

# 3D Restoration and Display of Carthage

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**Abstract:** In 1979, UNESCO included the ruins of the ancient city of Carthage as a cultural heritage and was included in the World Heritage List. Carthage was the political, economic, commercial, and agricultural center of the Mediterranean region of North Africa about two thousand years ago, so it has a high cultural research value. In order to present Carthage to the world, we did the following work: Firstly, we obtain initial data through the network and consulting relevant historical data. Then we use 3ds Max, Speedtree and other modeling software to model buildings, surrounding terrain and plants in the scene. Finally, we import the produced model into Unity 3d software to complete the entire scene and implement display and interaction functions.

**Keywords:** 3D modeling; 3ds max; restoration; display; Carthage

## 1. Introduction

The cultural heritage is the important witness of the evolution of human civilization. It is of great significance to protect and study cultural heritage for any country and nation. Nowadays, the protection of cultural heritage is facing unprecedented impact. The natural decline of historical heritage and the development of modern cities have increased the difficulty of cultural heritage protection. In addition, these ruins are usually dilapidated which fail to fully display the cultural significance they contain. With the development of 3D modeling technology, 3D display has great potential in heritage conservation and restoration [1]. The technology can be used to reproduce the surrounding environment and human activities, and it can better recover and reproduce cultural heritage. In addition, it also plays a prominent role in preserving historical significance and improving positive learning experiences.

At present, the research on relic restoration has been very mature. The museum of Qin terra-cotta warriors and the Xi'an four-dimensional aerial survey and remote sensing center cooperated with each other to digitally preserve No. 2 pit of Qin terra-cotta warriors in one year, laying a foundation for the preservation of Qin terra-cotta warriors [2]. Institute of Vertebrate Paleontology and Paleoanthropology, Chinese academy of sciences cooperated with the Beijing People's Site Management Office of Zhoukoudian to carry out archeological excavations on

the first site of Beijing Zhoukoudian site. They used 3D digital modeling technology to obtain detailed high-precision 3D stereoscopic image data of the ape-man cave, which enabled the reproduction of caves that ancient humans lived hundreds of thousands of years ago [3]. The Inner Mongolia Museum used 3D scanning technology to perform mapping in site of the Yuan Dynasty Upper Capital for subsequent digital museum construction [4]. The CyArk team used radar scanning and digital simulation technology to protect cultural heritage. At present, many cultural heritages were easily eroded, such as acid rain erosion areas, volcanoes, or earthquakes, which had been mapped, including the Acropolis, the ancient Peruvian city of Machu Picchu, Guatemala's Mayan Ruins and other ruins [5].

This research was based on the 3ds Max and unity 3D platform to restore and display the ruins of Carthage. Based on the existing conditions of the ruins, we collected relevant image texture data and historical information, and we used 3D modeling and virtual simulation technology to model the buildings, surrounding terrain, and trees in the scene to achieve scene roaming, flying, animation and audio commentary.

## 2. Outline Design

Due to the baptism of fire, the existing Carthage has been dilapidated. So the construction of 3D scene has the following difficulties: (1) Layout of the overall scene. (2) Appearance of each model.

The existing Carthage ruins only retain the streets, theaters, public baths, aqueducts, broken walls and broken columns, steel and other ruins of the Roman period, reflecting the architectural style and cultural appearance of the Roman period [6]. However, it is not enough to rely on these data for restoration. Therefore, we based on some terrain pictures and related historical data collected on the Internet. Besides, we summarized the characteristics of the ancient Carthage town scenes, and we combined the historical background of the time and set a tone for the design of the scene terrain on the basis of conforming to objective facts. Observing and recording the appearance features of real terrain, surveying the size of real houses, plants, placement angles, etc., to obtain the initial data for building the terrain [7]. The collected data pictures are shown in Figure 1, Figure 2.



Figure 1. Module of scene design.



Figure 2. Ruins of seaside.

The entire scene is divided into natural scenes and artificial scenes. Among them, the natural scene includes modules such as terrain, seawater, and plants. And the artificial scene mainly includes modules such as city walls, harbors, elevated canals, temples, and dwellings. Based on the determination of the five module positions, the module of scene design is shown in Figure 3.

