Digital Railway Museum: An Approach to Introduction of Digital Exhibition Systems at the Railway Museum

Takuji Narumi[1], Torahiko Kasai[2], Takumi Honda[2], Kunio Aoki[2], Tomohiro Tanikawa[1], and Michitaka Hirose[1]

[1] 7-3-1 Hongo, Bunkyo-Ku, Tokyo, Japan
{narumi,tani,hirose}@cyber.t.u-tokyo.ac.jp
[2] 3-47 Ohnari, Ohmiya-Ku, Saitama, Japan
{kasai,t-honda,aoki}@ejrcf.or.jp

Abstract. Museum is considered as an important application field for digital media technologies. In conventional museum exhibition, museum curators have tried to convey wisdom of mankind to the visitors by displaying real exhibits. Meanwhile, such conventional method for exhibition cannot tell vivid background information about the exhibit such as the social situation where it was made and the mechanism how it worked. Digital media can be used for enhancing delivery efficiency by providing the ability to express background information about exhibits. Based on this idea, we introduced digital exhibition systems, which help us to understand background information of exhibits, into THE RAILWAY MUSEUM (Japan) and held the "Digital Railway Museum" exhibition. In this paper, we describe about the exhibition and report on and knowledge and implication obtained from the exhibition.

Keywords: Digital Museum, Digital Exhibition System, Digital Display Case, Digital Diorama, Sharing Experience System.

1 Introduction

In every museum, a great deal of informational materials about museum exhibits has been preserved as texts, pictures, videos, 3D models and so on. Curators have tried to convey this large amount of information to the visitors by using instruction boards or audio/visual guidance devices within their exhibitions. However, such conventional information assistance methodologies cannot tell or show vivid background information about target exhibits.

Meanwhile, with rapid growth in information technologies, virtual reality and mixed reality technologies had developed and popularized in last decade. Today, we can present a high-quality virtual experience in real-time and in real-environment by using next generation display and interaction system: auto-stereoscopic 3D displays, gesture input devices, marker-less tracking system, etc. Thus, museums are very interested in the introduction of these technologies to tell the rich background information about their exhibits. There are some research projects about this kind of exhibition systems featuring digital technology [1, 2].

S. Yamamoto (Ed.): HIMI/HCII 2013, Part III, LNCS 8018, pp. 238–247, 2013.

In this paper, we report on our approach to introduce digital exhibition systems, which help us to understand background information of exhibits, into THE RAILWAY MUSEUM (Ohnari-Ku, Saitama, Japan) [3].

2 The "Digital Railway Museum" Exhibition

Industrial heritages have a great deal of background information such as their behaviors how these worked, their functions, the social situation where these were made, the location where they worked, how people used these, the relationship with other exhibits, historical trail and the process to create these. Especially, the behaviors and functions are essential for explaining a rail vehicle and its mechanism as an industrial heritage. Therefore there are great demands to introduce digital assistance for explaining these essences with real exhibits. We believe that digital media can be used for enhancing delivery efficiency by providing the ability to express background information about exhibits. Based on this idea, we have developed three types of digital exhibition systems: "Digital Display Case" for conveying the mechanism of exhibits through interaction, "Digital Diorama" for conveying the behaviors of exhibits and surrounding environment where the exhibits were used, and "Experience Sharing System" for conveying the manner of interaction with the exhibits by sharing the interaction which the participant took to others.

Then we held the "Digital Railway Museum" exhibition, and exhibited these systems. The "Digital Railway Museum" exhibition was a special exhibition which held from November 9th, 2011 to January 9th, 2012 at THE RAILWAY MUSEUM. In this exhibition, we aimed to examine the effectiveness and the possibility of our digital exhibition systems by letting visitors try our systems and gathering their reactions. We presented above-mentioned three digital exhibition systems. During the exhibition, all systems kept on running without any accident. The exhibition received over 60,000 visitors.

The following of this paper describes about each digital exhibition system and report on and knowledge and implication obtained from the exhibition and users observations.

3 Digital Display Case

3.1 System Overview

Digital Display Case system [4] enables museums to convey background information about exhibits effectively in an exhibition using interactive techniques and virtual exhibits. While previous studies [4, 5] have examined static exhibits, this study focuses on assisting visitors to understand the mechanisms of the exhibits. In this study, we chose the railway bogie as an example, and implemented a Digital Display Case system with which visitors can interact.

