORMATION SCIENCE, 5 (1): 68-73.

LIANG Yong, 2003. Study on the Framework System of Digital Agriculture]. CHINESE GEOGRAPHICAL SCIENCE, 13 (1): 15-19.

<http://www.westgis.ac.cn/>(accessed 12 May. 2005)

<http://www.gisworld.com/>(accessed 12 May. 2005)

<http://www.spaceimage.com/>(accessed 12 May. 2005)

<http://www.esri.com/>(accessed 12 May. 2005)