A Digital Reconstruction Procedure for A Disappeared City Space and Its Activities

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Computer simulation technology was used well in virtual archaeology during the past five years but will be insufficient gradually in the future, just because the simulations have extended from static issues, such as implements, architectures and a whole city, to motional issues, such as cultural activities in a city. This paper developed a digital reconstruction procedure that integrated three main technologies including 3D scanner, motion capture and virtual reality cave (VR Cave), and implemented it to virtually reconstruct Chang-an City that existed 1400 years ago but disappeared now. The results of the simulations are not only realistic enough to being inside but also highly approved by archeologists, art historian and architects.

***Keywords**: Virtual archaeology; 3D scanner, motion capture; virtual reality cave;*

Introduction

The data of historical architecture, either the east or the west, was recorded by writing, drawing, pictures and models ?Ma, 1984; Hsu, 1990; Lee, 1990; Liu, 1996?. The content of these data included structure, form, scale and material of building ?Fu, 1963; Guo, 1963; Lai, 1997?. With respects to a historical city, the media of recording data was the same as stated above; however, the content had expanded from representing a single building to the city as a whole. Not only the design principles but also the social system, the cultural activities, and the city life at that time were recorded (Tatsuhiko, 1986, 1994, 1995, 1997, 1998). By means of these recorded data, we are able to restore the architecture and the city as well as the cultural activities and the city life of that particular time.

Recently, because of the developments of computer graphic technology, many researchers attempted to use computer simulation to reconstruct ancient cities virtually, such as the Chan-An city in Tang dynasty (Heng, 1999) and the Aztec Temple Square (Serrato-Combe, 2001). Virtual Archaeology has already become a new method of archaeological reasoning solemnly. No matter if the ancient cities will be reconstructed physically or not, there is no doubt that using computer simulation will make the result more accurate (Heng, 1999; Potier, 2000; Tang and Liu, 2001; Tang 2001). Furthermore, it will even indicate problems that couldn't be found and solved by using ordinary research methods before (Tang and Liu, 2001; Tang 2001).

Problem and Objective

However, the main technologies that were applied in the virtual archaeology projects mentioned above, such as 3D modeling and high quality rendering, have gradually become insufficient. For examples, making 3D models of static implements, architectures and even a whole city manually wasted time and energy of research staffs. It was also hard to reconstruct the motions of people to simulate the activities of the city life. The

perception of high quality rendering images or animations still can't satisfy the fantasy of being in virtual space and so on. According to these limitations, the problem of this research is that how can we seek, use and integrate the newest digital technologies to make the process of virtual archaeology more and more complete?The objective of this research is to propose a digital reconstruction procedure for a disappeared city and its activities.

Methodology and Steps

The whole research project took Chang-an City of Tang dynasty that existed 1400 years ago but disappeared now as an example and was divided into two parts. The first part was the collection and reasoning of cultural and architectural data, and the second part was the integration and implement of new digital technology. Because the detail discussions of the first part have already published in relevant research papers (Tang and Liu, 2002), this paper will focus on the second part for further investigation. There are four steps in this research. First, we integrate several digital ways such as the use of 3D scanner, ordinary 3D modeling and speculative modeling to make static models. Second, we use motion capture technology to fabricate motional models that represent the activities at that time. However, how to integrate static and motional models in digital environment is still a very important issue. Finally, we use VR technology and VR Cave representation to improve the spatiality of high quality animations.

The construction of static models

The first way of making 3D models is the use of 3D scanner. Because there are many underground and well-protected relics preserved in museums, we can use 3D scanner (figure 1) to transfer the physical objects into digital data directly (figure 2). By so doing not only the time of making model will be decreased but also the complication of models will be increased. The second way is called ordinary 3D modeling. It means that according to accurate descriptions, such as measurements and textures, we can make digital models easily. Although many important relics are not available, we can still acquire accurate measurements and textures from some relevant publications of photography and research papers. The last way is speculative modeling. There are many figures of people and implements on wall paintings in the graves (figure 3), but these figures not only described objects roughly but also fade away their colors. So we try

Figure 1. The equipment of 3D scanner

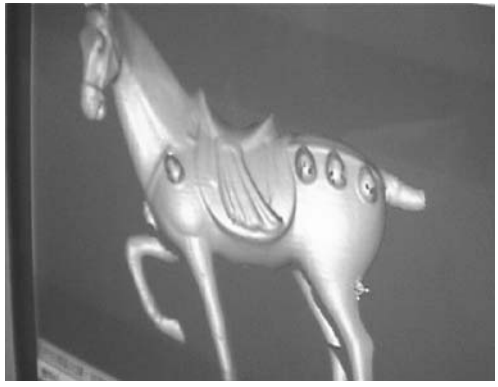
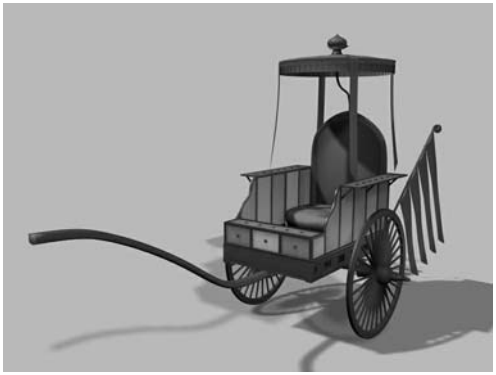


Figure 2. The result of 3D scanning



to reconstruct the scales and measurements of objects in the digital environment directly, and use image process technology to speculate the original colors of them (figure 4).

