Stereoscopic Kiosk for Virtual Museum

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Abstract- *In this paper, we present a stereoscopic kiosk for virtual museum, which combines techniques of stereoscopic displays, image-based rendering, virtual reality, and augmented reality. In our kiosk system, artifacts are presented as object movies, and can be integrated with both image-based panoramas and geometry-based scenes for constructing virtual museum. Two display devices are used in the kiosk: one is a touch screen, and the other is a stereoscopic display. Through the touch screen, the users can arbitrarily navigate in the virtual museum, select artifacts, and interactively view the detail information of the selected artifact. Once an artifact on the touch screen is selected, the stereoscopic object movie of the selected artifact will be synchronously shown in the stereoscopic display, which can provide the user a better experience in browsing 3D artifact.*

Keywords: Kiosk, Stereoscopic Display, Object Movies, Virtual Museum.

1. Introduction

In recent years, a large number of kiosks have been manufactured and utilized around the world, functioning as public internet stations, electronic self-service, informational terminals, and so on. Existing kiosks are quite convenient to use by the public, but have the drawback that objects are all presented in 2D form, for example, in the form of text, images, and video. Our idea is to develop a stereoscopic kiosk for the virtual museum, which can provide viewers an interactive 3D virtual museum, where they can stroll around and enjoy the delicacy of the artifacts.

Our goal is to construct a stereoscopic kiosk by combining the techniques of stereoscopic displays, image-based rendering, virtual reality, and augmented reality. Both image-based and model-based techniques can be used to build the virtual exhibition environment, and can provide viewers a realistic and interactive tour. The artifacts used for the virtual museum are carefully chosen from the *National Museum of History* and from the *Institute of History and Philology, Academia Sinica*.

The artifacts are presented as object movies in the virtual exhibition — the image of the artifact shown on screen is selected according to the viewing direction of the user. In this way, artifacts can be rotated and moved in 3D. Each artifact is captured as a stereoscopic object movie, and in our kiosk users can enjoy interactive stereoscopic experience of the artifacts without wearing the glasses. A review of the stereoscopic display will be introduced in the next section.

The system overview is depicted in Figure 1: The upper monitor is used for virtual exhibition, while the lower one is for stereoscopic display. Users visiting the virtual exhibition can bring out the artifacts by touching the screen. When users have selected some artifact in the upper monitor, the corresponding stereoscopic object movie will be shown in the lower display, and users can watch it through the glasses embedded in the control panel. The appearance of the kiosk is shown in Figure 2.

The remainder of this paper is organized as follows. Section 2 gives a review of techniques for stereoscopic display. Section 3 explains how the contents of our virtual museum are produced. Section 4 describes the system implementations and the results. Section 5 gives a conclusion.

2. Review of Stereoscopic Display

Stereoscopic displays have already been developed for a long while. The simplest way to provide stereo perception is probably the anaglyph method, which uses the colored filters, red/green or red/blue. Its drawback is that only grayscale, pseudo color or poly-chromatic images can be perceived.

Another technique is to use the liquid crystal shutter glasses. With this technique, the left and right images are alternated rapidly on monitor. The shutters are synchronized to occlude the right eye when the left-eye image is displayed on the monitor, and vice versa. Thus, each eye sees its appropriate image and the observer can have the stereo perception.

The third technique uses polarization glasses, which are special glasses that have polarized lenses. The polarization directions of the two lenses are

perpendicular to each other. This property makes it possible that the left eye sees only the left image. With this method, the two polarized images can be produced by two polarized projectors or by some specialized LCD monitor.

The fourth method for presenting stereoscopic imaging is to provide images for different eyes by using different monitors. A well-known example is the head-mounted display. With this method, the resolution, weight, comfort and cost are some critical issues.

The fifth kind is to use the auto-stereoscopic displays, which does not require the observers to wear any devices to see stereo. Some of these techniques need to track the observer [12][1], and some require multiple views [9] to obtain better stereo viewing. More details about auto-stereoscopic displays may be found in [4].

