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空間型 AR 技術を用いた博物館展示

Spatial Augmented Reality Technology Applied to Museum Exhibition

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Abstract: In recent museums, decrease of the number of visitors due to the shortage of attractive contents has become an important problem. In this study, the exhibition method that displays not only the exhibit object but also the additional information such as the background or atmosphere about the exhibit was examined. The spatial augmented reality exhibition system named AR View that uses a large semi-transparent mirror film was developed. In this system, it is possible to represent correct occlusion effect between the exhibit and the computer graphics image, by using the method of lighting projector. Moreover, the platform of creating exhibition contents independent of the display device and the rendering software was constructed. The example of the exhibition contents that represents a golden mask in Sican was created, and the effectiveness of the proposed technoque was evaluated using AR View.

Keywords: digital museum, spatial augmented reality, occlusion effect, exhibition contents.

1. Introduction

Recently, though the number of museums has increased, the number of visitors for each museum has decreased. One of the reason of this problem is thought to be that the people have come to acquire information easily due to the development of the Internet. That is, people are able to obtain necessary information without going to the museum, and the value of providing information in the museum has been decreased. Moreover, most current museums use simple exhibition method in which the exhibits are simply placed. Then, it is necessary for the audiences to obtain additional information from other media such as books or the Internet. Therefore, the intention of exhibition at the museum site cannot be transmitted enough to the audiences, and it causes the shortage of the attractive exhibition contents.

In order to solve such a problem, it is necessary to construct the mechanism in which the museum can provide attractive contents continuously. This study aims at establishing the exhibition method that presents the additional information such as the background or the atmosphere about the exhibit together with it, by using the information communication technology, especially applying the spatial augmented reality technology. In order to activate the museum exhibition using the virtual reality and augmented reality technology, "digital museum project" has been promoted by the Ministry of Education, Culture, Sports, Science and Technology since 2009, and this study was performed as a part of this project.

This paper discuss the functions required in the next generation digital museum, the method of applying spatial augmented reality technology to the museum exhibition, the prototype of museum exhibition system, the contents creation method, and the example of the exhibition contents.

2. Requirements of Museum Exhibition

In order to provide attractive contents continuously, some functional improvements are needed for the exhibition method in the current museum. In this chapter, the functions required for the next generation digital museum based on the information communication technology are listed.

First, in most current museums, the function of providing information is not sufficient, since they only exhibit the objects. Therefore, the introduction of advanced exhibition technique in which additional information concerning the exhibits is presented using the information communication technology is demanded. For example, when the ancient relics were exhibited, the presentation of additional information, such as where and how they were excavated, why they were made, and how they were used, would be very effective to understand the exhibits. Though the voice guide system has so far been used as a method of providing information about the exhibit, the integration between the exhibit and the additional information is not sufficient. The introduction of new exhibition technique in which the exhibit and additional information are visually integrated is required. Moreover, in this case, it is also required that the visual information is used effectively without obstructing the conventional exhibition method in the museum.

Next, as for the additional information presented using the information communication technology, it is desired to present information that cannot be transmitted to the audience by the conventional method of exhibiting only objects. For example, though the appearance of the ancient old town or the sound of "gaya" heard there does not remain, the representation of these information would be able to transmit the atmosphere about the exhibit to the audience. Even if these information was not recorded as images or

sounds, it can probably be reproduced from the information materials using the visualization or sonification technology. This kind of technique is often called virtual archeology, and it would become more significant research field in which the information communication technology plays an important role to the archeology [Barcelo00] [Kircher01].

Moreover, the visitors in the current museum can be cllasified into two groups that are the advanced amateur and the indifferent. The advanced amateurs are people that have a lot of chances to experience first-class cultural assets. On the other hand, the indifferents are people that rarely visit the museum. The museums are required to have exhibition function that satisfies both of these people. That is, it is desired that the museum exhibits objects not only in a static method but also in a dynamic way in which representation method can be changed according to the responses of the audiences.

