Mixed Reality Digital Museum Project

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Abstract. In our research, we propose Mixed Reality Digital Museum to convey background information about museum exhibits by using mixed reality technologies. Based on this concept, we construct and demonstrate three types of exhibition system: Digital Display Case, Digital Diorama and Outdoor Gallery. Also to supporting museum activity, we construct and demonstrate several approaches which are acquisition and application of visitor's activity, supporting curator's activity, recalling after visiting, and etc. In this paper, the authors first introduce the outline of "Mixed Reality Digital Museum" project under the sponsorship of MEXT (Ministry of Education, Culture, Sports, Science and Technology). Then, the basic concept and project formation of the project are quickly introduced. After that, among the many project subtopics, the authors introduce two types of museum system using Mixed Reality technology: "Digital Display Case" and "Digital Diorama." Result of the implementation of the first stage prototypes are introduced and future plan is discussed.

Keywords: Digital Museum, Mixed Reality, Digital Display Case, Digital Diorama.

1 Introduction

In this paper, the authors firstly introduce the outline of "Mixed Reality Digital Museum" project which started as a 5 year national project sponsored by MEXT (Ministry of Education, Culture, Sports, Science and Technology). In the digital museum project, following 3 basic concepts are employed.

1. To fuse real (object) and virtual exhibit (event)
2. To support museum visitor's experience as a whole
3. To use digital technology for the sake of museum itself

(1) is a concept focused on the exhibits point of view. Originally, the function of museums is to transfer knowledge from older generation to younger generation beyond long period by using "collection of real (physical) objects" as a media. In other words, working hypothesis of the system called museum is based on convince that most part of knowledge can be transferred only by "objects". Since most of physical objects remains for long period, museum system has been working very well. Of course, there exist various limitations in the museum system. For example, most of

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exhibits don't move. It is very difficult for us to imagine dynamic running of steam locomotives from the statically positioned exhibits. If we plan to prepare the exhibits to run, enormous cost will be required. The project call this kind of background information as "event" in contrast to "object". Feature of digital technology will give dynamic "event" aspect to static "object".

(2) is a concept based on the museum visitor's point of view. In order to appreciate exhibits, various background knowledge. If museum visitors study on some exhibit in advance, they will get more information when they actually see the exhibit. Also, if they make review after going back to their home, they may wish to go to the museum again as repeaters. Appreciation of exhibit is only part of the process or experience of obtaining knowledge. Digital technology can support this process as a whole.

(3) is a concept based on the museum management point of view. Interactive exhibits can accept information from museum visitors. For example, whether the visitor enjoy the exhibit (or not) can be monitored very precisely. This data will be very important for curators to plan next exhibits. Moreover, information directly gathered from the visitor may be useful as an important content for the exhibit.

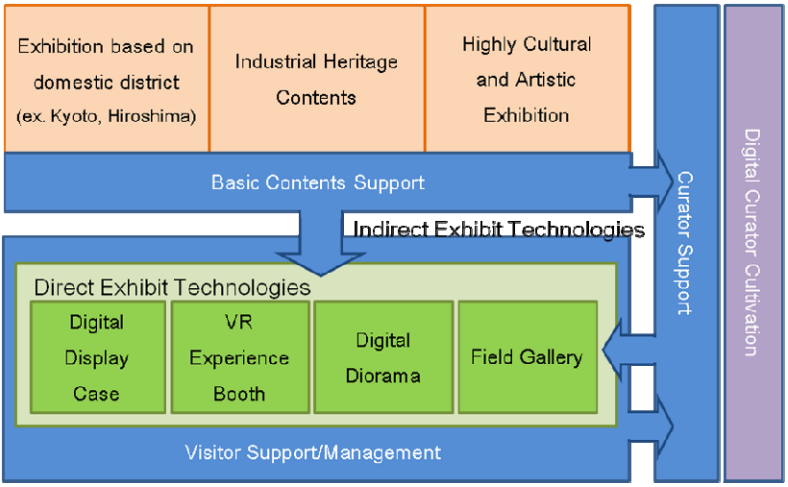

Fig. 1. Project Structure

2 Project Structure of Digital Museum Project

Based on the above mentioned concept, project structure is designed as shown in Fig. 1. Project will develop two kind of technologies; Direct Exhibit Technologies and Indirect Exhibit Technologies.

