

Virtual Gallery Talk in Museum Exhibition

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Abstract

In this paper, we present a case study of a museum exhibition using video avatar technology. In the National Science Museum of Tokyo, we exhibited a high-quality educational virtual environment, a reconstruction of the Copan ruins of Honduras. Using a real person's guidance and a virtual avatar's guidance, the visitors can learn about the Mayan civilization and history from the real guide, as if they are in the real Copan ruins with the guide. Using video avatar technology, audiences can listen to a detailed lecture by a Mayan archaeologist directly. Throughout these experiments, the augmented virtual environment is effective for historical learning.

Key words: Museum Exhibition, Virtual Reality, Video Avatar

1. Introduction

VR technologies are expected to enhance the function and usability of museums. Some advanced museums have started to digitize many types of information concerning their own collections and to construct a virtual museum using sensing and information technologies. However, the purpose of museums is not only to display rare objects to those interest, but also to convey knowledge to the public by enabling the research and investigation of natural and historical subjects. In a museum exhibition using VR technology, we should provide the same level of interactivity and capability for communication as a conventional exhibit. We proposed a new concept, "Excursion Metaphor" which facilitates the audience interactivity and communication with the actual guide.

We developed and operated a VR system for the special exhibition "MAYA -Kingdoms of Mystery-" held from March to May 2003 in the National Science Museum, Tokyo. We implemented two types of VR system during the exhibition, gallery talk in the VR theater with a real person and that with a video avatar. With the real person's guidance and the virtual avatar's guidance, the visitors can learn about the Mayan civilization and history from the real guide, as if they are in the real Copan ruins with the guide. By using video avatar technology, audiences can listen to a detailed lecture from a Mayan archaeologist at any time. We captured and demonstrated two types of video avatar, the actor who act as a guide in the real person's gallery talk and the Mayan specialist. In this paper, we describe the system configuration and the evaluation of the museum exhibition using a video avatar.

2. Museum Exhibition

In real museum exhibitions, visitors can walk through the museum, following a recommended route. Using an audio guidance device or reading explanation panels, visitors can assimilate knowledge about the exhibition contents. However, such supporting devices only provide a limited amount of information because of their lack of interactivity and users' communication support. Thus, most museums hold guided tours for limited numbers of people at irregular intervals. Participants of such tours communicate with the specialist and can learn about the exhibition by listening to the gallery talk. A gallery talk in a museum is very effective for learning. This is because, as mentioned above, participants' interactivity and communication is important to the acquisition of knowledge.

2.1 Excursion Metaphor

We use the term "Excursion Metaphor"[6] to describe a user interface which provides a wide range of usage from passive to interactive. Figure 1 shows the Excursion Metaphor concept. The system that presents information in accordance with a theme can be compared to an excursion in which a kindergarten teacher guides kindergartners. In the case of a guided tour service in a museum, a guide explains to the group that he/she is leading. In this case, it is not necessary to force a participant to concentrate on the particular exhibit that the guide is explaining. If a participant becomes interested in another nearby exhibit, he may leave the tour group temporarily to take a closer look at it. By adopting this metaphor, it is considered possible to realize an integrated exhibition system that has wide interactiveness and wide acceptability of attendance.





Fig. 1 Metaphor of Guided Tour

2.2 Gallery Talk

In sightseeing areas, many tourists participate in guided sightseeing tours. In such guided tours, tour guides teach their group of tourists about their heritage along a well organized route (Figure 1). Tour participants cannot only listen to their tour guide's lecture, but can also talk with his/her fellow participants, and check their guidebook according to their interests. Also, some participants may find and become interested in other features during the guide's explanation. These activities will provide them with a profound knowledge of the heritage they are viewing.

In virtual museum exhibitions, we should provide the same opportunities as those which audiences can have if they participate in an actual guided tour. Thus, we proposed and demonstrate two types of gallery talk in a VR theater (Figure 2). In the VR theater, the tour guide stands in front of a curved screen and presents the guided tour as if he/she were guiding the audience in the real heritage location as shown in Figure 2(a). Using video avatar technology, a video avatar in the virtual environment can carry out a more detailed explanation of the contents as shown in Figure 2(b).

3. Virtual Guide

3.1 Video Avatar

Generally, a computer graphics avatar is often used in a distributed virtual environment [2,3]. In remote communication, the presentation of the human figure is one of the important issues; by presenting the figure of a person at a remote location with photoreality, it is expected that participants will become able to communicate in a manner similar to face-to-face communication in the real world, including such nonverbal interactions as pointing, gestures, facial expressions, and eye contact. Thus, if smooth communication is desired in a virtual environment, avatars should be displayed photorealistically.



Capture

Capture

Fig. 3 Concept of 2D video avatar

Video avatar [7] is one methodology of interaction with

people at a remote location. By using such video-based

real-time human Figures, participants can interact using nonverbal information such as gestures and eye contact.

