Digital Display Case: A Study on the Realization of a Virtual Transportation System for a Museum Collection

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Abstract. This paper describes our proposed virtual transportation system. Our proposed system is a display case for use at art museums, which is based on computer graphics and image-based rendering (IBR) techniques. Using this system, anyone can simply create and realistically represent virtual cultural assets. This system consists of two main components: a display unit and a capture unit. The display unit is in the shape of a conventional display case in order to represent virtual cultural assets. The capture unit, which is created by attaching cameras to a conventional display case, reconstructs cultural assets using IBR techniques. In our experiment, we implemented a basic system using View Morphing as the IBR technique. The results show that this system can represent virtual cultural assets as 3D objects on the display unit by using arbitrary view images that are interpolated by View Morphing.

Keywords: digital display case, digital museum, image based rendering, virtual reality.

1 Introduction

In conventional art museums, visitors are not supplied with sufficient information to understand the background of heritage and cultural assets without learning about them in advance. For example, it is difficult for visitors to understand the background of cultural assets, such as the purpose of use, the excavation site, and historical events that took place at the same time. Therefore, new techniques for teaching background information have been researched in recent years. A “digital museum” is a new concept for teaching the background information of heritage and cultural assets.

As an example of a digital museum, the Tokyo National Museum in Japan and the Palace Museum in China have installed a Virtual Reality Theater to present virtual heritage and cultural assets reconstructed by digital archive technologies [1] [2].

We have been researching on a digital museum project based on augmented reality techniques. Our project investigates effective techniques for use in exhibitions of digital museums. These techniques will give more background information to visitors by overlapping the information with real heritage and cultural assets with the use of

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augmented reality techniques. In this paper, as one of our projects, we propose a new exhibition system for a display case.

2 Outline of the Digital Display Case

We previously proposed a digital display case [3] in response to the following requirements of an art museum:

1. The external appearance should resemble a display case in order to create a seamless arrangement with the conventional display cases in the gallery, and also to easily engage the visitors with the system.
2. The images displayed on the digital display case must be accurately correlated with the viewer's eye gaze in real time, in order for the viewer to perceive the complete illusion as real, that is, as if there are real objects in the case.
3. To enable the presentation of the internal structure or long-term changes in the cultural assets, rich digital content must be produced.
4. Visitors should manipulate the virtual cultural assets with a force feedback mechanism.

Figure 1 shows the design of the digital display case. It consists of four 3D displays on each side, a manipulating device to manipulate the position of a virtual cultural asset, and 3D glasses with a motion tracking device. The virtual cultural assets in the digital display case are represented as a 3D model that is produced by measuring the shape using a 3D scanner. The motion tracking device measures the position of the viewer's eyes, and the view on the digital display case is changed in accordance with the viewer's position. Using the digital display case, the visitors can experience the same views as with cultural assets in conventional display cases, because it appears that the virtual cultural assets have been placed in the display case. Furthermore, visitors can move and rotate objects by using the manipulating device. The digital display case can easily display various cultural assets by switching the 3D objects at the user's discretion.

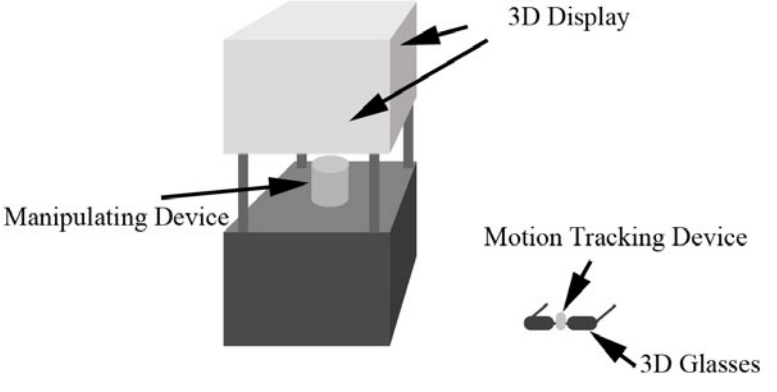

Fig. 1. The design of the digital display case

The digital display case is an important advance compared to conventional display cases from the viewpoint of simply displaying and manipulating various cultural assets. However, we need to prepare a 3D model to create the digital display, which is generally very time consuming even with the use of a 3D scanner, and we also need special techniques and tools to create high-quality content. This makes it difficult to place new objects in the digital display case at the museum, when there is no special operator to produce digital content. The curators of the art museum have high expectations for the digital display case, because they want to display a large number of cultural assets. This is possible with a digital display case; however, each art museum owns tens of thousands of cultural assets, and it is very difficult to prepare 3D models of all of them.

