Study on Three-dimensional Restoration and Display of the Qing Dynasty Relics in Xinzheng Henan Province

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Abstract: The Chinese civilization is extensive and profound, and the number of cultural heritage is huge, and the ancient architectural relics are all over the country. The application of three-dimensional modeling technology can restore and reconstruct the relics, which is of great significance to the research and inheritance. The DEM (Digital Elevation Model) data, texture image data and historical information were collected from the Qing Dynasty relics in Xinzheng Henan Province, used 3ds Max, Speed tree and other modeling software to model the buildings, roads and plants in the scene and to realize interaction and display by the models were imported into Unity 3d. In this study, the Qing Dynasty relics were truly restored and displayed.

Keywords: relics; three-dimensional restoration; 3ds Max; Unity 3d

1. Introduction

The protection and inheritance of cultural relics are of great significance to the country and the nation. It is not only the witness of history, but also the presentation of human development. There are many Chinese cultural relics, but with the passage of time, many cultural relics had been seriously damaged. Large-scale urban construction throughout the country is a great threat to cultural relics, so the protection of cultural relics is urgent [1]. The ruins of ancient buildings are seriously damaged and difficultly recovered. With the maturity of three-dimensional modeling technology, the ancient architectural relics can be restored and reproduced, which is of great significance to the research and protection of cultural relics.

At present, there are many studies on the three-dimensional restoration of ancient architectural relics. Basing on the image data of close-range photogrammetry and combining with the data of literatures, Wang et al. calculated and obtained the structural data of the Pagoda Temple of the 13th Dalai Lama Goldentop with three-dimensional model which was reconstructed by 3ds Max [2]. Xia et al. measured the wooden components by the ruler and processed the results in combination with high resolution digital camera, and then classified, simplified and mapped the data source with CAD, and then imported them into the virtual model library of GIS to realize the three-dimensional reconstruction of the ancient architecture landscape of Tang Dynasty [3]. Xin et al. acquired tremendous amount of point cloud data of ancient buildings by ground laser scanning technology and constructed the complex surfaces of ancient buildings by NUBRS modeling method, which had realized the three-dimensional reconstruction of a whole cavern [4]. The first virtual roaming system with historical and cultural charm displayed in China was launched by IBM and the Palace Museum--The virtual roaming system of the Forbidden City [5]. Over the period 1997 to 2007 experts from the United States, Britain, Italy and Germany used virtual reality technology to digitally reconstruct ancient Rome (Jun 2013). In the virtual Rome, the visitors can use computers to "walk" in the famous Colosseum of ancient Rome, or "rise from the sky" observe the relief and engraving on the Arc de Triomphe at close range [6]. The Virtual Laboratory of Cultural Heritage at the University of California, Los Angeles, used real-time three-dimensional visual database modeling technology and optimization tool of MultiGen Creator to restore the Cathedral of Santiago in Spain, which is one of largest Christian churches in Europe [7]. By using Quest 3D virtual roaming interactive software platform, Japanese Cad Center Company produced a virtual Inuyama Castle, which truly shows the panorama of Inuyama Castle [8].

Basing on the present situation of the Qing Dynasty relics, the DEM data and texture image data of the relics were collected, and use the three-dimensional modeling technology and virtual simulation technology to model the buildings, roads and plants of the ruins, and finally use Unity 3d to realize the functions of roaming, flying and audio explanation, complete the three-dimensional restoration and display of Qing Dynasty relics in Xinzheng.

2. Design Summary

2.1. Restoration Difficulties

After years of baptism and the serious damage of the Yellow River flood at that time, the remains of the Qing Dynasty are only part of the buildings, and the houses, walls, cooking ranges, vegetable fields, etc. left on the site are no longer complete, so it is difficult to restore the

scene. Scene restoration mainly has the following difficulties: 1) the collection of trace data is limited, and there are few remaining buildings on site; 2) the restoration of scene is carried out by measuring and recording the existing trace buildings, topography and other information, and the precision of the model in the scene is controlled; 3) It's also difficult how to express the life scene of ordinary people in Kaifeng area in the middle of Qing Dynasty through restoration.