As a last requirement from the offer side of the exhibition contents, the achievement of easy contents production is required. Though the several representation methods for the exhibition contents that use various devices based on virtual reality or augmented reality technology have been proposed, these contents are usually produced as special program or data depending on the display environments. These contents cannot be reused in other systems, and it causes the situation of the contents shortage in the current museum. Therefore, in the next generation digital museum, it is desired to construct the contents production method that use the advanced information technology independent of the display system.

In this study, in order to meet these requirements, the spatial augmented reality technology was applied. Augmented reality is a technology that integrates the image of additional information to the real world, and it would be effective to present additional information together with the exhibit of real object. Particularly, the spatial augmented reality technology generates the integrated space based on not the video see-through method using the HMD or other portable devices but the optical see-through method. Since it can present information using the image in the three-dimensional environment, the archeological information that cannot be represented by the real exhibit object can be represented with high quality of presence. Various representations depending on the movement of the audience can also be realized using the interaction function of the virtual reality or the augmented reality technology. In addition, the contents production framework in which the exhibition contents can be reused in various display environments independent of the special device was constructed

3. Spatial Augmented Reality Exhibition

As for the exhibition technique that uses the virtual reality or augmented reality technology, various systems have been developed and used. For example, in the exhibitions of "MAYA Kingdom of Mystery" [Inomata03] and "The Golden Capital of SICAN" [Shimada09], the ancient architecture and the excavated ancient relics were represented, respectively, using the virtual reality technology. In these exhibition contents, though the ancient objects were represented using the three-dimensional computer graphics image, the relationship between the virtual reality image and the exhibit of real object cannot be represented sufficiently, because they were presented in independent theaters. On the other hand, as an augmented reality exhibition system, Virtual Showcase that uses a table top display was developed, and it has been used in several exhibitions [Bimber01]. However, the usage of this system is restricted to exhibit small objects, and it is difficult to represent the background or the atmosphere of the exhibit using full scale images.

In this study, spatial augmented reality technology was applied to construct the prototype of the exhibition system. The feature of this system is realizing the full scale representation of the integrated scene between the computer graphics image and the exhibit, using a large semi-transparent mirror. Figure 1 shows an appearance of the spatial augmented reality exhibition system named AR View, and figure 2 shows the system configuration of AR View [Ogi07].

Figure 1: Appearance of spatial augmented reality exhibition system named AR View

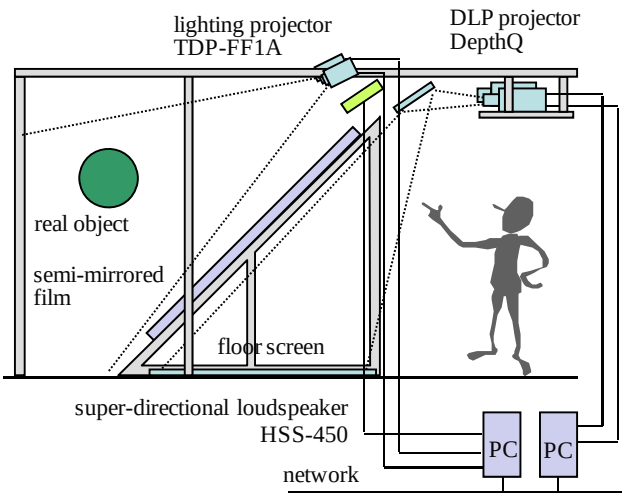

Figure 2: System configuration of prototype of spatial augmented reality exhibition system

AR View is a display system that optically combines virtual scene, projected by projectors, with the real world by

using a large (3.0m x 4.5m), highly transparent semi-mirrored film (visible light transmission is 87.8%). Large augmented reality space can be constructed by using the film type semi-transparent mirror. In this system, the semi-mirrored film is placed at an angle of 45 degrees to the floor, and the computer graphics image is projected onto the floor screen from the DLP projector (Inforcus DepthQ) placed at the ceiling. Since the users see the computer graphics image reflected with the semi-transparent mirror, they can perceive the virtual image behind the mirror film.

When it is used for the exhibition, the exhibit is placed behind the semi-transparent mirror. Then, the user can see the exhibit integrated with the computer graphics image. In this case, since the exhibit can be seen while it is being illuminated, the visibility of the exhibit can be changed freely by controlling lighting. LED projector, TOSHIBA TDP-FF1A, is used, instead of the standard light bulb, to project the light directly onto the exhibit. Since the brightness of the LED projector is low (15 ANSI lumens), it can be used to illuminate a human who is standing behind the semi-mirrored film together with the exhibit.