Fig. 1. Digital Display Case for conveying the mechanism of exhibits

The Digital Display Case system composed of three three-dimensional (3D) displays in the shape of a box. The reason why we chose the shape of a three-sided display case was that the appearance of the system would resemble a display case that could be introduced seamlessly in place of conventional display cases in museums. To view the exhibit, a user wears a pair of 3D glasses with a Polhemus sensor, which measures the orientation and rotation of the receptor using magnetic fields generated by the transmitter. Based on the point of view measured by this sensor, the system calculates computer graphics image to display on each 3D display. This enables the user to view a virtual exhibit from many angles as if it were actually inside the case (Fig. 1). Moreover the user can interact with the exhibit by using a controller like a master controller of an electric train.

In this system, a railway bogie was represented as an exhibit which had dynamic mechanisms. The bogie needs to suppress vibration in order to prevent vibration up and down the body when it is running on a rail. Therefore, it has axle and bolster springs. It also has flexible joints consisting of an annular gear, external gears, a spring, and so forth. The role of flexible joints is to transmit driving force from the motor to the wheels and to prevent vibration from being transmitted to the motor. Owing to this joint, trains can remain stable while running. On the other hand, these mechanisms are difficult to understand only with a real exhibit because these cannot be seen from outside when they are really working. Moreover, since the amounts of change of pieces are extremely small, the visitors cannot feel the effectiveness of the mechanisms even if they observe the exhibit working in real scale. Therefore, we intend to convey this mechanism to visitors by using interactive techniques.

In order to convey such mechanisms, the exhibition system requires functionality that enables visitors to interact with the exhibit and see how the mechanism works visually. Therefore, we implemented the system to allow the visitor to operate the railway bogie with acceleration or deceleration. In addition, this system possesses a function to make its parts transparent in six steps, so that visitors can see both the outside and the inside. Using these functions, visitors can observe the hidden parts of the mechanism as if the railway bogie was real and running. In addition, the amplitude of the rail, where the virtual bogie runs on, is defined to be larger than an actual

rail since it is necessary to distend the mechanical movement of the bogie in order to convey the mechanism to visitors. Moreover, the system visualizes the friction between parts by representing sparks which emerges at the point of friction with reference to the method by Sreng et al. [6].

3.2 Evaluation of Digital Display Case through the Exhibition

Digital Display Case was exhibited in the exhibition from November 9 to November 14, 2011 and from December 7 to December 19, 2011, excluding December 13. More than 4000 visitors interacted with this system.

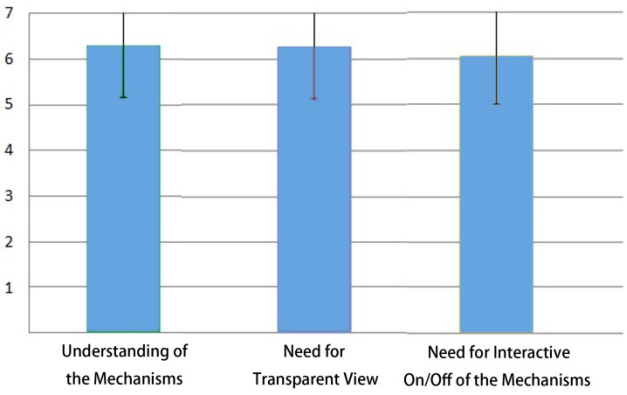

Fig. 2. User Evaluation of Digital Display Case (Average and Standard Deviation)

We asked participants to fill in a questionnaire with a seven-point rating scale and free descriptions after they experienced the exhibition. On the rating scale, higher numbers corresponded to more positive evaluations, and vice versa. Forty eight participants rated the following issues:

- Degree of the understanding of the mechanism how the railway bogie works.
- Degree of the needs for the transparency of the parts in order to understand the mechanism of the bogie.
- Degree of the needs for interactive switching on and off the mechanisms of the bogie to understand their functions.

Figure 2 shows the average and standard deviation of the rates to each item on the questionnaire. These results suggest the interaction with the exhibit in our system enhances delivery efficiency to convey the mechanisms of the bogie. Moreover it is considered that the system satisfied the requirements of THE RAILWAY MUSEUM to easily convey knowledge about the mechanism of the railway bogie to visitors.

In addition, we received many opinions regarding the exhibition in the free description. Among the positive opinions, there were several responses indicating that the exhibition was interesting and useful for understanding immediately the

mechanism of the railway bogie, that it was good to experience it in real time with explanations, that both children and adults who were not familiar with the railway could also enjoy it, and so on.

