

Tangible Photorealistic Virtual Museum

Diverse museum artifacts, such as ceramics, porcelain, and ritual bronzes, can convey a sense of a people's history and culture, time, or place. Following specific criteria about the protection, maintenance, and preservation of these artifacts ensures their proper care and restoration. Often, this means visitors must view the artifacts statically in a glass showcase, precluding any kind of physical interaction. Moreover, because of limited exhibition space, many equally precious, beautiful, and important objects in the museum's possession are unfortunately out of sight in storerooms. To make these objects more accessible, we developed a tangible photorealistic virtual museum system that lets people interact naturally and have an immersive experience with museum exhibits.

Our system displays the museum's exhibits using augmented panorama (AP),¹ a technique that enhances a panorama with object-centered image sets (OCISs), or object movies.² The AP gives viewers the impression that they're touring and observing the museum's exhibits. The vision-based tangible interface lets viewers focus on a particular object in the exhibit using a handheld 3D physical control cube (PCC), as Figure 1a shows. The PCC lets the viewer control the AP and examine an artifact for a more detailed appreciation. With intuitive hand movements, viewers can enlarge the object and rotate it in any direction. Furthermore, the virtual AP space doesn't have the limitations of real museum space. The system lets visitors enjoy any and all of the museum's artifacts stored in the system, even if they aren't physically on exhibit in the museum.

Augmenting panorama with the OCIS

AP is a special class of augmented reality in which OCISs are inserted into a static background scene recorded as a panoramic image. In Figure 2 (next page), the background scene is a panoramic image of a museum exhibition room, and the foreground objects are artifacts in the OCIS, a set of perspective images taken from different viewpoints centered on the 3D object. Because an OCIS is a discrete set of images, it usually requires hundreds of images to ensure its realistic rendering qualities. In general, a 3D object with a complex shape might need an enormous amount of polygon meshes, accompanied by high-resolution texture maps, to achieve photo reality. Such a 3D model is difficult to manipulate interactively. OCIS, however, maintains a relatively consistent amount of data for both complex and simple shapes, and current computers easily support its inter-

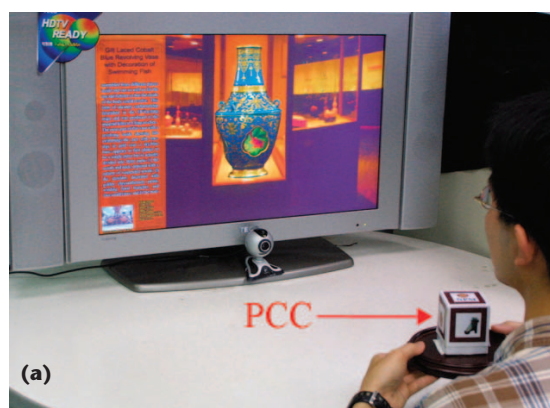
activity and sense of reality. These elements are particularly important in a virtual museum, which looks and feels real, and is interactive and 3D manipulatable. By using panorama and OCIS, we attain photorealistic exhibitions of the museum's artifacts without 3D models.

System overview

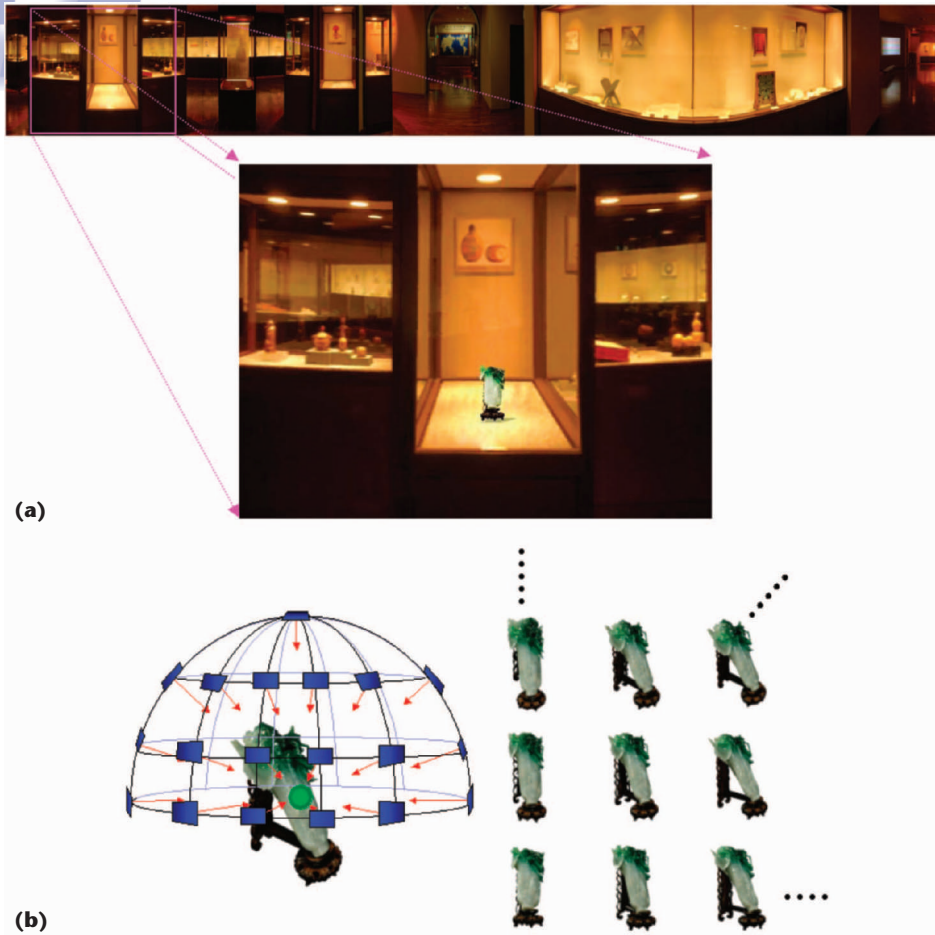
As Figure 1a shows, a video camera is positioned in front of the visitor under the kiosk's screen so the handheld PCC's movement doesn't block the camera's line of sight. Using the images captured by the camera, the system iteratively computes the PCC's orientation and position relative to the camera. A virtual plate in the virtual AP space