After comparing the above five kinds of stereoscopic techniques, we choose the polarization method for its relatively good viewing performance. A special feature of our stereoscopic kiosk is that the observers need not to wear the polarized glasses. In stead, the polarized glasses are fixed at a specific position, and the observers can bring their eyes to the fixed polarized glasses for viewing stereo.

3. Content Production

There are two common approaches to build a VR world: the image-based approach and the model-based approach. In the image-based approach, photo-realistic scenes can be generated, but it is hard for the user to view the scene from arbitrary viewing directions. In model-based approach, 3D models are constructed, and by rendering the 3D models, this approach can allow users to interactively view the virtual world from arbitrary viewing directions. 3D models used in this approach usually have to be created manually, and the generated virtual world is usually not very realistic. In our work, the artifacts are digitized with the image-based approach (or more precisely, the object movies approach) so that its digital presentation is photo-realistic. However, the 3D space for virtual exhibition can be either implemented with the image-based approach or the geometry-based approach. Sections 3.1 and 3.2 will explain how stereoscopic object movies are obtained and how to remove the background. Sections 3.3 and 3.4 introduce the methods used to combine object movies and virtual environment.

3.1. Acquisition of Stereoscopic Object Movies

In this work, we choose artifacts of the Tang Dynasty in *the National History Museum* and bronze ware of the Shang Dynasty in *Institute of History and Philology, Academia Sinica* to be displayed in our virtual museums. The artifacts chosen are the representatives with complete and correct records of excavation, and are valuable for academic research. Some of the artifacts are shown in Figure 3.

In order to render high quality and photo-realistic 3D artifacts in the virtual exhibition, we use image-based technique (Object Movie). An object movie is a set of images taken from different perspectives around a 3D object; when the images are played sequentially, the object seems to be rotated around itself. This technique was first proposed in Apple QuickTime VR [2] and its advantage of being photo-realistic is suitable for delicate artifacts. Furthermore, when captured, each image is associated with distinctive pan and tilt angles of the viewing direction, and thus some particular image can be chosen and shown on screen according to mouse motion of the user. In this way, the user can interactively rotate the virtual artifacts at will and enjoy what he/she cannot see or feel in general static exhibitions.

For capturing stereoscopic object movies, we use Texnai's autoQTVR standard edition, which provides accurate angular control and automatic camera control. As Figure 4 shows, the entire system is controllable with traditional PC, and after setup process, pictures will be automatically taken under some commands. Two sets of images are needed for the left and right eyes respectively to simulate human eyes' perception. Further detail of acquiring and displaying stereoscopic images may be found in [8]. A simple way to produce the two sets of images is to take one set of images first and then shift camera to the right to take the other one. The methods we used to generate stereoscopic object movies are shown in Figure 13 and Figure 14.

3.2. Background Removal

In order to improve the display quality of the object movie, or even to integrate the object into a new background [5], the original background of the object movie should be removed. Although many techniques of video object segmentation have been proposed [7][11], no automatic method is efficient enough for removing the background of object movies. To obtain a better segmentation result, the user intervention is necessary.

In this work, we develop an interactive software tool for removing the background of object movies, which lets the users perform the work of background removal in less time with least intervention. As the first step, our software tool automatically extracts an initial contour of each image in object movies based on the characteristics of the acquired images of object movies. These characteristics are (1) the distribution of background color is Gaussian, and (2) the color difference between foreground and background is distinct. If the initial contours of some frames are not good enough, the users can manually

correct some of those frames with some easy-to-use modification tools provided by our system. After user intervention, the verified segmentation results are used to refine other unverified frames with an automatic propagation process.

Figure 5 shows the initial segmentation result of the white vase sequence (collected in the *Institute of History and Philology, Academia Sinica*). Figure 5(a) shows the original sequence, and 5(b) shows the binary map of the segmented result (Red part is foreground and white part is background). In this case, the initial segmentation result seems good, and no user intervention is required.

