Research on Three-dimensional Water Resources Information System Based on ArcGIS

Rong Li*，Tao Sun, Guo Li
Ministry of Water Resources,
China Institute of Water Resources and Hydropower Research,
Beijing, China
lir@iwhr.com

***Abstract*—3D *(three-dimensional)* GIS (Geographic Information System) technique provides a data processing and 3D scene displaying platform for hydropower project. This paper aims at developing a 3D water resources information system. On the base of contrast and analysis of current 3D GIS software, the GIS database was established and the techniques of COM (Component Object Model) and 3D visualization were implemented. The system breaks through the limitation of traditional two-dimensional display and is independent of the development environment and current GIS platform, which can quickly provide decision support for the flood regulation and water storage. The proposed method can be applied into other related fields, such as design, development and application of 3D.**

Key words-Geographic Information System; Component Object Model; three-dimensional; ArcGIS

I. Introduction

GIS (Geographical Information System) is a frontier branch of science, which integrates Space Science, Survey and Mapping Science, Geography, Information Science, Computer Science, Environmental Science and Management Science. The GIS is not only capable of managing data, text information and graph, but also of integrating and analyzing spatial data from different sources, with diverse formats, structures, projections or resolution levels with the aid of computer, thus it is a new effective technical system in complex processing and analysis of spatial data [1].

2D (two-dimensional) GIS began in the computer aid mapmaking in the 1960's, and now it has gone deep into every application field. It is essentially based on abstract symbolic system, so it can not provide the original feeling of nature to people, and is difficult to overcome the shortcoming. However, 3D (three-dimensional) GIS can solve the problem [2]. With the development of Virtual Reality technology, the concept of "digital earth" has been put forward, and 3D GIS become a new technology to promote spatial analysis and expand information representation in GIS. By processing elevation data, 3D GIS can display the landform and objects in three dimensions to create an obvious scene. This display usage can also meet demand for management, analysis, estimation, decision and visualization [3].

II. System design

A. Study Area and Demand Analysis

Flood is the most frequent disaster in China, and it has become one of the most important factor in restricting the economic construction and sustainable development. Huai River, one of the seven river basins in China, has various degrees of flood disaster happenings for a long time. In order to serve the government for decision-making, the water resources information system has a technical difficulty to be overcome, that is how to exactly show the situation of disasters in a visualized obvious way. It is just about the advantage of 3D GIS, which is good at revealing the phenomenon and dynamic changes in real world by means of 3D graphics and images. As a result, 3D GIS can give a powerful technical support to lay out the 3D scenes of flood area. Nowadays, the most urgent problem for researchers in the work of water resources information system development is to display and analyze the river information in three dimensions.

B. Methodology

This system has to show the landform of Mengwa flood diversion-detention area in Huai River Basin and construct a series of flood scenes in three dimensions. Based on these landform and geographic data, the system has various basic functionality as well as three-dimensional real-time roaming. In order to implement the functionality, the system has been accomplished by two steps, and different method has been used respectively.

Step 1. Construct a 3D scene using basic geographic data, DEM (Digital Elevation Model) and remote sensing images.

Step 2. Take the COMGIS (Component GIS) as the oriented technology, secondary develop the three-dimensional system to complete the whole functionality.

III. 3D Scene Construction

A. 3D GIS Software Comparison

By reason of 3D display and analysis being a hot direction in GIS, almost all the existing GIS software add 3D modules. In the following section, several popular 3D GIS software in China and abroad is compared.

ESRI ArcGIS 3D Analyst is the 3D visualization and analysis extension of Desktop software. It adds two specialized 3D viewing applications, ArcScene and ArcGlobe, which extend the capabilities of ArcGIS Desktop and adds additional capabilities to ArcCatalog and ArcMap.

ERDAS IMAGINE has a 3D visualization tool named IMAGINE VirtualGIS. It uses OpenGL as its basic graphics language and allows the use of hardware accelerators for geometry or texture rendering. Also the IMAGINE VirtualGIS can be run on both UNIX workstations and PCs.

VRMap is an open and large-scale component-based 3D GIS platform. The secondary development platform is a 3D engine developed with the aid of DirectX and OpenGL.

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VRMap is equipped with basic 3D spatial analyzing abilities, such as quantitative analysis, inquiry statistical analysis, topographic analysis, two-point perspective computation, profile observation and flood analysis.