Direct Exhibit Technologies provide methodologies to implement fascinating exhibits. They relate to concept (1) and includes the followings:

1. Digital Display Case which provides compatibility to conventional exhibits
2. Digital Diorama which provides context or ambient information to the real exhibits.

3. VR Experience Booth which supports interactive experience related to real exhibits.
4. Field Gallery which provides exhibits outdoor environment with digital equipments.

Indirect Exhibit Technologies provide much broader exhibition environment and can be considered as basic information system of a museum. They relate to concept (2), (3) and includes the followings:

1. Basic Contents Support which is to obtain contents such as shape or motion of real exhibits to digital world from the real world.
2. Visitor Support/Management which is for providing visitor sophisticated museum experience as a whole system
3. Curation Support System which provide methodology to collect information automatically from museum visitors and help curator to design better exhibits.

Project members are composed by researchers from the University of Tokyo, Ritumeikan University, Keio University, NHK, NHK enterprise, NICT, Toppan Printing, Mitsubishi Research Institute. Also, for the experimental study, Museum such as Tokyo National Museum, Railway Museum, Museum of Contemporary Art Tokyo etc. are involved in the project.

Supposed experimental contents domains are divided into three:

1. Highly Cultural and Artistic exhibition
2. Industrial Heritage exhibition
3. Exhibition based on domestic district (such as Kyoto, Hiroshima)

(1) is a static movable property, (2) is a dynamic movable property and (3) is immobile property. So, these three categories cover most of the properties.

3 Direct Exhibit Technologies

3.1 Digital Display Case

There are some researches about exhibition systems featuring digital technology like Virtual Showcase [1]. However, few of them are actually introduced into museums. That is because they are greatly different from conventional display cases in shape. Therefore in this paper, we first construct the system in compatible with conventional display cases and panels [2].

Usually, museum exhibits are preserved inside a display case and cannot be touched, because exhibits will be damaged otherwise. The authors expect digital technologies such as virtual reality technology can solve this problem. Interactive capability of digital technology allows museum visitor to touch and handle exhibits freely.

If we want to illustrate background information by using conventional exhibition method, instruction panels will be used, but as mentioned before, this way is not effective. For example, some visitor may read panels but others don't. This is because most of the visitor see the exhibits in the display case and the instruction on the panel as separate things. Especially, the physical distance between exhibits and panels often makes it difficult to associate the information on panels with the exhibits.

The authors made the first prototype of the digital display case in the similar shape of conventional display cases but it can provide virtual exhibition by using real-time computer graphics. This system consists of four 3D displays assembled as boxshape and two 6DOF (Polhemus) sensors (one is for head tracking the other is for interaction with the virtual exhibit). Fig.3 shows the appearance of the system in operation. User wear glasses with head tracking sensor, and the system measures the position of view point. According to user's viewpoint, the system calculates the images to display and shows proper side of 3D virtual object as if it were in the case. Currently, conventional 3D displays with glasses are used for the prototype, but they will be substituted by glasses-less 3D displays [3-5] such as IP (Integral Photography).

We setup our developed Digital Display Cases at actual museum exhibition, the Railway Museum. This system has a function as same as a simulator. Visitor can drive the train track displayed in the case (Fig.3 left). By making some of the parts transparent, we can understand the functions of the mechanisms.

And the other prototype Digital Display Case was used in the Tokyo National Museum (Fig.3 right). This system enables visitor to interact with very expensive national treasures. In Japan, there are cultural assets called free-motion ornaments. It is a kind of figure model which can change its posture by hand. Since it is a kind of national treasure, almost no one can touch. So it is very difficult to know how it works. By using digital display case, visitor can interact with this kind of exhibit and understand that function.