After all frames of the object movie are verified by the user, we perform the alpha estimation process on boundary pixels of the extracted foreground to obtain the alpha values, because these pixels may be composed of both background and foreground. Here, we adopt the method proposed by Hillman et al. [3] to estimate the alpha values of the boundary pixels. Figure 6 shows comparison of the segmentation result before alpha estimation, 6(b), and after alpha estimation, 6(d). Using the alpha value, we can produce a smooth contour blending when we integrate OM into a new background, as shown in Figure 6(e).

3.3. Augmentation of Panoramas with Object Movies

The panorama is the most popular image-based approach, which could provide an omni-directional view. In this system, the panorama is a cylinder view stitched with images acquired by rotating a camera at a fixed point. In this approach, users are only allowed to see the contents of the panorama from specific viewing directions. The panorama recorded in a cylinder would be de-warped to an image plane when being watched from some direction, as shown in Figure 7.

A panorama is recorded as one single 2D image and an object movie is composed of a set of 2D images taken from different perspectives around a 3D object. The goal here is to augment a panorama with object movies in a visually 3D-consistent way. Based on the method proposed by Hung et al [5], a system for authoring and for browsing augmented panorama is implemented in this work. This approach requires the user to first select a 3D shadow reference frame and an object reference frame in the authoring system, as shown in Figure 8. In run time, the background, the shadow, and the object would be rendered in order. A result is given in Figure 9.

3.4. Augmentation of 3D Geometric Scenes with Object Movies

Several software suites are available for 3D model rendering and animation control these days. Here we adopt Virtools [13] to be our developing platform to create highly interactive 3D virtual environment.

3.4.1. Design and construction of 3D geometric models

Two 3D geometric models were constructed in this work for the virtual exhibition: one for the exhibition of Shang Dynasty, while the other for the exhibition of Tang Dynasty. The advantage of using 3D geometric models is that splendid and realistic scenes can be reconstructed though the scenes are not available in reality. According to some archaeological research, cave dwelling prevailed in Shang Dynasty, while palaces had been constructed in Tang Dynasty; thus, 3D scenes of caves and palace were designed respectively for the artifacts as showrooms. The 3D models were first constructed in 3ds max [14], and then exported to Virtools [13] for advance integration. Figure 10 shows some of the results.

3.4.2. Inserting object movies into Virtools

Virtools provides programmable software tools useful for developing interactive virtual reality. In this work, the scenes were first created in 3ds max as 3D models and then exported into Virtools for the purpose of the high interactive effects in virtual museum. Because in general, software suites provide only billboard in 3D space but cannot change the image shown on it according to the perspectives of the users, the task here is to build a module of object movie, a plug-in for Virtools, so that the object movies will be played in the 3D scenes when the module is executed in the run time. The programming procedure of the module to display object movies is approximately the same as what was illustrated about object movies in section 3.2. The production of shadows, however, differs. To create the relative shadows of an object movie, a rough 3D model was first created by using space carving technique [6]: given a set of images, a 3D cube was carved according to them, like carving in reality, and then a rough 3D model of the object could be attained. Since the model was only used for producing the shadows and was transparent in the run time, the one attained by space carving, though not sophisticated, was sufficient for the needs. The model was then exported into Virtools, placed to the exact position of the object, and set to be transparent. After lights were all set up, the model should be set to move and rotate synchronously with the object movie. In this way, since the shadows were rendered in real time with information of lights and geometric model in the 3D space, the shadows would be cast smoothly and naturally on all planes in the scene.

4. Implementation and Results

In this work, a kiosk is built as virtual museum, and two PC were included within the system: one for interactive virtual exhibition, the other for stereoscopic display of the 3D artifacts. The PCs are composed by Intel Pentium4 2.8 GHz with 2GB DDR SDRAM and NVidia Geforce FX5900 graphic chipset and are connected by LAN, so they can act synchronously. As shown in Figure 2 and Figure 15, the upper monitor is a touch panel, and the 3D scenes augmented with object movies are displayed on this one as interactive exhibitions. The lower one is built inside the kiosk for viewers to watch stereoscopic object moves of the artifacts with bare eyes through the eye-like panel, as shown in Figure 11 and Figure 15. When viewer chooses some artifact in the interactive environment, its stereoscopic object movie would be shown synchronously on the lower monitor. Moreover, a magnifier is provided with the system so that the viewer can see more details of the artifacts by using it, as shown in Figure 12.