By controlling the lighting projector, the correct occlusion effect between the real object and the virtual object can be represented [Bimber02] [Murase08]. When the computer graphics image is projected from the image projector without illuminating the real object by the lighting projector, the real object is occluded by the virtual object. On the other hand, when the real object is illuminated by the lighting projector and the computer graphics image is blackened, the virtual object is occluded by the real object. Figure 3 shows the above mentioned principle of realizing the correct occlusion effect. In this figure, a white box is a real object and a green cube means a virtual object.

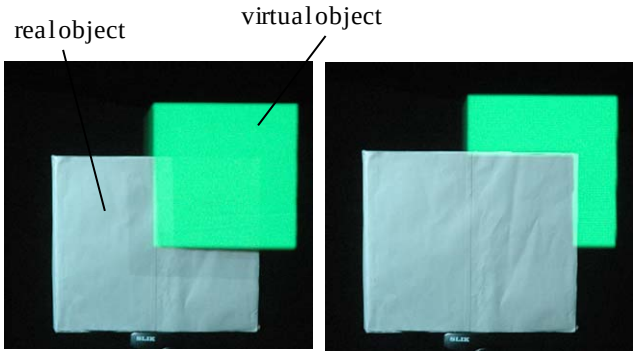

Figure 3: Principle of representing correct occlusion effect between real object and virtual object

By applying this method to the exhibition, it becomes possible to use various kinds of representations, such as showing only exhibit, showing only computer graphics image or showing combination between the computer graphics image and the exhibit. For example, the method in which the computer graphics image is projected onto the floor screen and the lighting projector is turned off can be used to explain the background of the exhibit without showing the exhibit. In order to show the exhibit, the method in which the computer graphics image is blackened and the lighting projector is turned on can be used. Moreover, the method in which the part of the exhibit is illuminated by the lighting projector and the part of the virtual image is projected can be used to show the exhibit in combination with the virtual image.

The image projector used in this system can project an active stereo image. Therefore, the user can feel the depth sensation for the three-dimensional computer graphics image by wearing the liquid crystal shutter glasses, and the user can recognize the integrated scene between the exhibit and the virtual image in the three-dimensional environment.

In this system, accurate registration of the computer graphics image with the real object is very important. Since a sweet spot at which the user can see the strictly correct scene is restricted to one point, it is necessary to guide the audiences to around the sweet spot where some audiences can see the nearly correct scene at the same time. Therefore, in this system, super-directional loudspeaker was introduced to guide the audiences to the sweet spot in natural way.

As a super-directional loudspeaker, American Technology Corporation HSS-450 is used. This speaker system generates super-directional sound using the ultrasonic wave, and it can spread the sound within the diffusion angle of about 3 degrees. In the museum exhibition, it is possible to guide the audiences to the sweet spot where they can hear the sound clearly as well as they can see the correct scene, by presenting the narration sound that explains the exhibit using the super-directional loudspeaker as shown in figure 4. However, in this technique, though the super-directional sound is outputted, the sound field that cannot be controlled would be generated when the sound waves were reflected repeatedly against walls and floor. Therefore, it is necessary to construct the walls and the floor in the exhibition room with the acoustic absorbent material.

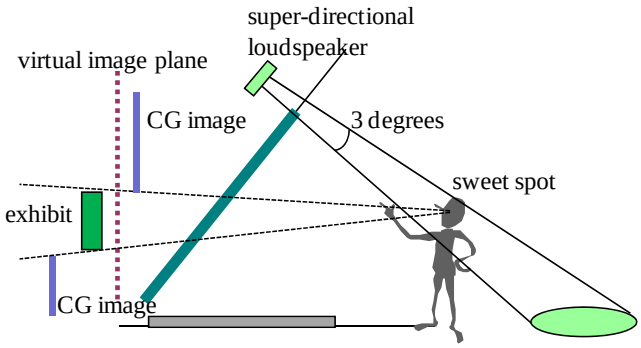

Figure 4: Audience guidance to sweet spot by super-directional loudspeaker

4. Contents Creation

In the museum exhibition using the virtual reality or the augmented reality technology, it is necessary to produce exhibition contents for each exhibit respectively. This problem brings the increase of cost for the contents production, and it consequently causes the shortage of contents in the current museum. In this study, we examined the contents production method in which the exhibition contents can easily be produced, and they can be reused in