B. Technical Scheme —ArcGlobe

Considering the requirements of real-time roaming speed, data scale, visual effect and system running stability, ArcGlobe is selected as the environment to construct 3D scenes. Any type of data with spatial reference on the 3D surface can seamlessly interact with ArcGlobe, which breaks through the size limit of data storage and can display large amounts of data quickly and effectively. That is to say, whether its extent is local or worldwide and whether its size is large or small, the raster, vector and terrain dataset can be processed more intelligently in 3D perspective environment than in 2D.

IV. SECONDARY DEVELOPMENT

A. System Development Based on COM

COMGIS is a kind of methodology of software development which merges the Object-Oriented technology and component technology into GIS. The principle of COMGIS is dividing the main functionality modules into some controls which can be available for different functionality. The final GIS application can be implemented by visualized development tools via integrating various controls regardless of GIS and non-GIS[4].

The component technology can facilitate the efficient seamless integration of GIS and hydrologic models [5]. Fig.1 shows the framework of seamless integration of COMGIS and applications.

GIS Application		
Special Model	COMGIS components	other components
Visualized development environment (VB,VC,JAVA)		

B. COM in ArcGIS

ArcGIS Desktop is made up of ArcObjects components. ArcMap, ArcCatalog, ArcScene and ArcGlobe modules are all built and developed via "high-level language" by calling ArcObjects interfaces to implement the functionality.

ArcObjects is a set of platform-independent software components, written in C++, that provide services to support GIS applications on the desktop, in the form of thick and thin clients, and on the server. It is built by using component technology, and provides multiple interfaces based on COM. These interfaces consist of over 1200 objects which can be used to customize, extend and develop GIS applications. They also support map display, management, storage and other operation. The development using ArcObjects is not a single customization with ArcGIS functionality, but within the whole ArcGIS framework. However, it is expensive to develop with ArcObjects components because the desktop software must be installed on the same machine in the meantime.

ArcGIS Engine can be viewed as a set of low-cost and lightweight ArcObjects components. It is available for any standard development environment, including .NET, COM, Java, C++ and all the popular operating system, for example, Windows, UNIX and Linux.

As for a GIS application developed with ArcGIS Engine, its implementation needs only a RUNTIME, and not need to install ArcGIS Desktop at the same time, thus decrease the cost of system development greatly. What's more, ArcGIS Engine has more controls than ArcObjects which has just two: MapControl and PageLayoutControl.

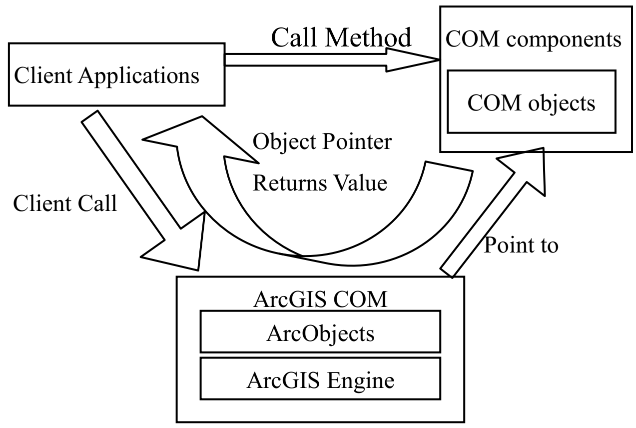

Figure 2. Mechanism and running process of COM objects in ArcGIS

V. IMPLEMENTATION

A. System Developing Procedure

In order to display the landform of Mengwa flood diversion-detention area in HuaiRiver River Basin and construct a series of flood scenes with functionality of 3D viewing, roaming, fly-through simulations, querying and so on. The working flow diagram shown in Fig.3 illustrates the flow of system development.