Our team has implemented 3D scenes both by using the image-based technique and by using the model-based technique, as shown in Figure 16. For the 3D scenes constructed by geometric models, viewers can interactively view the virtual world from arbitrary viewing directions, but for that built as panoramas, viewers can only watch from some specific viewpoints. In general, the exhibition space implemented by the image-based approach appears to be more realistic.

The outer panel of the kiosk is shown in Figure 11. Viewers can watch the stereoscopic object movies through the eye-like circles in the center of the panel, and rotate them using the trackballs on the upper right. Further, the functions of the buttons on the upper left are to change the artifact and to magnify.

Our kiosk had been exhibited in F@imp2004 and received many positive feedbacks. It is now in exhibition at the National Palace Museum, and a snapshot is shown in Figure 17.

5. Conclusion

We have developed a stereoscopic kiosk for virtual museum. The kiosk consists of two displays. The upper one is a touch screen that allows the user to interactively navigate in the virtual museum. The lower one is a stereoscopic display that shows the stereoscopic view of the selected artifact. In our virtual museum, the 3D artifacts are represented by stereoscopic object movies, which can provide photorealistic rendering. As to the modeling of exhibition environment, we have tried both the image-based approach (more precisely, using the panoramas) and the geometry-based approach (using 3D geometric model), as shown in Figure 16. With

our kiosk, the user can interactively navigate in the virtual exhibition and can obtain a much better experience for browsing the 3D artifacts through the stereoscopic display. In the future, it is possible to extend the applications of stereoscopic kiosks from virtual museum to virtual mall, and thus produce much larger market.

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Figure 2: Appearance of the kiosk. (a) is the design model, while (b) is the real appearance of the kiosk after implementation.

Figure 3: Some of those artifacts displayed in our kiosk

Figure 4: Acquisition of Object Movies with autoQTVR.

(a)

(b)
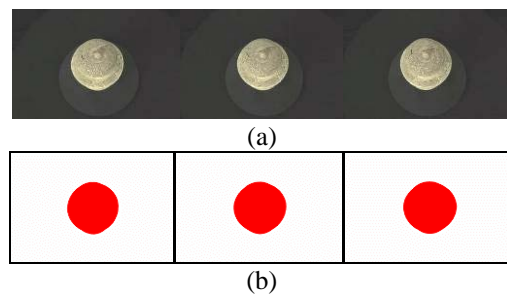
Figure 5: The initial segmentation result of the white vase sequence. (a) shows the original image sequence. (b) shows the segmentation result.

Figure 1: System overview
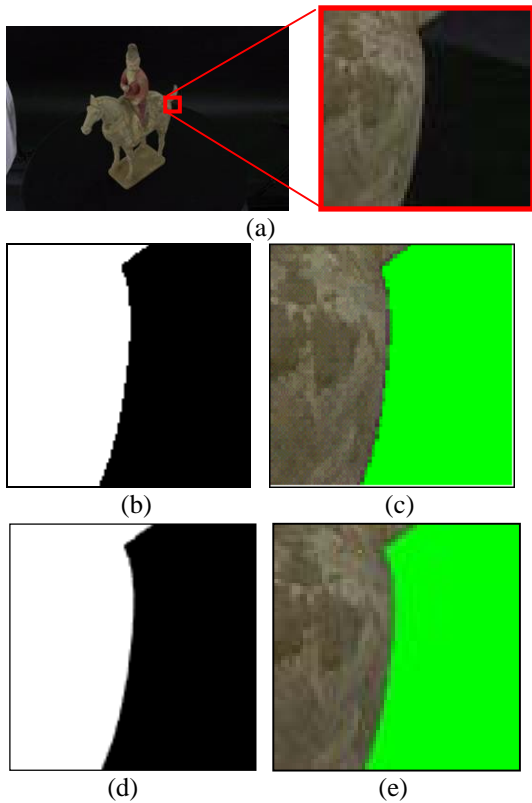
(a)