various display environments and in various museums. In the augmented reality system that uses a special hardware or a device, the contents are usually developed as special programs, respectively. However, in the programming based contents production, the contents cannot be separated from the hardware or the device, and it affects the production cost and the circulation of the contents. Therefore, the method of producing contents for the spatial augmented reality exhibition system, that is independent of programming, was developed.

Figure 5 shows the process of the contents production method used in this study. In this method, Autodesk 3ds Max is used to create contents. 3ds Max is popular 3D modeling, animation and rendering software, and it is used by many contents creator in various fields. This software tool can be used to define not only the three-dimensional shape of the objects but also the animations, such as the movements of the objects or the walkthrough. Moreover, since the modeling in 3ds Max is not affected by the hardware of the display system, the contents can be created without considering the display device used in the exhibition. Thus, the three-dimensional model and the animation data are created using 3ds Max for each scene according to the scenario of the contents. In the actual contents production for AR View system, the three-dimensional models of both the virtual objects and the real objects are created, and the movements of objects and the camera work are defined using the animation function in 3ds Max.

The three-dimensional model and the animation data defined in 3ds Max cannot be used in other environment such as AR View. Therefore, it is necessary to provide a common data format to share data between the modeling tool and the display system. In this study, REMO data format (.xrm) is used. REMO is virtual reality software developed by I-NET Corp., and REMO data (.xrm) can be outputted from 3ds Max by installing plug-in software REMO Exporter that converts max data to xrm data. This xrm data is finally converted to rmw format data that can be loaded and rendered using REMO SDK on Linux environment by the REMO conversion tool.

In order to represent the augmented reality scene in AR View system, the rendering software AR Viewer was developed using REMO SDK. AR Viewer has functions such as loading the rmw format data, rendering the image of virtual object, rendering the image for lighting projector, and executing the animation. In this case, AR Viewer can load plural rmw format data and switch scenes sequentially in the specified order. Therefore, the contents scene can be presented by switching the data of computer graphics image and lighting image synchronously for each scene according to the scenario of the contents.

Figure 6 shows the software structure of AR Viewer. AR Viewer software is executed on two PCs, one is for rendering the computer graphics image and the other is for rendering the lighting image. Both processes load the same model data of virtual objects and real objects that were created in 3ds Max, and render the corresponding images respectively. In AR Viewer, offline rendering is performed to represent the correct occlusion effect between the virtual objects and the real objects because the user's view position and the projector position are different. Since these processes are executed in the rendering software of AR Viewer, the contents creation in 3ds Max can be separated from the display devices.

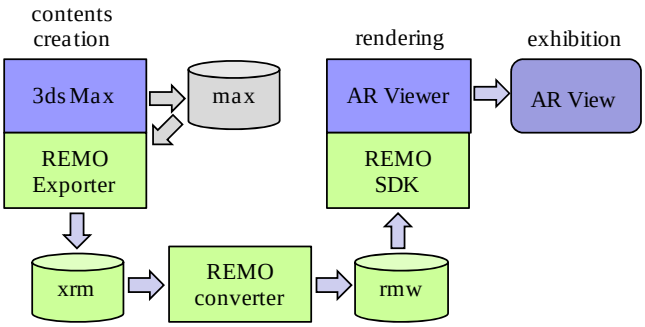

Figure 5: Process of contents production method for spatial augmented reality exhibition