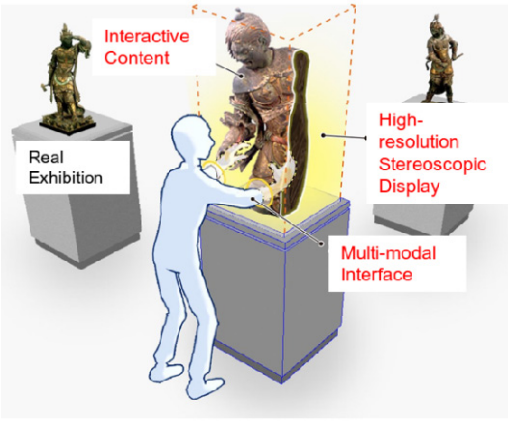

Fig. 2. Concept of Digital Display Case

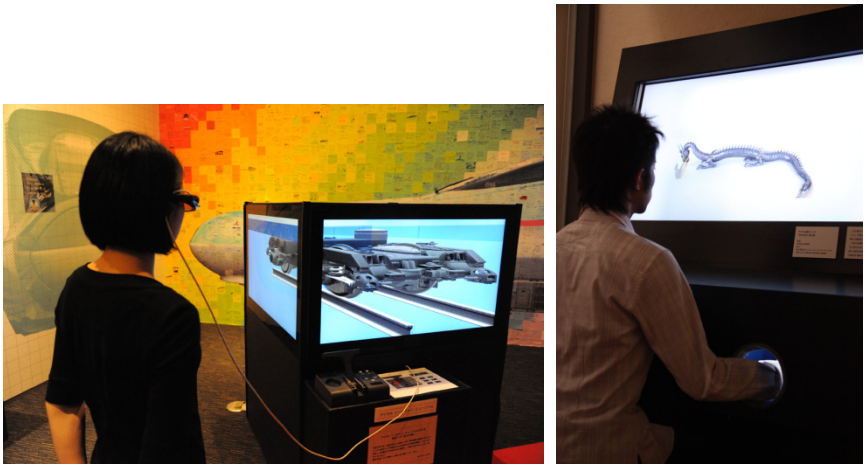

Fig. 3. Digital Display Case (left: the Railway Museum, right: Tokyo National Museum)

3.2 Digital Diorama

In conventional exhibition, diorama is used to show how and under what situation the exhibits are used by building a mockup similar to a movie set. Digital diorama aims to realize the same function by using mixed reality technology.

In particular, our proposed system superimposes computer generated diorama scene on a exhibits by using HMD, a projector, etc. By this approach, the system can present the vivid scene or situation to visitors with real exhibits: how to be used, how to be made and how to be moved them. Based on this concept, we implemented prototype system superimposing reconstructed virtual environment from concerning photographs and videos on the real exhibit (Fig. 4).

In order to smoothly connect old photographs or movies with the current exhibit, we have to estimate the relative position where the photos or videos are taken. This matching system constructed with mobile PC and web camera [6]. The matching system tracking user's assigned feature points on current image and outputs difference vector from old photo view point to current photo view continuously: yaw, pitch, right/left, back/forward and roll. According to the instruction from the system, we reached the past camera position [7].

To super-imposing old photograph or movies on real exhibits, the authors employed iPad-based AR system. At the estimated camera position, visitors experienced reconstructed past locomotive scene by using image based rendering method [8] (Fig. 5). The evaluation results show that camera position estimation and image matching between current and past images are evaluated very well. Moreover, many subjects said that the system for this experiment was good for knowing the background contexts of exhibits.

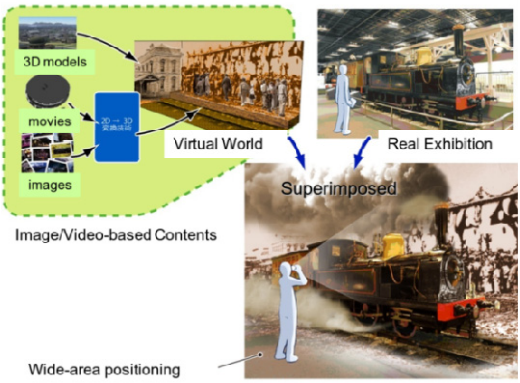

Fig. 4. Concept of Digital Diorama

Fig. 5. Digital Diorama in the Railway Museum

3.3 VR Experience Booth

VR Experience Booth is an immersive VR system in which users can experience large-scale cultural heritages or related event of intangible cultural heritages with high presence by using multi-modal information display, visual, auditory, and haptic displays.