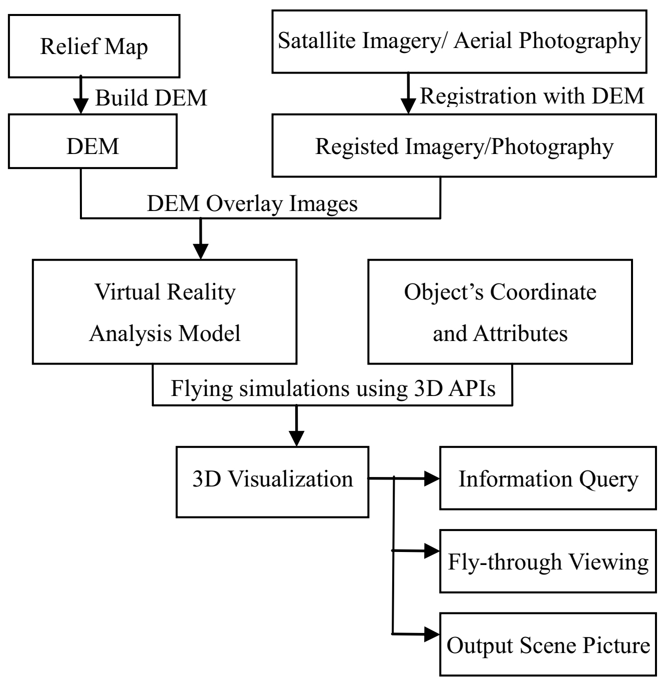

Figure 3. The flow diagram for procedure of system development

B. Data

The system inputs remote sensing images with high degree of resolution as the base map of 3D scene. The reached area is a broad area relative to the height of the terrain, so the apparent of terrain surface is rather flat. In order to enhance the sense of depth in the scene, and to bring out subtle features in the terrain, the height of the terrain is exaggerated by 5 times.

In addition to various basic geographic information layers, several flood layers are also be loaded into the 3D scene, so that the changes of flooding area can be reflected in detail.

C. Key Technology

In the process of system implementation, a comprehensive 3D scene is firstly designed and constructed on ArcGlobe platform. Then secondary develop the application system in the object oriented programming language, Visual Basic 6.0, by calling ArcGIS Engine. By taking advantage of COM methodology, the integrating framework is built and the functionality of 3D viewing, flying simulation, querying and output is implemented.

D. Functionality

A user-friendly GIS interface was developed to allow for 3D display and easy spatial manipulation. The functionality provided by the system is as follows:

(1) Three-dimensional display. To render a 3D scene more quickly, the amount of data required for display is reduced: only the portion of the image within the observer's field-of view is loaded into memory. The ortho-images have been loaded into the scene, and terrain data with various scales in Mengwa flood diversion-detention area in Huai River Basin are visualized in three dimensions. Using perspective, objects farther away are rendered at a lower resolution than objects closer to the observer. To increase the 3D effect of the display, high degree of resolution is used for high relief images, while low resolution is used for low relief images.

(2) Data operation. The spatial data loaded into the scene are divided into three types: floating layer, draped layer and elevation layer. Each type of layers can represent the spatial position relative to the earth's surface. They also can be manually changed from one type to another if needed. The terrain data can be unbounded zoomed, roamed, rotated and refreshed, and any layers can be added or deleted.

(3) Thematic mapping. Thematic maps can be created according to different themes. The map can convey the spatial distribution of a wide variety of qualitative and quantitative information. Almost any subject that can be expressed as a geographical distribution can be mapped. For example, the analyzed result can be directly shown on E-map, so that users can clearly learn the spatial distribution of flooding. The thematic maps can be stored in client computer as well as printed output.

(4) 3D Pan. Take the elevation data as underlying layer for the scene to be roamed. By making use of the direction keys and other functional keys on keyboard, the video or viewpoint can be adjusted forward, backward, upward or downward to observe from different angles. The functionality facilitates real-time flying through and panning around the 3D scene.

(5) Information querying. The system integrates quickly spatial indexing technique and efficient graphics arithmetic, which provide powerful tools for spatial query and analysis, so that user can analyze surfaces, query attribute values at a location on a surface, and analyze the visibility of parts of a surface from different locations.

VI. CONCLUSIONS

The 3D water resources information system of Mengwa flood diversion-detention area in Huai River Basin has an advantage given by COM methodology. This system development way can be used in other relevant projects by reason of shorter development period, lower cost and no need for additional GIS secondary languages.

One of development trend in 3D water resources information system is simulating flood routing in flood diversion-detention area. So it is necessary to do more research on combining special water flow models with visualized development environment to develop 3D flood routing information system, which can perform more perfectly and support government to make decisions better.

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