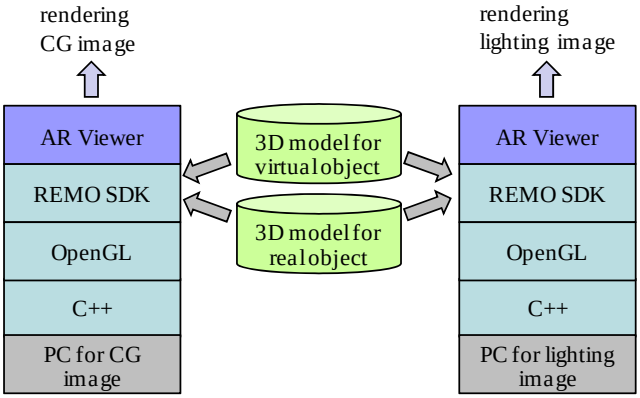

Figure 6: Software structure of AR Viewer executed in PCs for rendering CG image and lighting image

5. Examples of Exhibition Contents

In this study, the example of the exhibition contents that use the spatial augmented reality display AR View and the rendering software AR Viewer were produced. One of the content was the representation of golden mask in Sican, in which the three-dimensional model that was originally created for the virtual reality theater in the exhibition of "The Golden Capital of SICAN" was used.

In the original contents movie, the excavation of Huaca Loro temple that is one of the ruins of Sican, and several relics excavated at East and West tombs around the temple, were explained. Especially, the golden mask excavated in East tomb is one of the typical relics of Sican. In this study, the computer graphics model created for the original contents was applied to produce the augmented reality exhibition contents by integrating it with the real object of the golden mask.

First, in this exhibition contents, the three-dimensional computer graphics image of Huaca Loro temple was represented with the exhibit being concealed by the computer graphics image. Next, the exhibit of the golden mask was displayed with the computer graphics image as a augmented reality scene, and finally only the exhibit was displayed to the audiences. Figure 7 and 8 show the examples that the audiences are experiencing the above-

mentioned contents in the augmented reality exhibition system.

Figure 7: Example of augmented reality scene displaying golden mask of Sican with computer graphics image.

Figure 8: Example of displaying an exhibit of golden mask of Sican in AR View system.

6. Discussion

In this study, a prototype of the exhibition system required in the next generation digital museum was constructed by introducing the spatial augmented reality exhibition technology. In this prototype, though the functions of presenting additional information, representing atmosphere, and producing contents easily, were implemented, the audiences could not interact with the contents, because the movements of virtual objects or view position were implemented using the animation function. In the future system, the achievement of the interaction function with the exhibition contents would be required. In order to realize the effective interaction, it is necessary to examine how the functions of switching the scenarios interactively or walking-through the virtual world are used.

In this paper, though the exhibition technique using AR View was described, various methods of implementing other kinds of spatial augmented reality techniques can be considered. For example, table top system such as RealFiction's dreamoc can be used to exhibit small objects. Moreover, as a method integrating additional information with the exhibit, the human image of the researcher or the specialist concerning the exhibit can also be integrated to represent the atmosphere. In this method, the image of the remote human is transmitted to the museum and it is synthesized to the exhibit of real object or the computer graphics image of virtual object in real-time [Ogi09].

Figure 9 shows the example of synthesizing the human's video image to the computer graphics contents. In this example, the video image of the remote researcher is superimposed as a video avatar on the computer graphics contents of Sankin-kotai (system of alternating residence) at Kumamoto castle in Edo period that was reconstructed from the document information. By using this method, the audiences can hear the explanation about the exhibit not only from the curator in the museum but also from the researcher or the specialist existing at the remote place, and the concept of the spatial augmented reality exhibition that represents the atmosphere can be realized effectively. In the future work, various techniques that apply the spatial augmented reality exhibition technology to the actual museum will be examined.

Figure 9: Example of synthesizing remote human’s video image with CG contents

7. Conclusions

In this study, as a design of next generation digital museum using the information communication technology, the usage of spatial augmented reality exhibition technology was proposed, and the prototype system was constructed. In addition, the platform of producing the exhibition contents easily was constructed and the examples of the exhibition contents were created.

Though the basic function was implemented in the current prototype, it is necessary to examine the problems, for example which color of the image should be used to overlap the exhibit, what kind of interaction function should be introduced according to the audience's response, and how the audience's attention should be controlled, to apply this method to the actual museum exhibition. Future work will include solving these problems experimentally and establishing the practical exhibition technique.

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