

3D Digital Archive Experience for Historical Architectures

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Abstract. *Digital archives that use 3D CG models, for example, relating to historical architecture and archaeological sites, are now commonly created for a wide range of purposes. Unlike actually visiting historical architecture, access to digital archives and browsing of their content are computer-related. Thus, users cannot easily gain a deep understanding of the content and are less likely to truly enjoy it. Therefore, in this paper, we propose a method to support collaborative experiencing of 3D digital archives related to historical architecture. To achieve this goal, we developed a prototype system for a 3D digital archive of historical architecture using VR technology. The system offers an interactive interface.*

Keywords. *3D digital archive; experience; comparison; VR*

Introduction

Since digital archives can be accessed quickly and conveniently, these are now commonly created for a wide range of purposes. These archives are widely used for study, school, social education and regional development as well as for recording, preserving and restoring items of cultural heritage such as historical buildings, art works and archaeological sites.

Early digital archives only digitized and kept text and photographs but modern digital archives now include photographs, videos with text explanations and 3D CG models. In the past, 3D digital archives had to be created from photographs, which were scanned and then converted into digital data. This was expensive and inconvenient. Advances in the performance and reductions in the cost of 3D scanners, along with improvements in

digital photogrammetry have made it practical to measure and record the shape of target objects directly in digital form. In addition, 3D scanners can automatically calculate the form of an object and the size of the image required, and can directly record the information onto digital media. My research group has conducted several 3D measurements of archaeological sites in Japan and abroad and has created various 3D models and digital archives. The 3D model can be of huge objects which one can walk around, such as places with historical architecture or archaeological sites. The digital archives described in this paper assume a 3D model, hence the term 3D digital archives.

Many case studies reflecting the expansion of 3D digital archives have been presented at the international conferences (Beraldin et al., 2002; Kalnins et al., 2002; Pollefeys et al., 2003; Schnabel et al., 2004). The main focus of these studies has

been on ways to create 3D models and digital archives. However, there have been no detailed studies into how these can be used or how they can be experienced.

The main feature of 3D digital archives is that users do not see just a flat 2D image of the content out of context, but can see the content from all angles in its natural setting by original condition reproduced in virtual space. In addition, users can experience the subject as if they were in the real world. Furthermore, in the real world, simulation that cannot be observed can be carried out and scientific investigation can also be conducted.

Based on such a concept, we propose a system whereby the user can observe large-scale 3D digital archives conveniently and efficiently. In this paper, we explain how our method enables users to view 3D models of historical architecture and then explain how the user experiences the 3D content of an archive while 'walking' in virtual space through them. Moreover, we discuss our prototype system. As users become more familiar with how to use this system, it should stimulate interest in 3D digital archives of historical architecture. Moreover, as more people understand how to use the content we believe that such archives will become more popular.

3D digital archive experience by comparison

Digital archives basically take various types of information (e.g., 2D images, 3D models, texts, and drawings) then digitize and organize them by content. We define the user's acquisition of information about these digital archives as the 'digital archive experience'.

The conventional digital-archive experience was a visit to a museum, and only the content and the information which were exhibited were seen. The digital archives currently offered on websites allow only browsing. These cannot allow users to experience the exact information they want and the

content they want to see. The user only acquires information that is offered. These systems are like an encyclopedia in that they only give information about a subject rather than discuss it as in an educational program. This means that users without specialized knowledge might find it difficult to grasp the relationships between content elements while obtaining information about each digital archive. Some users might not clearly understand an explanation or might not be interested in particular content because the explanation or level of detail is targeted at users of a difficult level. Users will want to confirm archive with their own eyes through indirect experience. In addition, users want to experience detailed material.

Therefore, we propose a system in which even through users does not actually go to a historical site, they can have the experience of looking at its architecture. Also, even if users cannot actually touch the ruins, they can experience detailed color and textures. In order to realize these objectives, we developed a 3D digital archive experience system that uses VR technology. In this system, users can have the same experience as if they were actually at the site by arranging 3D digital archives in virtual space.

There are currently many digital archives of historical architecture and cultural heritage created using 3D CG. However, simply looking at a 3D digital archive in virtual space is not enough. The user also needs to understand it. In the case of a historical building, there are in particular many portions of the building that a user needs to learn about through experience. For example, an understanding of the structure of an original building can be gained by looking at the present building. Digital archive experience systems that help users to understand content are therefore required.

We propose comparison as an effective method of helping understanding. People may be compared with other objects in order to understand a certain object. By considering the difference, a person can recognize and understand an ob-

Prototype System

This system was designed for experiencing the 3D digital archive that we made. It included the features of a traditional walk-through simulation and specially aimed at allowing users to experience the system through browsing, in the following ways.