2.2. Scene Design

Through the analysis of the existing situation of the relics, it is determined that the scene restoration work mainly focuses on the design of houses, walls, terrain, vegetable fields, animals, plants and other parts. The scene design module is shown in Figure 1.

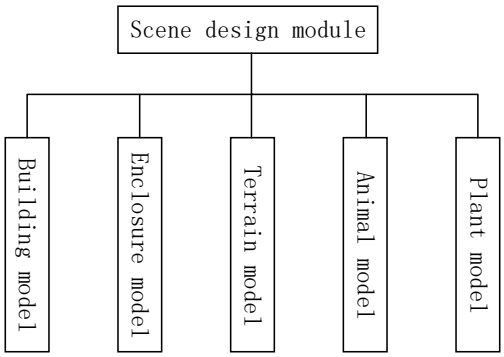

Figure 1. Scene design.

3. Dataset

3.1. Historical Data

According to historical records, the Yellow River burst at the 31st fort, Xiangfu flood land, Henan Province in August 1841 (the 21st year of Daoguang). The overflowing Yellow River encircles Kaifeng for eight months, which is unique in the flood of the Yellow River in Henan Province [9]. More than two meters away from the excavation site, a relatively complete grass and wood structure roof, composed of beams, rafters, straw cover, etc., should be two meters away from the roof by the flood as a whole. It can be seen that the flood in that year brought great disaster to the people [10]. The Qing Dynasty relics of Xinzheng located in the western suburbs of Kaifeng City, Henan Province are an existing courtyard site destroyed by floods. It provides precious documents for the study of the Qing Dynasty urban history of Xinzheng.

The site was found in the exploration of cultural relics with the urban capital construction. In July 2017, it was begun to salvage ability archaeological excavation, whose area totals 840 square meters, and the ancient courtyards of East and West were cleared out. Abundant building materials, farm implements, kitchenware, tableware, supplies and other relics were unearthed [11]. Some of the remains are shown in Figure 2, The remaining houses, walls and cooking ranges in the picture, including the chicken coop on the left side of the front door, can be seen clearly, which provides a basis for the restoration of the vestige scene.

Figure 2. Courtyard ruins

Based on the historical records and unearthed relics, it is speculated that the site was destroyed by the flooding of the Yellow River in June the 21st year of Taoukwang. The excavation of this site intuitively shows the life scenes of ordinary people in Kaifeng area in the middle of the Qing Dynasty. To a certain extent, it reflects the level of productive forces, cultural outlook, spiritual beliefs of the society at that time, and also provides precious documents for the study of local history of Kaifeng City.

3.2. DEM Data

DEM data of terrain is an important basic data for constructing the whole three-dimensional scene. It can intuitively display the terrain characteristics of the Qing Dynasty relics in Xinzheng. The acquisition of DEM data is mainly accomplished by lidar, and manual editing is needed. Finally, the DEM data of relic terrain is generated (Figure 3). According to the DEM analysis of the remains, the upper part is the north courtyard, the left part is the vegetable field, the lower part is the South courtyard, and the middle part is the lane, so that the layout and location of each part of the scene can be clear. DEM data can provide relative proportions and comparisons in modeling, avoid manual measurement in every building, simplify operation and save time.