4 Digital Diorama: "Reminiscent Window"

4.1 System Overview

The Digital Diorama system is a mixed reality system which superimposes virtual environment onto real exhibits [7]. In a museum exhibition, a diorama is a technology for showing usage scenes and situations of the exhibits by building a set or painting background image like a film. The Digital Diorama system aims to offer more features than the function of existing dioramas in museum exhibitions. In particular, our proposed system superimposes computer generated diorama scene on an exhibit by using mobile devices. With this approach, the system can present vivid scenes or situations to visitors with real exhibits: how it was used, how it was made and how they moved. Moreover we consider this system can help users to understand the relationship between the real exhibit and its background information in historical materials.

Fig. 3. "Reminiscent Window" to overlay usage scenes onto the real exhibits

Based on this concept, we made the system named "Reminiscent Window," which overlays usage scenes in a video material onto the real exhibits and makes a user to experience how the camera operator captured the scene around the exhibits by inducing them to move as in the same way as the camera operator (Fig. 3). In this system, users can freely observe a spatial expansion of the world reconstructed from a news video, which captured the exhibit worked, by moving the device. At the same time we allow users to experience how the camera operator captured the scene by inducing them to move in the same way as the camera operator did by using visual feedback.

In this study, the video sequences which they were filmed from immutable position were only used; only the orientation of the camera can be changed. First, standing at the point from where the video content was taken relative to the target object, the user

points the device camera at the exhibit that is present in the video. Then the system recognizes it by using SURF-based detection method [8], and superimposes the image of the first video frame onto the exhibit. Next, when the user rotates the device to observe the surrounding area without translational movement, the system displays the frame that was taken in the direction in which the user is looking. The system used a gyro sensor embedded in the tablet device to determine the direction in which the user is facing. To determine the direction of the camera in each video frame, we calculated the directions manually in advance.

In order to induce users to move in the same way as the camera operator, the system generates three types of visual feedback: Induction for letting users start moving, Induction for letting them keep on moving, and Induction for letting them stop moving. When users start to move, we give the initial velocity to the overlaid image. Thus, the position of the video content frame moves to the direction the system induces (Induction for letting users start moving). If users try to stop moving the device in the middle of the rotation, the frames move ahead of the user in accordance with the inertial (Induction for letting them keep on moving). This is similar to the movement of the inertial scrolling in GUI. Using this method, not only is the position of the video frames moved in the direction the system aims to induce, but also the directional flow is conveyed in the video screen. Valid effects can therefore be expected to be achieved by means of "vection" effects, which some researchers used to give a change in human behavior [9]. Moreover, when users turn the device beyond the range associated with the image, we keep the frame of the video content to the inside of the range associated with the image (Induction for letting them stop moving). This prevents users from moving the device out of the range, and help users to experience the video content only within the range associated with the image.

4.2 Evaluation of "Reminiscent Window" through the Exhibition

"Reminiscent Window" was exhibited in the exhibition from November 9 to November 14 and from December 14 to December 19, 2011. More than 3500 visitors interacted with this system.

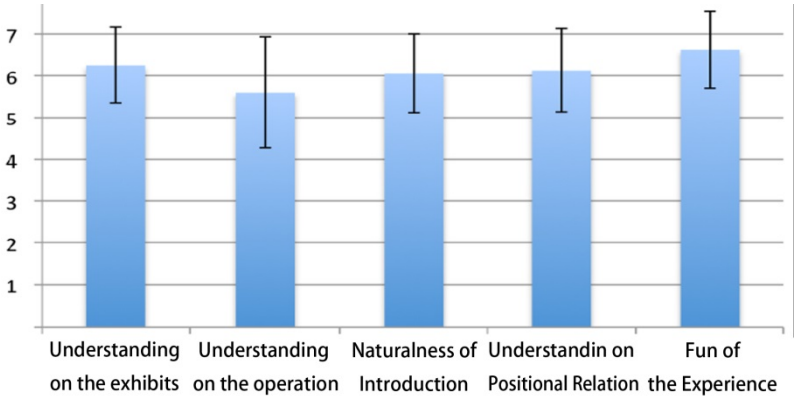

Fig. 4. User Evaluation of "Reminiscent Window" (Average and Standard Deviation)

We asked participants to fill in a questionnaire with a seven-point rating scale and free descriptions after they experienced the system. On the rating scale, higher numbers corresponded to more positive evaluations, and vice versa. Eighty five participants rated the following issues:

- Degree of the understanding on the exhibits.
- Degree of the understanding on how to operate the system.
- Whether the overlaying method which switches from the real exhibits to the past world reconstructed from videos was natural
- Degree of understanding on positional relationship between exhibits and objects in the past world recorded in videos.
- Degree of fun of the experience which the system offered.

Figure 4 shows the average and standard deviation of the rates to each item on the questionnaire. These results suggest the mixed reality exhibition system enhances delivery efficiency to convey the background information such as how it was used and what situation it was used in.