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1 Tangible photorealistic virtual museum system. (a) A museum visitor uses the handheld physical control cube (PCC) to select an object in the exhibit. (b) A museum visitor appreciates the virtual museum using a head-mounted display.



2 An example of (a) augmented panorama and (b) object-centered image sets.

represents the PCC's movement in real space. The visitor uses the PCC to browse the AP, get the OCIS of the exhibit of interest from the AP, find the appropriate showcase, observe the artifact, and return the artifact to the exhibit showcase. This behavior is intuitive to a visitor actually observing objects in a museum. The system also provides a head-mounted display with a camera on it (Figure 1b) to let the visitor feel more immersed in the experience.

PCC pattern tracking and pose estimation

Correct computation of the PCC location held by the visitor requires a fast and accurate pattern-tracking and pose-estimation methodology. Recently, researchers have used planar markers for image-sequence-based tracking, such as the ARToolkit library, to maintain stable performance.³ However, when the camera's viewing direction is nearly perpendicular to the plane's normal, the plane degenerates to a line and becomes invisible. In our system, such a singular case could restrict visitors from appreciating the object's side views. The visitor might therefore miss particularly significant views of the artifact. To solve this problem, we extend the planar marker to a 3D calibration object (the PCC), and thus prevent degeneration.

For each planar marker visible to the video camera, the system computes transformations between the video

camera and the planar markers. To achieve a better initial transformation, the system computes the reprojection error of all visible 3D corners (four corners of each identifiable planar marker) using these transformations. The system then selects the transformation with the minimal reprojection error as the initial transformation. We use Chen et al.'s⁴ pose-estimation algorithm, which is based on the iterated closest point (ICP) principle,⁵ to solve the camera pose-estimation problem.

Although the ICP-based pose estimation method works well even for long sequences, it can suffer from jittering. By extending the property that the motion between two continuous frames is relatively small, we assume that the current frame's rotation and translation are the same as the previous frame's. We then apply Chen et al.'s algorithm to obtain the PCC's motion. With this approach we achieve a remarkably stable motion of the virtual plate and OCIS.

Results

Figure 3 illustrates the process of controlling the AP, which represents the virtual museum in a kiosk. Figures 3a and 3b show a visitor using the handheld PCC to control and browse the AP to search for an

exhibit or object of interest. Upon locating the exhibit or object, the visitor extends his or her hand toward the kiosk, causing the virtual plate to approach the artifact. As the virtual plate approaches, the object revolves on its axis and becomes brighter, as Figure 3c shows, indicating that the visitor is selecting it. Once the visitor selects the object, the system displays a brief description of the object on the left side of the screen. Figure 3d shows this event together with the original background rectangle, which reminds the visitor of the exhibit or showcase from which he or she selected the object. Figures 3e and 3f demonstrate the outcome of using the PCC to view the object up close and rotate it to observe its details.

Ongoing and future work

Our system for real-time interaction with photorealistic museum artifacts in a virtual space demonstrates a new immersive approach using tangible interfaces in museum exhibits. Such advancements supplement visitors' traditional enjoyment of their museum visits. By using the virtual AP space, our system substantially expands visitors' potential to appreciate museum artifacts that are hidden in storage rooms because of limited exhibition space.

Compared to magnetic tracking devices and gloves, our approach offers a more economical solution for real-time interaction, a more intuitive control method, and



3 Visitor using the physical control cube to (a) view the exhibition room in the National Palace Museum, Taiwan, and (b) spot an object of interest (the Ivory Spheres). (c) As the visitor approaches, the Ivory Spheres revolves on its axis and grows brighter. (d) Information about the Ivory Spheres is displayed on the screen. (e) Viewing the Ivory Spheres up close and (f) rotating it to examine details.

superior flexible 3D manipulation in the AP space. Visitors must maintain the handheld PCC in the system's workspace; otherwise, the system can't detect the PCC pattern position, and only the last frame's results remain visible until the visitor returns the PCC to the workspace.

Currently, our system contains images for one exhibition room with multiple showcases. We plan to enlarge our system by combining multiple APs acquired from different museum exhibits with diverse showcases. ■

Acknowledgments

We thank the National Palace Museum for providing the exhibitions described in the article. We also thank Professor Mikulas Popper for his great help in writing this manuscript. The Taiwan National Science Council supported this research in part through NSC 93-2422-H-001-0004 and NSC 93-2752-E-002-007-PAE.

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