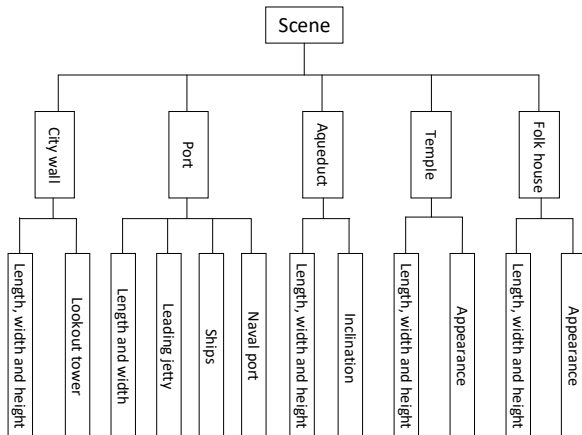


Figure 3. Module of scene design.

### 3. Restoration and Display of Ruins

#### 3.1. A Model Making

This research adopts the polygon modeling technology in single-sided modeling technology. This technology has a small amount of calculation and fast rendering speed, and it is usually suitable for large scenes. When making a model, you must first pay attention to the fact that coplanar phenomena such as superposition and crossover are not allowed between the patches of the 3D model, and

the case of missing faces or face flips in a single model is not allowed [8].

The quality of the texture map directly affects the similarity of the model made to the buildings in the real world and the roaming effect. A good texture map can not only enhance the reality of the entire scene, but also effectively reduce the burden of the roaming system and improve the operating speed of the entire roaming system [9]. Due to the texture images collected on the Internet have different resolutions. If you directly add texture mapping to the model, it will reduce the imitation of the model. Therefore, texture images need to be processed. First, the collected texture pictures are classified according to the overall vision picture and the detail picture. The detail picture includes the building label, the building's logo, and the close-up texture. This way, we can easily distinguish the texture of the corresponding orientation of the photo during post-processing. Secondly, we can use Photoshop software to process the collected photo to texture material to obtain the corresponding texture material. Finally, we should choose low resolution texture map without affecting the display of the roaming system. It not only can reduce the memory and resource consumption of the entire system, but also improving the system's fluency and user experience [10]. The texture map of processed wall is shown in Figure 4.

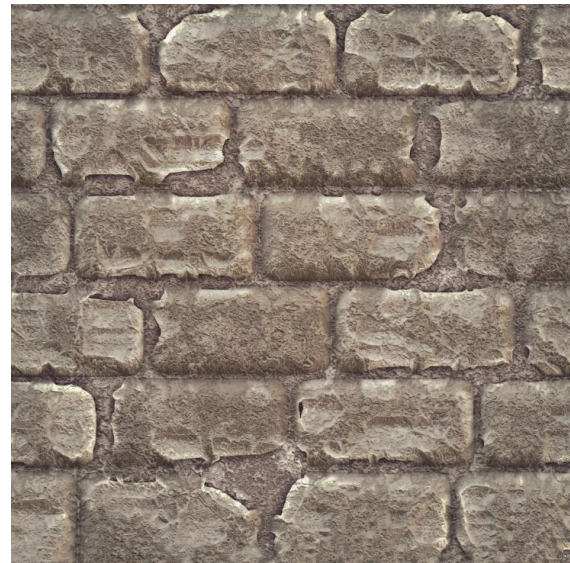
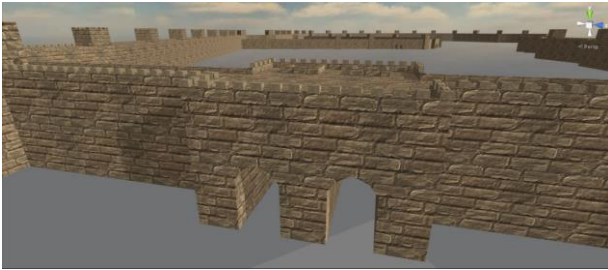


Figure 4. Texture map of processed wall.

The production methods of several main models in the scene are as follows:

The first is the city wall model. According to the collected historical data, the direction of the entire city wall and the location of the city gate are determined. The production of the city wall is divided into the inner palace wall and the outer city wall. Taking the production of the outer wall as an example, we based on the collected size information of the city wall and combined with the Roman architectural style. At the same time, we compared with the surveyed real city wall data, on the basis of conforming to objective facts to make models of city gates, walls, and observation decks. We exported the created model as an obj file and then made color maps. Accord-

ing to the color maps, we used the CrazyBump software to create the corresponding normal maps. Finally, we imported the obj file into Unity 3D and assigned these two maps to the corresponding attributes of the shader of the current model to increase the realism of the wall. The city wall model is shown in Figure 5.