In addition, we received many opinions regarding the exhibition in the free description. Among the positive opinions, there were several responses indicating that they feel full immersion as if they were actually in the past world. This kind of comments indicates that the interaction such as looking around evokes immersive feelings and lets visitors understand the background information intuitively.

5 Experience Sharing System "Time-Leaping Seat"

5.1 System Overview

Experience-based exhibitions are effective in helping people understand the mechanism, functions, and background information on the exhibits. Visitors, however, do not necessarily experience the exhibits in the expected way. A museum cannot prepare explainers for all the exhibits, and the information on description panels is sometimes not enough. Then, we propose a system that records and superimposes past visitors interaction around an exhibit three-dimensionally. Visitors see the behaviors of past visitors, and obtain a better understanding of the exhibit.

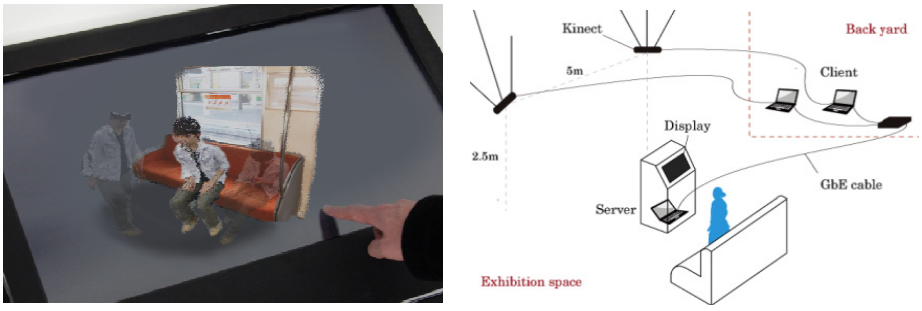

Fig. 5. Experience Sharing System "Time-Leaping Seat"

The proposed system, named the "Time-Leaping Seat" (Fig. 5), consists of the train seat of an exhibit, two depth cameras, two client PCs, a server PC, a touch panel interface, and cables. In our system, a real-time 3D reconstruction technique is used to superimpose images in exhibition space. One of the most effective methods that are capable of real-time 3D reconstruction is to use a combination of image cameras and depth sensors. Wilson et al. [10] developed the "LightSpace" system, which realizes interaction between images and real objects. This system consists of a projector and multiple depth sensors set on the upper side. Our proposed system also uses multiple depth cameras, like LightSpace. The system offers visitors two experiences:

1. Visitors can see a scene in which the exhibit, they themselves, and past visitors are together.
2. Visitors can see a scene where they are sitting on other seats of exhibits (on which they cannot sit in practice).

Visitors sat on the exhibit seat first. The real seat and the current visitors were reconstructed on the touch display in real time. Persons in the exhibit space were recorded as three-dimensional moving data for ten seconds when the visitors tapped a recording button on the display. Past visitors were superimposed on the real-time scene when the current visitors tapped a playing button. In addition, visitors could control the reconstructed scene intuitively with their fingers or a stylus pen, and view it from all directions.

5.2 Evaluation of "Time Leaping Seat" through the Exhibition

The Time-Leaping Seat was exhibited in the exhibition from November 16 to November 21 and from December 21 to December 26, 2011. More than 1600 visitors experienced this system.

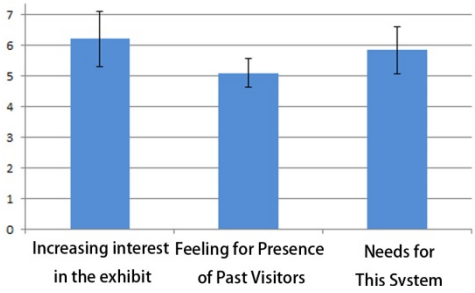

Fig. 6. User Evaluation of "Time-Leaping Seat" (Average and Standard Deviation)

We asked participants to fill in a questionnaire with a seven-point rating scale and free descriptions after they experienced the system. On the rating scale, higher numbers corresponded to more positive evaluations, and vice versa. Thirty six participants rated the following issues:

- How this system increases interest in the exhibit and interaction with it.
- Degree of the feeling for presence of past visitors as if they were along with.
- Degree of needs for this system to introduce interaction method with exhibits.

Figure 6 shows the average and standard deviation of the rates to each item on the questionnaire. The responses showed that we achieved our objectives: visitors understood the exhibit's functions intuitively, the proposed system enhanced their interest in the exhibit, and visitors' experiences could be shared with subsequent visitors.