3 Virtual Transportation System

To solve the problem described in Section 2, we propose our virtual transportation system. Figure 2 shows the design of this system. This system consists of a display unit and a capture unit.

The display unit is used to exhibit virtual cultural assets. The basic functions and shapes of the display unit are identical to the previous digital display case.

The capture unit views real cultural assets and captures images of them. The shape of the capture unit resembles a conventional display case and can exhibit real cultural assets in a manner similar to conventional display cases. The capture unit has a function that can automatically generate images of arbitrary views by using image-based rendering (IBR) techniques. IBR techniques are image processing techniques

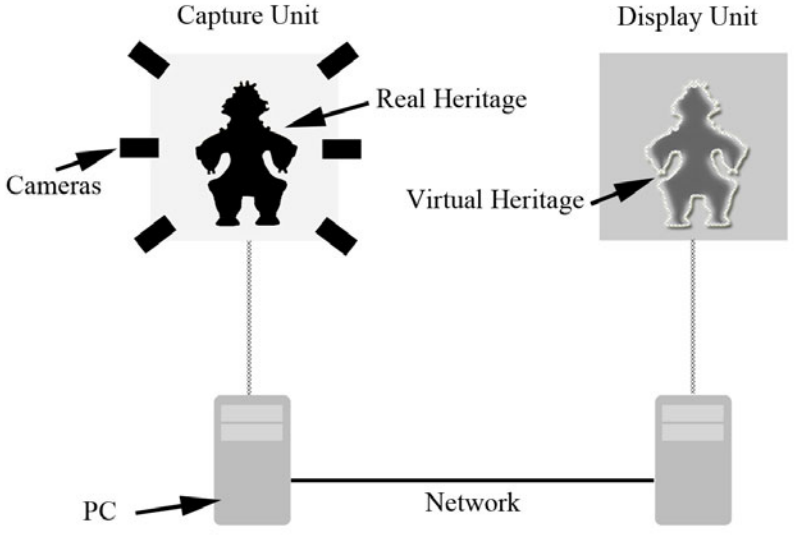

Fig. 2. The design of our virtual transportation system

that can generate the viewpoints of virtual cameras from the pictures of one or more real cameras. To capture input images for use of IBR techniques, multiple cameras surrounding the cultural assets are attached to the inside of the capture unit. Each unit is connected to a PC, and the two PCs are connected via network.

Following are the processes required to run this system:

1. The cultural assets are placed in the capture unit.
2. The capture unit captures multiple input images of the cultural assets.
3. The capture unit's PC sends the input images to the display unit's PC via network.
4. The display unit's PC computes the arbitrary view images from the received original images by using IBR techniques.
5. The images are displayed on the display unit.

The advantages of our system are it takes only a short time to reconstruct images of the assets, the processes are simple, and the output images are highly realistic. In terms of the reconstruction of the cultural assets, it takes only a few minutes to compute the arbitrary view images from the multiple input images taken by the cameras. Because process 1 entails only placing the cultural assets in the capture unit and processes 2–5 are computed automatically, the steps are simple to perform. The images of the virtual cultural assets in this system approximate the state of a real view better than that obtained by using a 3D scanner, because this system directly generates the images from the pictures of real cultural assets, in contrast with the view created by 3D scanners, which only approximately simulates the shape and lighting.

4 Experimental Result of the Prototype System

To indicate that the concept of our virtual transportation system is effective, we constructed a prototype system. By evaluating the prototype system, we verify that the capture unit can generate arbitrary view images in the same way as if 3D cultural assets were placed in the display unit.

In the prototype system, we selected View Morphing as the IBR technique [4]. View Morphing is an image morphing technique that can generate interpolated images of virtual cameras arranged on a line segment between the two cameras. One advantage of View Morphing is that it requires the use of fewer cameras than that required by other IBR techniques. Therefore, the number of cameras in the capture unit can be decreased, and the cameras can be arranged inconspicuously. However, because View Morphing can only generate the images of virtual cameras on the line segment, our experiment limits the transformation areas of the view on the display unit to horizontal directions. If we need to generate arbitrary viewpoints that include both horizontal and vertical directions, tri-view morphing [5] or trifocal transfer [6] may be required.

