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Research on fine management and visualization of ancient architectures based on integration of 2D and 3D GIS technology

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Abstract. Aimed at ancient architectures which own the characteristics of huge data quantity, fine-grained and high-precise, a 3D fine management and visualization method for ancient architectures based on the integration of 2D and 3D GIS is proposed. Firstly, after analysing various data types and characters of digital ancient architectures, main problems and key technologies existing in the 2D and 3D data management are discussed. Secondly, data storage and indexing model of digital ancient architecture based on 2D and 3D GIS integration were designed and the integrative storage and management of 2D and 3D data were achieved. Then, through the study of data retrieval method based on the space-time indexing and hierarchical object model of ancient architecture, 2D and 3D interaction of fine-grained ancient architectures 3D models was achieved. Finally, take the fine database of Liangyi Temple belonging to Wudang Mountain as an example, fine management and visualization prototype of 2D and 3D integrative digital ancient buildings of Liangyi Temple was built and achieved. The integrated management and visual analysis of 10GB fine-grained model of the ancient architecture was realized and a new implementation method for the store, browse, reconstruction, and architectural art research of ancient architecture model was provided.

1. Introduction

Though historic buildings are products of human civilization and also both the material wealth and moral wealth of modern humans, they could be damaged by developments, constructions and nature disasters. As a result, lots of large historic structures have been damaged in various degrees and protection of historical and cultural heritage faces a crisis situation. In recent years, with the fast development of subjects like virtual reality, geography information system and 3D laser scanning, virtual reappearance of historic building and mutual study of artistic details of historic building structure, function, installation and so on could be realized by digital ancient buildings characterized technically by 3D GIS and depending on fine 3D model of historic building. And it is significant for study and protection of historic building[1].

At present, emphatic achievements have been obtained by digitalization protection projects of historic building of both here and abroad. For example, Tsinghua University scanned partial structures of Xixi Erxian Temple of Lingchuan County, Shanxi Province and east palace of Foguang Temple of

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Beijing. And then ideograph of section of spar frame flat was drew and by comparison with point clouds of present situations, evaluation of quantized distortion was obtained[2].

With most digital process focused on surveying and restoration here and abroad, it lacks systemic management and friendly exhibition for digital data. Concerned with characteristics of historic building like large data, refinement and high-precision, a way to realize 3D fine management and visualization of historic building based on integration of 2D and 3D GIS is proposed by this paper and integrated management and visualization analysis for fine model of historic building more than 10G are realized taking fine data library of Liangyi Temple, Wudang Mountain for example.

2. Data analysis of digitalized historic building

To analyse various data of digitalized historic buildings, type, data volume, data feature and so on would be considered. As digitalized data of historic buildings include fine component model, surveying maps, textual data, images, videos and so on which all own their features, it is essential to analyse and understand each data feature for effective management of data of historic buildings based on digitalization management platform. Features of several important digitalized historic buildings data are introduced in the following and main problems and key technologies existing in data management are analysed at the same time.

2.1. Textual data

Writing of textual data is based on collecting and classifying of surveying objects and textual data include local chronicles, literatures, inscriptions owned by buildings and relative historical facts recorded by prefaces. Contents unable to be expressed by maps could be described with detail with surveying contents recorded in text.

Historical culture, locations, history reform and repair change were recorded by textual data of historic buildings. From the perspective of management, textual data would be saved in attribute database as attributes of component models of historic buildings.

2.2. Fine component models

Compared with 2D flat images, 3D models of historic buildings seem more vivid and lively both in exhibiting appearance of historic buildings and in showing internal form, structure, mode of connection and so on which are convenient to observe historic buildings in various perspectives, so 3D models are been adopted by large amount in protection and exhibition of historic buildings[3]. By the way, 3D models built by AutoCAD own material properties which could carry on render process to achieve the reality effect and size information which shows historic buildings precisely.

The present filing means of wood component is mostly realized in the form of document to manage. Though a few attributes of components and the rough graph could be looked up in AutoCAD, it is impossible to show users names, attributes and graphs of components at the same time and to add, find and delete components directly.