In addition, we received many positive opinions regarding the exhibition in the free description. On the other hand, some opinions indicated that the system offered visitors an interesting experience that they could sit on past seats; however it did not provide them with enough information about the seat itself although visitors expected them. Therefore the system can be improved by combining other method to giving explanations of exhibits according to the behavior of the visitors.

6 Conclusion

This paper describes about three types of digital exhibition systems, "Digital Display Case" for conveying the mechanism of exhibits through interaction, "Digital Diorama" for conveying the behaviors of exhibits and surrounding environment where the exhibits were used, and "Experience Sharing System" for conveying the manner of interaction with the exhibits by sharing the interaction which the participant took to others, based on the knowledge and implication obtained from the "Digital Railway Museum" exhibition at THE RAILWAY MUSEUM. To summarize the primary findings:

- Digital exhibition systems, which combine real exhibits and background information by using the virtual and mixed reality technology, expand the range of expository activities and enhance delivery efficiency to convey background information about the exhibits.
- Interaction with digital exhibition systems increases visitors' curiosity and interest in the real exhibits and its backgrounds, and provide a greater understanding of its value.
- By sharing the visitors' experience, the way to interact with digital exhibition systems becomes more comprehensive. Moreover, sharing the visitors' experience enhances interest in exhibits.

Both visitors who experienced our systems and museum curators who introduced our systems in their exhibition felt effectiveness and capability of our systems. While the current study is the first step, we believe that the proposed system can help visitors in various situations in museums. For applying these systems to various situations and various exhibits, of course technological improvement is needed. On the other hand, we believe this kind of interaction is most important to develop not only novel, but also useful and effective exhibition systems. The digital exhibition systems in this paper are developed through a deep interaction among researchers, engineers and museum curators. In future, we aim to improve these systems to provide more realistic and sophisticated experiences by not only technical improvement but also schematization of management methods to treat digital exhibition systems and its contents. Then finally we aim to introduce these systems in the museum as a permanent installation.

Acknowledgements. This research is partly supported by "Mixed Realty Digital Museum" project of Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan. The authors would like to thank all the members of our project especially staff members of THE RAILWAY MUSEUM.

References

1. Oliver Bimber, L., Encarnacao, M., Schmalstieg, D.: Thevirtual showcase as a new platform for augmented realitydigital storytelling. In: Proceedings of the Workshop on Virtual Environments 2003, pp. 87–95 (2003)
2. Nakashima, T., Wada, T., Naemura, T.: Exfloasion: Multi-layeredfloating vision system for mixed reality exhibition. In: Proceedings of Virtual Systemsand Multimedia (VSMM 2010), pp. 95–98 (October 2010)
3. Japan Railway Museum, http://www.railway-museum.jp/
4. Kajinami, T., Hayashi, O., Narumi, T., Tanikawa, T., Hirose, M.: Digital Display Case: Museum exhibition system to conveybackground information about exhibits. In: Proceedings of VirtualSystems and Multimedia (VSMM 2010), pp. 230–233 (October 2010)
5. Kajinami, T., Narumi, T., Tanikawa, T., Hirose, M.: Digital displaycase using non-contact head tracking. In: Proceedings of the 2011 International Conference on Virtual and Mixed Reality: New Trends - Volume Part I, pp. 250–259 (2011)
6. Sreng, J., Bergez, F., Legarrec, J., Lecuyer, A., Andriot, C.: Using anevent-based approach to improve the multimodal rendering of 6DOFvirtual contact. In: Proceedings of Virtual Reality Software and Technology (VRST 2007), pp. 165–173 (2007)
7. Narumi, T., Hayashi, O., Kasada, K., Yamazaki, M., Tanikawa, T., Hirose, M.: Digital Diorama: AR Exhibition System to Convey Background Information for Museums. In: Proceedings of the 2011 International Conference on Virtual and Mixed Reality: New Trends - Volume Part I, pp. 76–86 (July 2011)
8. Bay, H., Tuytelaars, T., Van Gool, L.: SURF: Speeded up robust features. In: Leonardis, A., Bischof, H., Pinz, A. (eds.) ECCV 2006, Part I. LNCS, vol. 3951, pp. 404–417. Springer, Heidelberg (2006)
9. Kurose, I., Kitazaki, M.: Postural Sway Induced by Visual RadialMotion: spatio-temporal sensitivity to heading direction. Transactionsof Information Processing Society of Japan 8(2), 189–198 (2003)
10. Wilson, A.D., Benko, H.: Combining Multiple Depth Camerasand Projectors for Interactions on, above and between Surfaces. In: Proceedings of the 23rd Annual ACM Symposium on User InterfaceSoftware and Technology (UIST 2010), pp. 273–282 (2010)