Figure 3 shows a replica of the cultural asset utilized in our experiment. The cultural asset, which is called DOGU, is a traditional ceramic figure in Japan. Figure 4 shows the setup for photographs of the DOGU. In these photographs, the DOGU was put on a turntable, and light was placed over the DOGU. The camera was set in a horizontal direction and aimed at the center of the DOGU. We captured the DOGU while the turntable was rotated by 30 degrees. View Morphing generated interpolation images that were each rotated by 3 degrees for the input images that were each rotated by 30 degrees. Figure 5 shows the pictures and the interpolation images.

Fig. 3. A replica of the cultural asset (DOGU)

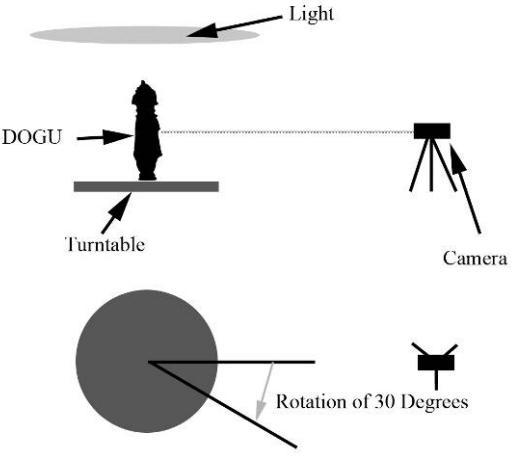

Fig. 4. The setup for photographs of the DOGU

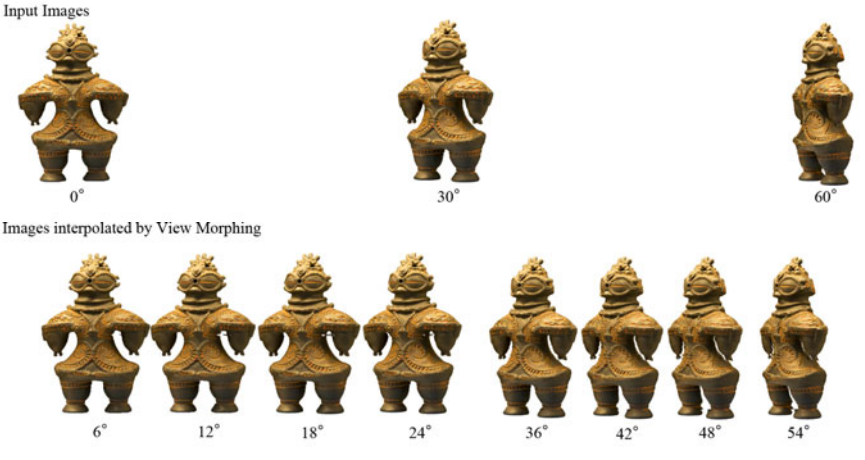

Fig. 5. Pictures of the DOGU and the images interpolated by View Morphing

In our experiment, the pictures of the DOGU were prepared as input images beforehand, and the interpolation images were pre-computed by View Morphing. The computation time was approximately 2 min to interpolate nine images from two input images at a resolution of 10 megapixels.

Figure 6 shows a demonstration of the prototype system. Figure 7 shows a mock-up of the capture unit, and Figure 8 shows the display unit. As a result of the demonstration, we obtained opinions that the virtual cultural asset was viewed similar to a 3D object, even though these images were interpolated by View Morphing by a two dimensional image processing technique. Therefore, we conclude that our proposed system can obtain views that are the same as those obtained using the previous digital display case, and that we can simply reconstruct virtual cultural assets by using IBR techniques.