Fine component models of historic buildings could be transferred into the type of Multipatch utilizing 3D data management ability of GIS. As one feature class of ArcGIS, Multipatch which could both show 3D models of components and save texture information of models is used to describe surface of 3D entity.

2.3. Images and Videos

In surveying of historic buildings, digital images could show information of the structure and the form. Digital videos record information of historic architectures in dynamic ways to show building information and the style of art directly. Images and videos are mainly used to enrich attributes of historic buildings. They are saved in attribute database as attribute data and are related with historic buildings by fields.

3. Integrated management of image library and models

Digital data of historic buildings include spatial data. Attribute data and spatial database includes fine component model, surveying maps, textual data and 3D point clouds. Attribute information of historic buildings includes 3D fine model and attributes of surveying maps, for example, statistical data of historical literature, the material of historical buildings, types of components, size information and so on.

Quick display, inquiry and seek of various data and construction management of 3D model components could be realized by integrated management and display of digital data in various forms. High-efficient, fast and integrated management method could be adopted to realize classify of historic buildings data, to management in different levels and integrated inquiry of 3D model components. As a result, protection of historic buildings is more efficient and easier.

3.1. Hierarchical management of ancient architecture component model

Typical ancient architecture was assembled from many wood components in the form of building blocks. In modern times, in the ancient architecture construction process, some engineers were accustomed to divide architectural component into five layers: column base, decoration, beam mount, roof, dougong.

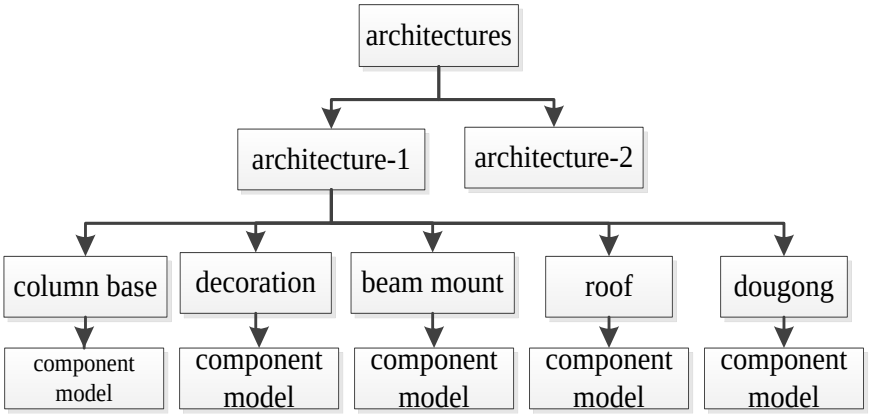

Figure 1. The hierarchical organization of component 3D model.

3.2. The management of ancient architectures components attributes

According to the actual need of the protection of ancient architectures, the attribute information of the ancient architectures cover a wide spectrum, including the geometric properties of the building elements (such as the size of the building elements, the volume and cross-sectional area, etc.) and the physical properties (such as construction time and repair information). Based on the principle of normalization, for these attributes of the wood components, it is necessary to design a 2D table to describe each component, which contains the code of component, construction time, its father architecture, the father architecture's building layer it belongs, the information of repair person and time, etc.

Table 1. The design of ancient architecture's attributes database.

Field	**Type**	**Length**	**Name**	**Description**
ID	double	8	component code	NOT NULL
Name	double	20	component name	NOT NULL
Type	char	20	component type	
Date	date		construction date	
Remark	char	100	Remark	

4. The retrieval method of ancient architecture 2D and 3D data

4.1. The retrieval of 2D and 3D data

To make the 3D model of ancient architecture achieve realistic display, its geometry data and texture data must have a very large data size, for example, the 3D geometric data size of one architecture Wudang mountain Liangyi temple is more than 200M. The actual project always involves a group of architectures and their digital management, and this will produce vast amounts of spatial data, which is a challenge to the model data's query, retrieve and display. Therefore, a specialized indexing mechanism must be designed for the spatial database of the digitized ancient architecture, which is spatial index. Spatial index is a kind of data structure which is arranged in a certain law based on the geographical location and shape of spatial elements and a relationship between spatial objects[4].