(b)

(c)

(d)

(e)

Figure 6: Comparison of the segmentation before alpha estimation and after alpha estimation. (a) shows an original image. (b) shows the alpha map before alpha estimation. (c) shows the segmentation result with green background using the alpha map shown in (b). (d) shows the alpha map after alpha estimation, and (e) shows the segmentation results with green background using the alpha map shown in (d).
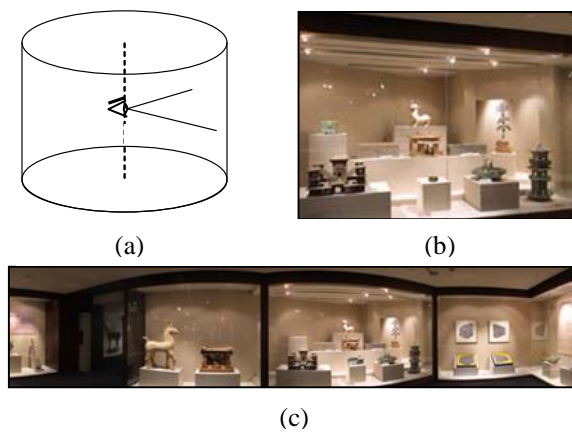

(a)

(b)

(c)

Figure 7: (a) depicts the cylinder used to record the panorama. (b) is a de-warped image from the area within the red rectangle of panorama (c). (c) is the panorama (in part) of an exhibition room in the National History Museum.
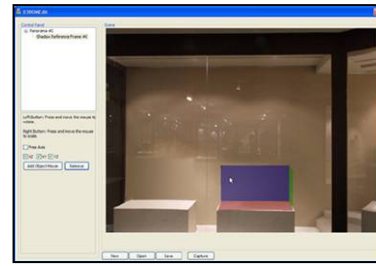
Figure 8: The authoring tool for augmenting a panorama with object movies. The section marked as red, green, and blue is the coordination system used for placing the billboards of object movies.
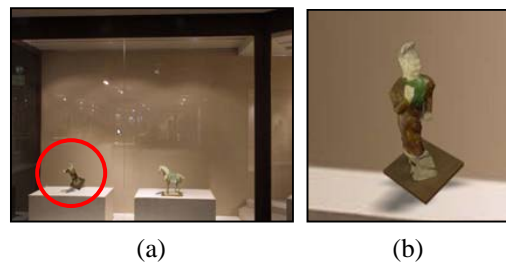

(a)

(b)

Figure 9: Results of augmentation of panorama with object movies. (a) An object movie, circled by red line, is rotated in the 3D scene. (b) The result after zooming.
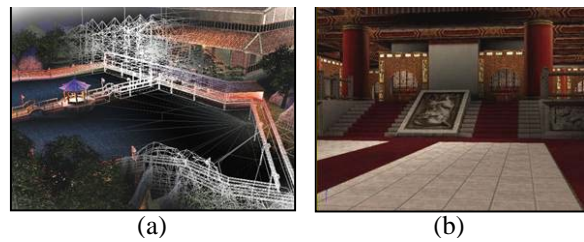

(a)

(b)

Figure 10: (a) The construction of 3D geometric model of the palace in Tang Dynasty. (b) Some view inside the palace.
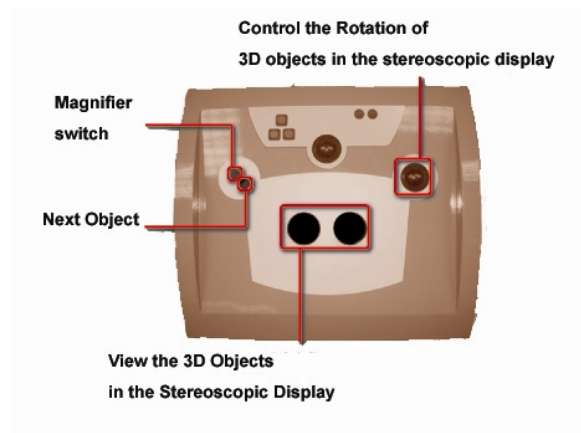

Figure 11: The control panel of the kiosk.