**Figure 5.** City wall of scene.

The model of the port is divided into two parts: commercial port and circular military port. A small island in the middle of the military port has space for multiple ships at the same time, and it is externally connected to the commercial port. Firstly, the circular military port was produced. The outer ring of the military port was divided into three layers, which were produced layer by layer. The production of the pillars of the outer ring wall was completed by rotating the copy command. And the central part of the military port was divided into four layers. The bottom support was made first, and then the upper and lower doors and windows were made using the connect and delete commands. Secondly, the commercial port was made by combining the location of the city walls and residential houses, and then the dikes and ships were added to enrich the details of the port. The model of the port is shown in Figure 6.



**Figure 6.** Model of the port.

According to the historical data, it was known that the drinking water in the city was introduced from the mountain through the elevated canal. The entire elevated canal was made of stone, and only a few sections were remained. We designed the shape of the elevated canal by surveying its size and combining the characteristics of Roman architecture. After we adjusted the size and angle, the prepared texture maps were placed on the corresponding portion of the elevated canal. Finally, in order to make the model more natural, we added a script to create the effect of water flow in the elevated channel.

The part of the model that cannot be seen during the 3D scene roaming process is not necessary to make it. For example, the polygons that are not visible at the bottom of the 3D building can be deleted directly. This can reduce the number of faces of the model to improve the rendering speed of the scene [11]. Besides, it is necessary to consider the fineness of the production of model. For models that are far away from the field of view, such as sand dunes, you can make quick rough models. But for other models such as houses, people, and ports, you need to make more delicately. However, the number of faces of a single object should not be too much. Generally, it is suitable to control the number of faces of a single object below 7000.

### 3.2. Construction of the Scene

The entire 3D scene was constructed with reference to Figure 1 and Figure 2 as the prototype of the scene. The layout design based on the historical literature information and combined with the characteristics of houses, people, ports, etc.

The first is the terrain design of the 3D scene. For the edge of the terrain, we adjusted the angle around the terrain to make a hilly effect. As for the middle part of the terrain, different bump levels were made by the built-in tools to express the fluctuations of the ground and make the entire scene terrain more natural.

The second is the import of the scene model. After we exported the produced model from the 3D modeling software in FBX file format, we imported it into Unity 3d software, and the texture map file will automatically generate the standard of corresponding shader. But you need to select the shader corresponding to the special material to display the material effect correctly. Because the default unit of the scene in Unity 3d is meter, the model will be reduced to one percent when we import the model. So the scaling of models needs to be adjusted to one to one. In addition, the tree model created by Speedtree was imported into Unity 3D, and the terrain brush function of Unity 3D was used to design the terrain of Carthage and the placement of trees.

The lighting effect of the entire scene plays an important role in the rendering of the scene and the user experience. Unity 3d software provides three kinds of light sources (point light, directional light and area light). However, by using only these three light sources will make the surface of some building models appear to lack light. At the same time, Unity 3d software provides a natural light source. You can add ambient light components directly to the scene. To ensure brightness, you need to add a directional light source as the main light source of the scene. Finally, in order to make the seawater more delicate and realistic, we added a script to the seawater object to make the seawater slightly rippling and simulate the shape of the seawater in nature. The overall scene is shown in Figure 7.





Figure 7. Overall scene.

#### 4. Module of Roaming and Interaction

Interface design of this system used NGUI plugin of Unity 3d. After importing NGUI plugin, we created a UIbutton object and a C # script, and then we added the script to the canvas to achieve the login function of the system.

In Unity 3d, we added a first-person character controller to the scene and used iTween plugin to implement the flight function. In addition, we added function buttons to the scene and binded the corresponding c # script to let users choose functions such as flying, roaming, and animation. In order to allow users to better understand the historical and cultural background of the site, we had also added audio explanations to the system, so as to bring users the integrated experience of viewing and listening during the roaming process. The interactive interface is shown in Figure 8.



Figure 8. Interaction interface.

#### 5. Conclusions

This article first determines the architecture of the scenario construction, and it analyzes and collects the data to implement the relevant functions, besides it is based on the collected data combined with objective physical information and propose a feasible method of relic restoration. The simulation modeling based on this method can

reduce the loss of system resources, and completely display the ruins of ancient buildings, and provide physical data for the study of historical culture.

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