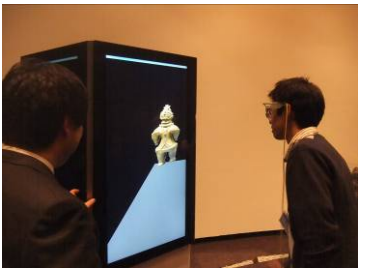

Fig. 6. The demonstration of our prototype system

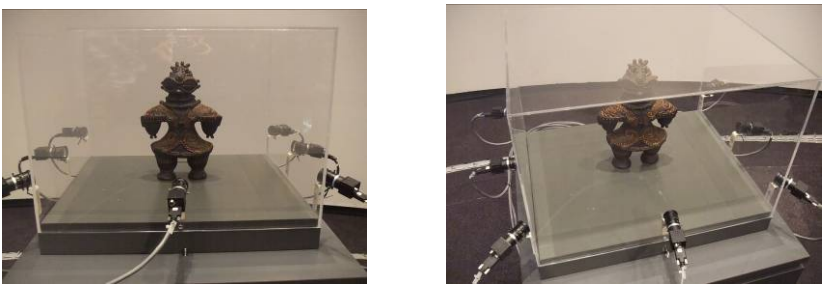

Fig. 7. A mock-up of the capture unit

Fig. 8. The virtual DOGU in the display unit

On the other hand, we encountered the following problem. The images interpolated by View Morphing included outlier which has a negative impact on the perceptual quality as shown in Figure 9. This is derived from the failure of scanline matching. Because visitors at art museums will pay close attention to the details of cultural assets, these outliers can be a serious problem. When we adopted IBR techniques other than View Morphing, broken points were also observed that were derived from the failure of scanline matching.

Fig. 9. An enlarged view of an interpolation image of the DOGU

5 Future Applications

This section introduces two future applications that our proposed system will achieve.

The first application is a remote exhibition system (Figure 10). This system aims to create an experience that reproduces the effect as if the visitors of an art museum were viewing the actual cultural assets in real time. This system can be achieved by displaying the cultural assets along with views of the actual surroundings in the display unit.

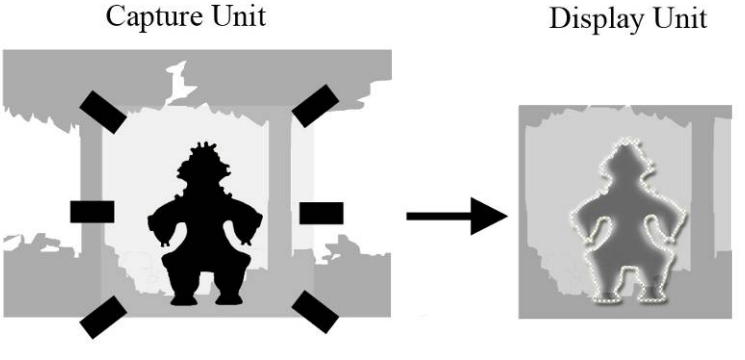

Fig. 10. A remote sightseeing system

The second application is a remote education system (Figure 11). This system predicates that anyone in the world can be educated by specialists without the physical transportation of cultural assets and specialists. This system can be achieved by techniques in which the specialists explain by manipulating real cultural assets in the capture unit, and where the display unit reconstructs the virtual cultural assets being manipulated.

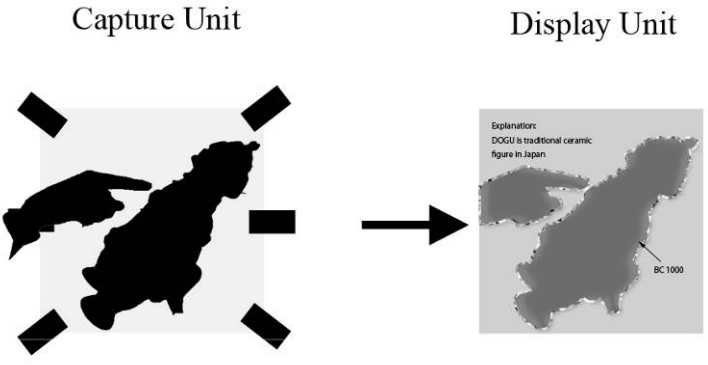

Fig. 11. A remote education system

6 Conclusion

This paper proposed a display case for art museums that utilizes computer graphics and IBR techniques. Our virtual transportation system consists of a display unit and a capture unit. The display unit can exhibit the virtual cultural assets as real, as if there are real cultural assets in the display case. The capture unit can automatically reconstruct the cultural assets in a short time by using IBR techniques. This system requires only the placement of the cultural assets into the capture unit. The experimental result of the prototype system shows that the images of the cultural asset interpolated by View Morphing were viewed as 3D objects.

As a future work, to solve the problem that the interpolation images created by IBR techniques cause outliers derived from the failure of scanline matching, we will further investigate the IBR technique used in this system. In addition, in order to achieve the remote sightseeing system and the remote education system, we will investigate techniques for acquiring surroundings and lighting and for performing real-time computations.

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