In a primitive implementation of a video avatar[4],

namely, a 2D video avatar, the video image is projected

onto a virtual plane at the location of the remote

participants in the virtual environment; in the

implementation of a 3D video avatar, a video image is

projected onto a 3D surface model obtained using a

stereo camera or a range finder. By using many cameras,

we record many image sequences of the target user from

various viewpoints to reconstruct the user. We can

provide a photorealistic image of the user by switching

these image sequences (figure. 3).

Presentation

lmage

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(a) External View



(b) Internal View



Fig. 4 Surrounded Capturing System

3.2 Capturing System of Virtual Guide

To capture images of various angles of the virtual guide, we constructed a capturing system (figure 4(a)(b)). The capture system consists of a cylindrical room that is equipped with eighteen cameras, node PCs and a management PC (see figure 4(c)).

The radius of the room is 2000[mm], and the interior wall and floor of the room are covered by a blue screen sheet for ease of chroma-key processing. The cameras (DFWX700, SONY) are located around the wall of the room at intervals of 20 degrees at a height of 1200[mm] from the floor, and are fixed so that the optical axes of the cameras are horizontal and cross at the center of the room. To maintain the performance of the system, the cameras should not be managed by one PC, therefore we



Fig. 5 Snapshot of the virtual Copan ruins



(a) Exhibited "Alter Q"



(b) Reconstructed "Alter Q" Fig. 6 Real and Virtual Altar Q

used node PCs that connected to each camera individually. Each node PC only controls one camera, and the image processing is carried out independently. Each node PC captures an image from each camera, and extracts a human figure from the captured image within the frame rate of the cameras (15 fps).

3.3 Display System of Virtual Guide

To exhibit the reconstructed Mayan ruins, we implemented the virtual environment "Virtual Copan" using a high-end VR system, which we called the "VR theater".



3.3.1 Virtual Copan

For the museum exhibition, we implemented highquality historical VR content, "Virtual Copan" which showed the reconstruction of the Copan ruins of Honduras, one of the ruins of the Mayan civilization (figure 5). The Copan ruins are one of the most wellknown ruins of the ancient Mayan civilization, and are located at the westernmost end of the Republic of Honduras, Central America. Many outstanding buildings constructed with advanced technology and many artistic stone carvings can still be seen in the Copan ruins, and the ruins were recognized by UNESCO as a World Heritage site in 1980.

The Virtual Copan consists of two scenes; a faithfully reconstructed appearance of the present-day ruins, and a restored Copan as it was during the height of the dynasties' prospenty, based on the most recent research. Both scenes were produced under the supervision of the Honduran Institute of Anthropology and History. The area of ruins reconstructed is about 600 x 400m, including almost all key buildings and objects, such as a stone monument and an altar. The scenes also include the background so that it do not become unnatural when the view looks down on the scene of the whole ruin from the sky (figure 5).

Figure 6 shows a stone object called "Altar-Q" which forms the front of shrine No. 16 today. The Altar-Q is the most important epitaph which serves as a key to understanding both of the Copan dynasties and the fate of the ancient city around Copan, have been discovered in the Copan ruins. When experiencing the museum exhibition, visitors can observe the Mayan hieroglyphics engraved on the upper surface of the Altar-Q, and they can make the discoveries that a Mayan character consists of two or more elements, similar to a Chinese character (figure 6(a)). By applying high-resolution texture (over 2048x 2048 pixels) to such typical stone monuments, the visitors of the "Virtual Copan" can approach sufficiently close to the object of interest without losing detail too (figure 6(b)).

3.3.2 VR Theater

Our constructed VR theater has a 4m x 14m cylindrical curved screen with a 9 meter radius providing a 150 degree horizontal by 45 degrees vertical field-of-view (figure 7(a)). This theater has a capacity of 150 visitors who can participate in the exhibition simultaneously. During the exhibition, three actors worked as guides of the "Virtual Copan" in front of the curved screen, as shown in figure 7(b). Each actor has a different scenario, and they guided visitors through the Copan ruins from different viewpoints. One was a King of Ancient Copan, another was an archaeologist of the Copan ruins, and so on. A high-performance graphics workstation (sgi, Onyx 3400, Infinite Reality 3, 3pipe) rendered high-resolution and high-quality images in real time, according to the



(a) VR theater (National Science Museum Tokyo)



(b) Gallery Talk in VR theater Fig. 7 VR theater in Mayan Exhibition



Fig. 8 System of Museum Exhibition

actor's input through an input device.

Also, to rendering video avatar, we set up three PCbased VR systems (figure 8). These VR systems are integrated to the Theater type VR system through a gigabit ether network. We are currently developing a scalable VR system, a heterogeneous networked VR, which integrates different types of VR systems and enables different performances, and the use of different devices and user environments [1][5]. To support different types of display devices, modeling and rendering algorithms, interaction models, input devices, and network infrastructures, we modularize each subsystem of the virtual environment, rendering, interaction and communication.