- Users can walk through the 3D digital archives freely, and the system provides comparative views of other related content.
- Collision detection is set up so that when a user collides with the wall of a model, rebounding will occur. This gives a similar impression to colliding with the wall of a building while walking in the real world.
- Gravity fixes users at the same eye level from the floor. We control the user's view by carrying out gravity setup, being careful not to dive into the bottom of the floor, in the same way as that of walking in the real world.
- Users can compare the many contents interactively in the system. Users only select the compared contents and the system displays them immediately.
- Users can choose the system interface they prefer to use. The system interfaces a user can choose include a mouse, a keyboard, a game controller, and a space/mouse traveler.

The process of making a 3D digital archive

experience system can be divided into six steps (figure 2).

Step1: Data is created to 3D models and geographic information system (GIS) models by modeling software or a 3D scanner, or created to 2D images by digital camera.

Step2: We gather all data from modeling work such as 3D models, GIS models, photos, textures, etc.

Step3: A renderer groups all models together to form a scene within circumference environment setting, material setting and alterable models. All data is converted for Virtools.

Step4: A developer assigns attributes and behaviors to the objects, such as camera settings, light settings, collision detection, level of detail (LOD), gravity, etc. The developer produces an interface for users' requests.

Step5: A developer exports the 3D digital archive experience system for testing and debugging.

Step6: A developer saves behavior block, scene, etc. made while testing the system in the data base.

Next, we designed the GUI including a fundamental operation function as shown in figure 3. Especially, we distributed mind so that the comparison navigation function which is the most important concept of this system could be fully utilized. For example, to enable the comparison of many

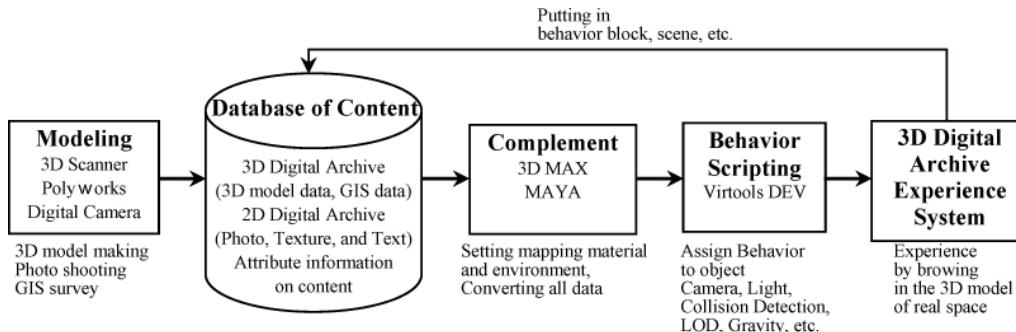


Figure 2. Process flow of making a 3D digital archive experience system

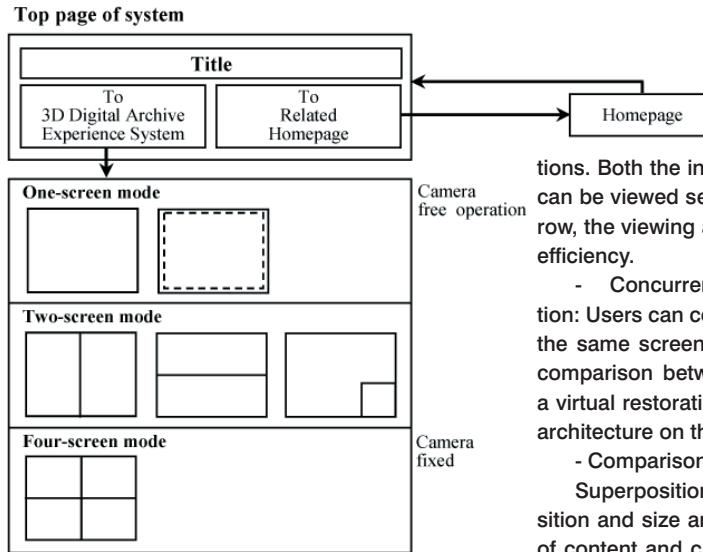


Figure 3. Graphical User Interface (GUI) flow System Functions

types of content, it designed the screen switch of a one-screen comparison, two-screen comparison, and four-screen comparison.

The following items show the main system functions of the scene.

- Walkthrough function: Users can capture an image while moving about freely in the 3D digital archives of historical architecture. This function supports the ability to view objects in many direc-

tions. Both the interior and exterior of the building can be viewed separately. If the interior is too narrow, the viewing angle can be adjusted for greater efficiency.

- Concurrent comparison navigation function: Users can compare many types of content on the same screen. For example, they can make a comparison between the present conditions and a virtual restoration of the ruins or other historical architecture on the same screen.

- Comparison navigation in one-screen

Superposition comparison: Comparison of position and size are possible by layering two types of content and changing the transparency of one or the other.

Putting in a comparison object: The size and scale of content can be easily grasped because anyone can insert and display a 3D model of known size.