Based on the spatial retrieval mechanism of existing mature GIS software, there are two methods to achieve retrieval for the spatial data in database. One is to retrieve spatial object according to the attribute information of spatial data. Another is according to the position of spatial data and uses the spatial retrieval method such as point query, line query or plane query to retrieve spatial object. The spatial object can be retrieved according to its attribute, the position of 3D model in the ancient architecture and their connection relationship.

4.2. Linkage of 2D and 3D data

Digitized ancient architecture management always involves a group of architectures or all the ancient buildings in a region, not just single building. For the convenience of displaying the location of digitized ancient architecture model as well as retrieving the digitized ancient architecture model at a certain geographic position, a mechanism about the linkage of 2D and 3D data is designed after making full use of the respective advantages of the 2D data and 3D data to improve the query efficiency of ancient architecture model.

5. The digital management system of Wudang mountain Liangyi Temple

5.1. System Introduction

Digital ancient architectures management and visualization system was designed and developed with the help of powerful visualization and data management functions of GIS. GIS and virtual reality technology was combined in this study. Utilizing ESRI's ArcEngine development package, fine management and visualization prototype of 2D and 3D integrative digital ancient architectures of Liangyi Temple was built and achieved.

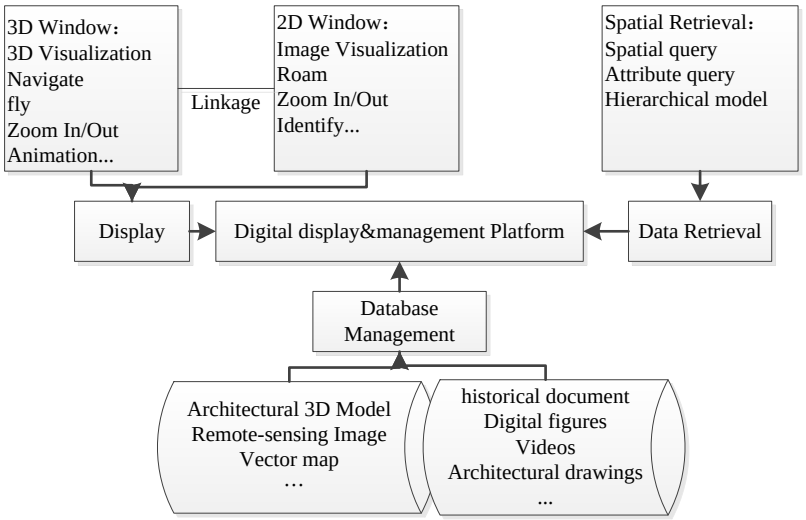

Figure 2. System function module.

5.2. Establishment of the ancient architecture database

GIS system has powerful information retrieval and analysis capabilities, which is based on the strong support of its database[5]. The information of ancient architecture includes spatial information and attributes information, and ancient architecture database should contain spatial database and attributes database based on these two sources of information.

Spatial database is mainly consisted of raster data and vector data. Raster data include remote sensing image, raster map, etc. Vector data include intensive model of ancient architecture component and 2D vector map, among these, the intensive model of ancient architecture component is stored in one Geodatabase according to different levels, and the 2D vector map is stored in another Geodatabase.

Attributes database includes not only the attributes information corresponding to spatial data, such as size and type of the component, but also other attributes information, such as documents, pictures, and so on. These attributes information are classified and stored in different access tables, in which the code of each model is corresponding to the code of space object in spatial database.

5.3. Design of functional modules

Data display, data retrieval, database management functions were integrated in the fine management and visualization prototype of 2D and 3D integrative digital ancient architectures of Liangyi Temple.