Fig. 9 System of Virtual Gallery Talk

By using our scalable VR architecture ,we can effectively construct a VR system for a virtual gallery talk system (figure 9). These VR system should be able to share information on the user's viewpoint and orientation. The communication mechanism of the PCbased VR system receives the VR theater's viewpoint information and sends it to the application manager. The rendering mechanism of each VR system is customized for each VR system. In our prototype system, each different type of virtual environment can be run on each VR system and final image are rendered by merging separately rendered images.

4. Experiment

4.1 Gallery Talk using Real Guide

By using the large-scale VR theater and the constructed photorealistic VR contents, "Virtual Copan" we can provide an experience for the audience as if they are in the Copan ruins. In addition, the tour guide stands in front of the curved screen and presents the guided tour as if he/she were guiding the audience in the real heritage location. One type of tour involves performances by actors, playing the roles of a Mayan king, a Mayan astronomer and a present-day archaeologist (figure 7). In this type of gallery talk, the actor's talk is previously determined, but the actor interacts with the audience by observing their reactions responding to questions. Through and such communication, the audience can feel as if they are in the Copan ruins and can assimilate knowledge of the Mayan civilization.

The other gallery talk is given by a Mayan archaeologist (figure 10). Because the guide is a specialist on the Mayan civilization, he is able to change the content of his talk according to the audiences' reactions and questions. Through communication with this specialist,



Fig. 10 Guided Tours in VR theater

the audience can assimilate more extensive knowledge of the Mayan civilization.

In a real guided tour, capacity is limited by the physical space in real environment. However, by using VR technology, a large number of visitors (over 120,000 people) can participate in the guided tour in the VR theater. Also, we recorded the guide's voice and the route of the guided tour, and we can provide any gallery talk, including the specialist's gallery talk, at any time in the VR theater. Furthermore, in the VR theater, an audience has a 150 degrees horizontal field-of-view and can look around the heritage. So, they can look not only at the object which the guide is explaining but also at the location and background of the object. In ordinary museum exhibitions, we can look at objects and photographs which explain the context in a limited way. A gallery talk in the VR theater can overcome the disadvantages of both real museum exhibitions and guided tours.





Fig. 11 Captured Video Avatar Data of Virtual Guide

4.2 Gallery Talk using Virtual Guide

Using the video avatar technology, we can reconstruct a virtual guide according to the user's position. By appending the position and orientation information to the constructed video avatars, we can place them in the virtual environment. By calculating the relative distance and direction between the user's viewpoint and the avatar's position, we also switch and play back the proper image sequence of the avatar according to the user's viewpoint in global coordinates.

In our prototype system, each different type of virtual environment can be run on each VR system and final image are rendered by merging separately rendered images. Therefore, it is easy to combine the proposed video avatar with the photorealistic virtual environment as shown in figure 9. The user's figure in the rendered results is the video avatar, and this figure moves according to the user's viewpoint and his/her actions. By combining the virtual guide with the virtual environment, audiences can freely explore the "Virtual Copan" or participate in a guided tour which is shown in the theater.

We captured two types of video avatar, the actor who act as a guide in the real person's gallery talk and the Mayan specialist. Using these video avatar, we demonstrated two types of experiment and evaluated the efficiency of the video avatar.

4.2.1 Experiment 1: Mayan specialist's avatar

In experiment 1, the guide who stands in front of the screen begins by calling in the specialist's avatar who can answer the spectator's questions. First, using the video avatar capturing system, we captured video avatar data of Dr. Nakamura, a Mayas archeologist, talking about six important monuments of Copan ruins. Figure 11 is an raw avatar data in the direction of the perimeter of Dr. Nakamura acquired by the capturing system.

In this prototype system, the operator begins play back of the captured avatar data according to the instructions



Fig. 12 Gallery Talk by Virtual Guide

of the guide, and Dr. Nakamura's video avatar is presented as if he stands by the monuments of Copan ruins. The guide controls the audience's viewpoint by using input devices, and the audience can move through the "Virtual Copan" ruins and hear the specialist's explanation as if they are in a guided tour of the Real Copan ruins. In real Copan ruins, only a limited number of people can hear the specialist's explanation. The audience in VR theater can listen to the explanation as if they are actually hearing a presentation in front of the monuments. Moreover, the audience can move freely while hearing the explanation because the avatar data is presented in all directions (figure 12).

To evaluate the effect of the introduction of the avatar in an actual exhibition, the subjects experienced 2 types of performance, the performance in which only a guide is present Figure 12. Gallery Talk by Virtual Guide and the performance in which the guide occasionally summons the specialists' avatar according to the subjects' demand. We evaluated the efficiency of the video avatar using five-level review about the following questions.