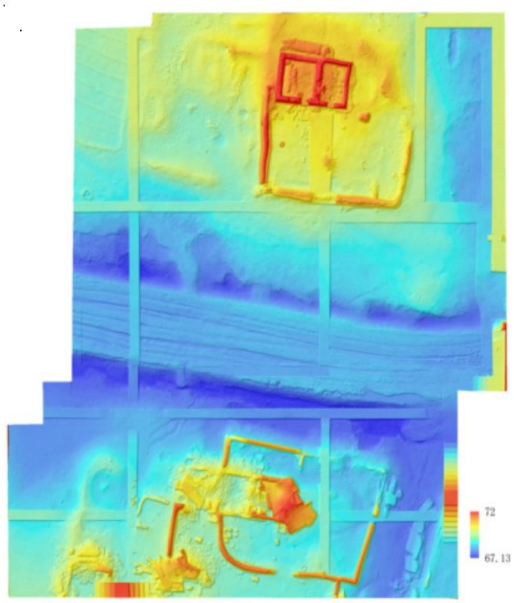

Figure 3. DEM data

4. Rehabilitation and Display of Relics

4.1. Scene Construction

This study used polygon modeling method to build the scene of houses, walls, terrain, vegetable fields, animals and plants and other three-dimensional models by 3ds Max, Sketch Up and other three-dimensional modeling software combined with DEM data. This method can quickly construct three-dimensional models of the whole scene, and then use the tools such as UVW mapping in the modeling software to carry out the texture mapping, which can restore the true appearance of relics. Among them, houses, walls and terrain are the main contents of scene restoration, so it is necessary to conduct fine modeling, while animals such as cattle, sheep, ducks, chickens, trees, grass and other plants in the scene are auxiliary for scene restoration display, so the model making is relatively rough, which reduces the difficulty of scene restoration to a certain extent.

The overall and detailed photographs of the buildings were collected. The quality of photographs directly affects the similarity of the models and the reality of the scene, so there are higher requirements for the time, intensity, location and tilt angle of the camera [12]. Photographs processed by photoshop can be used as texture maps for buildings, floors and walls [13]. Trying to choose smaller resolution maps can save the memory resources and improve the fluency without affecting the overall effect of the display [14].

The models were exported to FBX file in the three-dimensional modeling software, and then imported into Unity 3d. The corresponding standard materials will be automatically generated by the maps. If it is a special material, we need to select the Shader corresponding to the special material to display the material effect correctly. In addition, the scaling ratio of the models need to adjusted to one-to-one because the default unit in Unity 3d is meters, and the models will be reduced to 1% when were imported. The models made by 3ds Max were only rigid models. It needed to adjust various parameters of the scene to make the models more vivid and real after imported into Unity 3d.

Speedtree is a professional modeling software that can create custom tree models. The tree models can be directly imported into Unity 3d by Speedtree for Unity plug-in. The scene lights can be set up after the building models and terrains were putted in the right position in Unity 3d. Unity 3d provides simple natural light source. To ensure that the brightness of the whole scene can't be too intensity, it is necessary to add a directional light source as the main light source of the scene. The light settings in the whole scene play an important role in the rendering of the later scene and the user experience [15]. Some scenes of the Qing Dynasty relics in Xinzheng are shown in Figure 4, Figure 5 and Figure 6.

Figure 4. Scene of the Southern Courtyard

Figure 5. Scene of North Courtyard

Figure 6. Details of some scenes

4.2. Implementation of Interactive Function

The realization of collision interaction between people and buildings in the scene depends on the collider components of Unity 3d, which can detect collision between objects in the scene, so as to simulate the real collision effect in the real world. There are many kinds of collider components. Box Collider component is used in this study, which is the most widely used. The collision detection function can be realized by adding the component directly to the objects in the scene.

In this study, the interactive displaying interface of the relic restoration is developed based on NGUI plug-in which is the powerful UI component. Firstly, the NGUI plug-in is imported into the Unity 3d project. Secondly, interactive buttons are created according to the requirements. Finally, the C# script is created and the script is bound to canvas to write code to realize the interactive function. The interface is shown in Figure 7.

Figure 7. Interaction interface of scene

5. Conclusions

In this study, the DEM data and texture image data were collected from the Qing Dynasty relics in Xinzheng Henan Province, Determine the architectural style of qing dynasty dwellings, and then the models of the relics were carried out by using three-dimensional modeling technology and virtual simulation technology. Thus the three-dimensional restoration and display of the Qing Dynasty relics were completed in Unity 3d, and the functions of roaming, flying and audio interpretation were realized. Cultural relic resources are not renewable and once destroyed, they cannot be made up. This study provides a workable idea for the realization of three-dimensional restoration of relics. The three-dimensional restoration display system was constructed by this method which can intuitively display the life scenarios of the ordinary people in Kaifeng area in the mid-Qing Dynasty. To a certain extent, it reflected the productivity level, cultural outlook, spiritual beliefs of the society at that time, and also provides precious data for the study of Kaifeng local history.

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