For developing the system, sub-group (Ritsumeikan University) developed following sub-technologies; high-quality interactive character animation and crowd animation technologies, interactive immersive 3D visualization and interaction, presentation of balance sense using motion platform and visual and auditory feedback, interactive immersive sound image reconstruction, dynamic and high-diversity visualization of intangible cultural heritage, sophistication of 4DGIS "Virtual Kyoto[9]", real-time high-fidelity visual-haptic reconstruction. Fig.7 shows Current prototype individual VR experience booth.

We exhibit a part of our research activities, "Multi-band super high-resolution image of accessories of Funaboko", "Reconstruction of street-view using GIS and VR", "Virtual Yamaboko Junko using CG and high-fidelity sound image" at Kyoto City Intangible Cultural Property Exhibition Room [10].

Fig. 6. Concept of VR Experience Booth

Fig. 7. VR Experience Booth (left: recording "Gion Matsuri", right: prototype VR booth)

3.4 Field Gallery

Field gallery synthesizes a virtual exhibit in the real place. This is a dual relationship to Digital diorama. Digital diorama synthesizes a virtual environment to the real exhibit. By using MR technology, virtual world will be precisely located in the real world. Old buildings which do not exist anymore can be displayed in the actual place. Visitor can enjoy exhibits not only in the gallery but also at the place where they are actually located.

Sub-group (Ikeuchi-Lab, the University of Tokyo) reconstructed the lost buildings of Asukakyo with CG and synthesized them with the real landscape of Asuka Village. To improve the quality of the synthesized image, we worked on the problem of the photometric consistency in MR using fast shading and shadowing method based on shadowing plane and pre-rendered basis images. The system was opened to public in 2009 and 2010, and questionnaire surveys were carried out to evaluate the shadowing method and MR-system [11,12].

Fig. 8. Concept of Field Gallery

Fig. 9. Field Gallery “Virtual Asukakyo”

4 Indirect Exhibit Technologies

Indirect Exhibit Technologies is technologies for realizing “totally supporting museum activities.” The technologies are developed for collaboration between the above mentioned direct exhibit technologies and the conventional exhibition technique which are used in general museums.

Our project members consider that total (before and after) services are very important as well as the on-site (at museum) one. For this aspect, sub-group (Kakehi Lab., Keio University, Naemura Lab., the University of Tokyo) developed networked visualization of congestion situation (Breathing Museum), social networking to share visitors' feelings (Post-Visit Board) [13,14], and personalized mementos for each visitor (Peaflet). They are effective for making people want to visit museums and promoting greater understanding.

Furthermore, from museum side, museum curators or officers, it is important visitor's detailed behavior log to design museum exhibition gallery and arrange exhibits. Sub-group (Aizawa Lab., the University of Tokyo) developed a computer vision-based mobile museum guide system named “Navilog” [15]. It is a multimedia application for tablet devices. Using Navilog, visitors can take a picture of exhibits,

and it identifies the exhibit and it shows additional descriptions and content related to it. It also enables them to log their locations within the museum. We made an experiment in the Railway Museum in Saitama, Japan.

Fig. 10. left: Post-Visit Board, right: Digital Omoide Note

Fig. 11. Navilog

5 Conclusion

In this paper, first the authors outlined the basic concept and project formation of the digital museum project sponsored by MEXT. After that, among the many project subtopics, introduced two types of museum system using Mixed Reality technology: "Digital Display Case," "VR Experience Booth," and "Digital Diorama," "Field Gallery." These systems are designed for enhancing the current museum exhibition by presenting the background information of the exhibits. Then, by using implemented prototype systems, the authors demonstrated the effectively to convey synchronic and diachronic background information with their physical exhibits simultaneously. Although these are still an experimental level, both museum curators and subjects of our system feel capability of proposed system.

In future, the project members plan to brush up these prototype system for providing more realistic and sophisticated experiences, by using novel technologies such as auto-stereoscopic display, haptic device, markerless tracking and so on. By integrating with indirect exhibit technologies, which developed as well as the other subtopics R&D, the project will realize and establish useful and practical digital museums for both museum curators and visitors.

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