- 1) Is it easy to have understand the explanation?
- 2) Has what has been explained been understood well?
- 3) Have the dimensions of the monuments been faithfully understood?
- 4) Is it easy to understand where you are?
- 5) Did you feel that it was possible to go to the place being explained by the guide/avatar?



The review result of the questionnaire by 12 people are shown in table 1. In questions (1) and (2) "Simplicity of explanation", the evaluation of "Only guide" was higher. There were a lot of comments such as "The video avatar brings about the feeling of TV reproduction, and the speech is indifferent and one-sided" in relation to questions (1) and (2). It seems that the video avatar's explanation, which differed from the actor's explanation, was incomprehensible because the Mayan specialist was too academic and talked indifferently.

In question (3) "Grasp of size" (4) "Grasp of place" "Avatar use" was higher. There are a lot of positive opinions such as "The specialist's explanation can be experienced as if one is in the ruins," and "The size of objects and the feeling of distance with in the surroundings can be understood well." From these results, it can be seen that the video avatar technology supplements the explanation by the guide.

Table 1. Review Results of Experiment 1 (five-level)

Question	(1)	(2)	(3)	(4)	(5)
Only guide	4.58	4.67	3.67	3.36	3.75
Avatar use	3.67	4.25	4.25	3.36	3.00

4.2.2 Experiment 2: Collaboration between real and virtual actor

In experiment 2, which differed from experiment 1, the guide entered into the Virtual Copan as video avatar and conducted the virtual tour (figure 13). Moreover, the same scenario as that of the performance was used, and the video avatar was used to assist the explanation of a scene of Popolna and celestial observation.

We asked the audiences who participated in the experiment to answer the questionnaire, and the questionnaire was collected from 54 people. In the questionnaire, the three scenes in which the video avatar was used and the recognition were evaluated using a five-level review. (five-level evaluation ranged from "It was very comprehensible" to "It was very incomprehensible".) The questions are as follows.

- **Popolna** Impression of scene of Popolna (figure 13 (a)) In Popolna, actor's avatar lies down on the actor back, and the same person negotiates mutually.
- Night Impression of scene of celestial observation (figure 13 (b)) Actor's avatar appears simultaneously with other portraits as an ancient astronomer to explain the appearance of celestial observation at that time.
- **Rosarira** Impression of scene of Rosarira (red temple) (figure 13 (c)) In the scene of Rosarira, the actor enters the screen as a video avatar, and carries out commentary instead of the actor in real space. The actor operates the avatar from behind the screen.



(a) Scene of Popolna



(b) Scene of Astronomic observation



(c) Scene of Rosalira Fig. 13 Scene of Virtual Gallery Talk

Size Has the size of Rosarira been understood from the appearance of the person?

Table 2 shows the result of the questionnaire of the abovementioned four items.

It seems that the evaluation of the scene is very high from table 2. The evaluation of "Simplicity of explanation" increased with the introduction of the avatar as in experiment. Moreover, there were a lot of comments such as "There was a person who was changing and a situation at that time was comprehensible," and "The size of the temple in the underground can be well grasped." From this result, the



effect of introducing astronomer's avatar at that time into the virtual environment was observed.

Moreover, the same questionnaire as that for the usual performance was repeated to the evaluate the entire performance. The answer by five-level evaluation to the question "Did you feel that you were actually in Copan ruins?" was 3.94 while the mean of the usual performance was 3.89. For the question "Was the performance sufficiently long?" it was 2.66 while the mean of the performance was usually 2.38. From these results, the evaluations of the avatar and the presentation time seems to be good enough compared with that of the usual performance.

Table 2. Review Results of Experiment 2 (five-level)

Scene	Popolna	Night	Rosarira	Size
Average	3.00	3.60	4.01	4.28
Standard decimation	1.11	1.03	0.83	0.89

5. Conclusions

To implement the virtual museum exhibition, we proposed a novel concept, the "Excursion Metaphor" which can complement a real museum exhibition without reducing the educational content. On the basis of this concept, we integrated different types of VR systems using scalable VR architecture[5]. By augmenting real museum exhibitions with interactivity and the capability for communication, our concept enables a more effective and impressive learning experience than a conventional museum exhibition.

We implemented two types of VR system, a gallery talk in a VR theater with a real person and that with a video avatar. Using the real person's guidance and virtual avatar's guidance, the visitors can learn about the Mayan civilization and history from the real guide, as if they are in the real Copan ruins with the guide. Using video avatar technology, audiences can listen to a detailed lecture by a Mayan archaeologist. Through the experiments, it can be seen that the video avatar technology effectively supplements the explanation by the actor. In the future, museums will be able to provide customized exhibitions according to visitors' purpose, interests and motivations, by integrating real exhibitions with many types of virtual museum exhibitions.

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