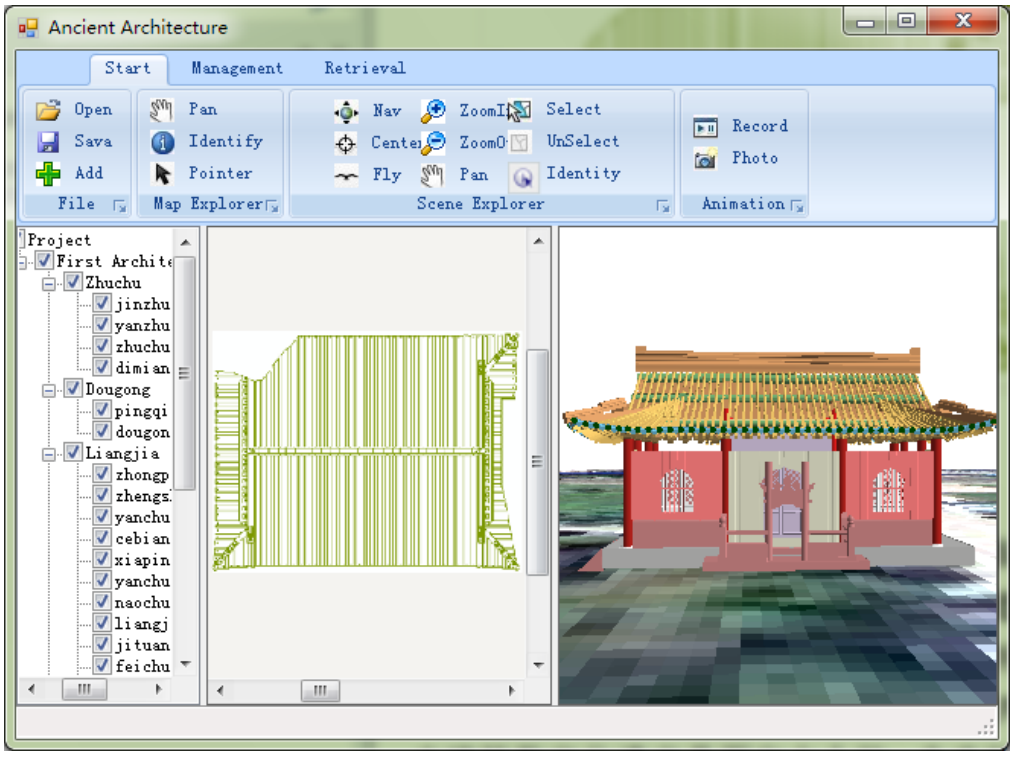

Figure 3. System Interface.

5.3.1. Data display. The Visualization interface includes two-dimensional window and three-dimensional window, architectural vector map and grid maps were displayed in the 2D window. Functions such as map-display, layer-control, zoom in, zoom out, move were achieved. Digital model of Liangyi Temple and remote-sensing images were displayed in the 3D window. Functions such as Navigation, fly, zoom in, zoom out and animation were achieved.

5.3.2. Data retrieval. On one hand, SQL statements were used to retrieve spatial or attribute data which meet the keywords. On the other hand, spatial query was used to retrieve spatial objects which meet spatial relationship.

5.3.3. Database management. Through the connection to the database, browse and display of models, maps, videos, etc. were realized. Spatial and attribute data can be added, deleted, modified and refreshed. Spatial and attribute database management of Liangyi Temple was realized.

6. Conclusion

With the rapid development of virtual reality, geographic information systems, 3D laser scanning and other disciplines, and people's growing concern of protecting ancient architectures, Research on digitization of ancient architectures will further. Take the fine database of Liangyi Temple belonging to Wudang Mountain as an example, a 3D fine management and visualization method for ancient architectures based on the integration of 2D and 3D GIS was studied, an idea for the protection of digital ancient architectures was provided. Meanwhile, it should be noted that the digital ancient architectures were shown for public, so future direction of ancient architectures digital management platform will be networked.

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