The fabrication of motional models

In order to represent the cultural activities lively, we try to transfer a freezed posture of people on a wall painting into animations of realistic motions. Let us take dancing for example, and there are three steps to do. First, we use motion capture technology to record the actions of the dancer who is familiar with the dance of Tang dynasty (figure 5). The theorem of motion capture is that eight infrared cameras can sense the locations of 32 reflex balls that are pasted on important joints of human body, and the computer can acquire the motions of people after calculate the digital data of 32 reflex balls. Second, we bind the data to a model of human body that was made by mimicking the figure of wall painting (figure 6). Finally, the software calculates the interactions between the body and the cloth on it, and the live actions of a female dancer with beautiful cloth are conducted (figure 7).

Figure 3. The figure of car on the wall painting in the grave

Figure 5. The processes of motion capture

Figure 4. The result of speculative modeling

The integration of static and motional models

After having the static models of architecture, models of implements, and models of actions, we start to integrate them together digitally and specifically. Let's take playing chess for example. In the beginning, we based on a painting that

Figure 6. The human figure on the wall painting

Figure 8. A painting that recorded the arrangement of interior furniture

Figure 7. The final result of making motional model

Figure 9. The arranged interior models in an architectural model

recorded the arrangement of interior furniture (figure 8), and try to put the models of implements together in 3D virtual environment where we can move objects and viewpoints freely. By so doing we can realize the actual location and relationship of every objects. Second, we put the arranged interior models into an architectural model (figure 9). We can't sure where is the accurate place, and

Figure 10. The result of playing-chess simulation

Figure11. The theorem of polarizations

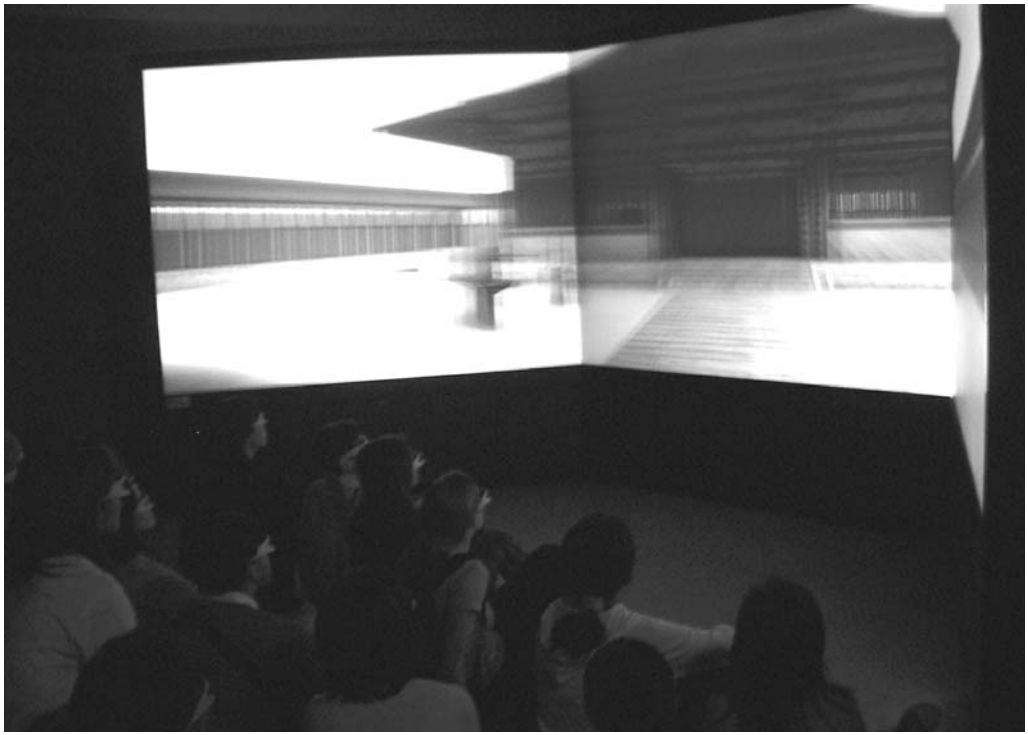
Figure 12. The design of the VR Cave

just put them at a pavilion which size is suitable for the interior arrangement to speculate. Finally, according to stories of playing chess recorded in some literatures, we combine the human model that can act the motion of playing chess with the whole architectural models (figure 10).

Immressive and stereo representation

After conducting the high-quality models and high-resolution animations, we try to imply the VR technology to convert the flat animations into stereo and immersive representation. Making two-eyes animations that have 5 degrees different of viewpoints is the first step to do. By means of the polarizing filters, we can control that each eye only can perceive each particular animation, and the sense of stereo is conducted (figure 11). In order to create the sense of immerse, the Opto-Electrics & Systems laboratories (OES) of Industrial Technology Research Institute (ITRI) in Taiwan design the VR Cave system (figure12). This equipment is composed by three projection screens, each of which have 120 degrees included angles, and six projectors. After projecting six animations on three screens, the watcher wearing polarizing glasses can have the sense of being inside (figure 13).

Figure 13. The result of VR Cave simulation



Results

In conclusion, because of the digital reconstruction procedure that contains 12 steps in 4 main parts, we successfully reconstruct the Chang-An city of Tang dynasty and activities happened in it including foreign diplomats entering Chang-An city, drinking in Li-fun, foreign diplomats entering Lin-Da Palace, playing polo game, ladies playing chess, and Banquets in the Palace (Tang and Liu, 2002). These simulations are highly approved by archeologists, art historian and architects.

Table 1. The content of Virtual Chang-An City

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