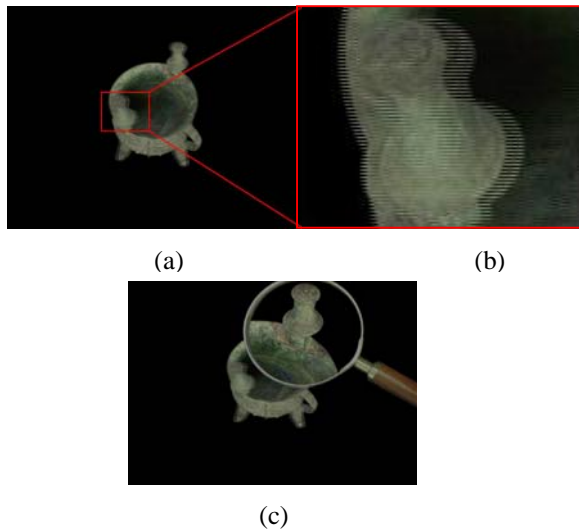(a)   (b)

(c)

Figure 12: (a) is stereoscopic images. (b) shows the zoom-in view of the red rectangle shown in (a). The virtual magnifier useful for viewing high-resolution image is shown in (c).
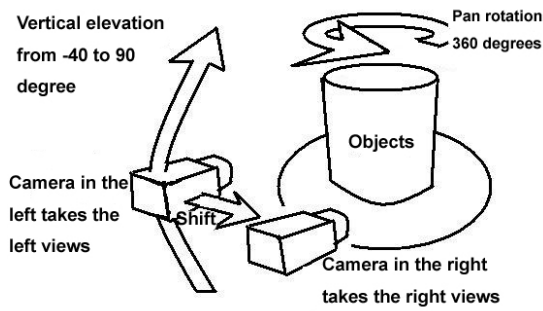

Figure 13: A system diagram shows how we capture stereoscopic object movies. Here, we capture the entire left eye's object movies, and then capture right ones.
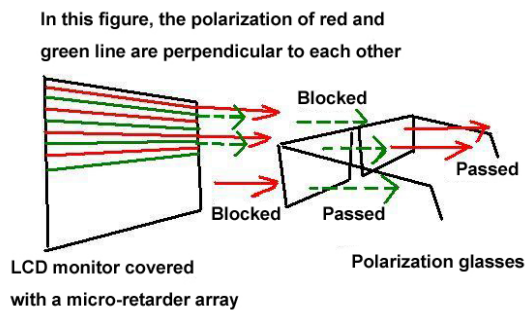

Figure 14: This figure shows how the LCD monitor present stereo with polarization glasses. The light coming from its adjacent rows has perpendicular polarization direction
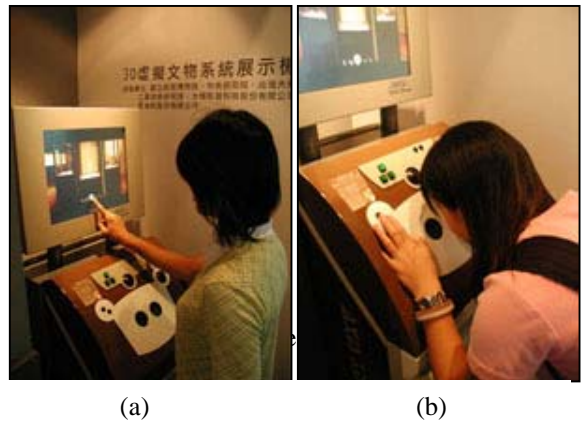

(a)   (b)

Figure 15: (a) shows how to control the touch screen and (b) shows how to see stereo with our kiosk

(a)   (b)

Figure 16: (a) shows the integration of object movies and 3D geometric scene, and (b) shows the integration of object movies and a panorama.

Figure 17: Our stereoscopic kiosk is now in exhibition at the National Palace Museum.