- Comparison navigation in two-screens

Vertical/Horizontal screen division mode: It is possible to compare contents while walking in a virtual space by displaying two types of content on the same screen simultaneously. This function en-



Figure 4. Walkthrough function



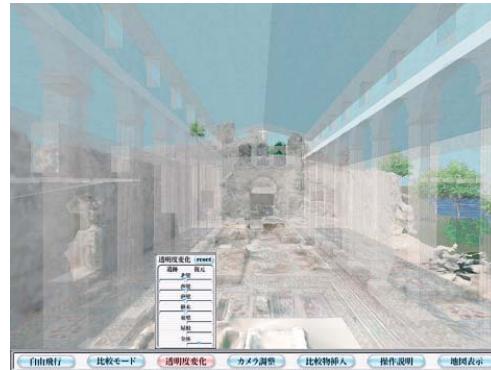


Figure 5. Superposition comparison function

ables the understanding of the space composition by defining two cameras and installing two aspects in content while using each function. The controller that operates the camera is shown in both screens. It is also possible to have a controller that operates the camera of both screens simultaneously in the center of a screen, and always to walk along the same route in both contents.

Guide screen mode: The comparative screen is divided into two identically sized sections that can be compared. Moreover, another proposal can also be displayed on a small guide screen, concentrating on one proposal greatly and looking at it in depth. In this case, it is also possible to change the screen.

- Content position grasp function by photograph viewpoint selection: A photograph

viewpoint function preselection capability chooses one photograph from the prepared photograph database. Then, the photograph selected at the lower left is displayed prominently. At the same time, a model is displayed on two upper screens with the same viewpoint as the photograph. It is possible to arrange a camera at the decided viewpoint location by using this function.

- Cross-section function: This can display a cross-sectional view of the historical architecture. The user can control the cutting plane. This is useful for understanding the inner structure in detail.

Conclusion

We proposed a system that promotes the use of digital archives and content using a software



Figure 6. Comparison function by a comparison object

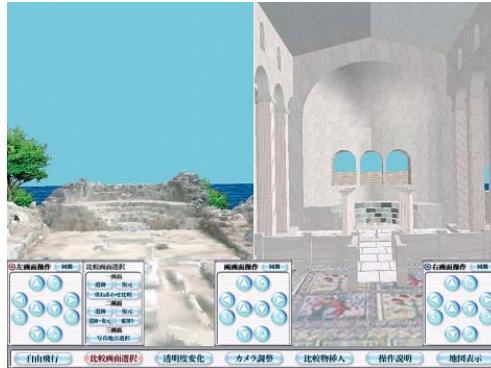


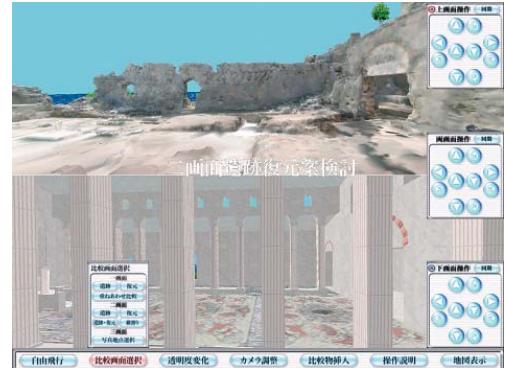
Figure 7. Comparison function by two-screen division mode

program that allows users to interact with the archives, thus raising the users' level of satisfaction. Thanks to the precision of this digital archive, it is now possible to reuse such an archive for varied purposes. Furthermore, the interactive interface built on the real-time rendering system enabled the development of a knowledge-exchange digital archive, thus providing alternatives to traditional archives. Previously, people were not able to access the techniques used in constructing historical architecture.

Now, people interested in this subject may find this material more useful than any other available resource or investigation into historical architecture construction and cultural background. People interested in structures of historical architecture and cultural assets can now understand and view



Figure 8. Comparison function by a guide screen mode



these easily using the 3D digital archive experience system, which contains analytical data from the created model. Therefore, the 3D digital archive experience system, the object of this study, is now considered as a crucial academic compilation that contains architectural technologies and cultural aspects of historical architecture that have previously lacked clear academic definition.

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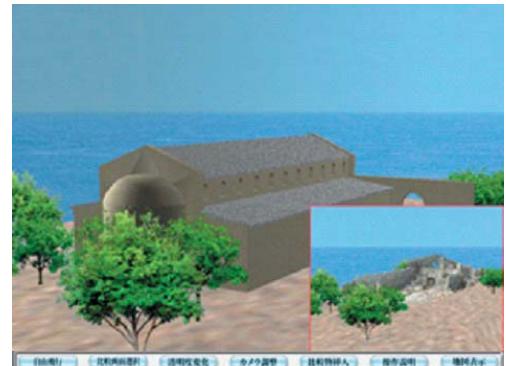




Figure 9. Content position grasp function by photograph viewpoint selection function

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Figure 10. Cross-section function