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High Presence Digital Archive of Disaster Experience

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***Abstract*—In order to keep the awareness of the problem without fading the experience of past disaster, it is effective to reexperience it with high presence sensation. In this study, earthquake disaster experience system that records the scene of the disaster and represents it with high presence sensation was developed. In this method, the scene of the real world is recorded using virtual sphere model and it can be represented in immersive projection display such as CAVE or dome display. By using this system, the user can experience high presence scene using the effect of virtual depth sensation.**

Keywords-digital archive; disaster experience; high presence sensation; CAVE; dome environment;

I. Introduction

The Great East Japan Earthquake which has not been experienced in recent years attacked Japan in 2011 [1]. Currently, one year has passed from the earthquake disaster and reconstruction has progressed to some extent. But the awareness of the issue of countermeasure against disaster might be fading. In order to consider the countermeasure against disaster, it is important to have the awareness of the problem continuously without fading the experiences of past disasters. Therefore, the construction of the reexperiencing system which can record the actual disaster with high presence sensation and present it to the user as a reappearance of prior experience is expected.

On the other hand, in recent years, high presence video images have been widely used according to the spread of 3D television or 4K projector. It is considered that the high presence video images can be used effectively to create contents for immersive projection displays such as CAVE or dome theater. Though the immersive projection display has mainly been used to visualize data or represent virtual reality content, it can also be used effectively as high presence display device for the video based image contents.

In this study, the earthquake disaster experience system which records the scene of the earthquake disaster with high presence sensation and represents it using the immersive projection display was constructed. This system enables the user to experience the disaster scene with high presence sensation by projecting the high resolution images that is recorded as 360 degree panorama image onto the immersive projection displays such as CAVE or dome theater. This paper describes the method of archiving disaster scene and experiencing it with high presence sensation using CAVE or dome display.

II. High Presence Digital Archive

Digital archive technology that digitizes cultural or historical objects as digital data has progressed in recent years. Although at first the research of digital archive dealt with two-dimensional information such as document or picture, it is spreading to three-dimensional objects such as building or artifact. As an example of the digital archives of the three-dimensional objects, the collections in Kyushu National Museum have been archived using the high resolution images [2]. In other examples, Ikeuchi et al. have conducted three-dimensional digitization of cultural heritage or ruins by using the laser range sensor [3].

On the other hand, as for the record of disaster situation, the function of displaying the satellite photographs captured before and after the Great East Japan Earthquake was added in Google Earth [4]. Watanabe et al. created earthquake disaster map that visualizes photographs and Twitter information about the disaster on Google Map based on the geotag information [5]. By comparison with past earthquakes, the development of the Internet enabled us to record and to distribute information at individual level by using several application tools such as Twitter or YouTube. From this point of view, the Internet has played an important role to record the situation of the earthquake disaster.

However, in order to transmit the experience of the earthquake disaster to other people vividly, the text and photograph information are insufficient. In order to understand the real situation of the disaster, it is important to look at the real scene or exist in the real place by oneself. This study aims at developing high presence digital archive method that can transmit the vivid experience to other people as well as records the situation of the disaster.

III. Capture of Real World

In this study, in order to archive real world scene with high presence sensation, the method of creating high

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resolution panorama image was used. Though the methods of using fish-eye lens or curved lens have often been used to capture omni-directional video image, the resolution of the captured image would be reduced [6]. Therefore, in this study, the method of synthesizing the high resolution static image of the background scene and the video image of the dynamic objects was used.

The background panorama image is captured by using the digital single lens reflex camera Nikon D70 that is attached to tripod using the camera platform Fanotec Nodal Ninja 3-II. In usual tripods, it is difficult to create an accurate panorama image since the center of camera rotation and the center of lens are not coincident. In this camera platform, the camera body is mounted on the tripod with the offset so that the center of lens is coincident to the center of camera rotation. By using this tripod, the images of 360-degree scene are captured so that parts of neighboring pictures are overlapped. The number of the captured image is twelve at 0 degree, eight at +45 and -45 degrees, and one at +90 and -90 degrees. Then, the total number of the images used to create panorama image is thirty.

From these images, archive data of omni-directional image can be generated by texture mapping the stitched panoramic image onto the virtual sphere model. When the archive data is represented in the immersive projection display, the image corresponding to each screen is generated according to the structure of the display system from the spherical data. Figure 1 shows taking photographs in the disaster area, and figure 2 shows the panorama image created from the captured photographs.

Figure 1. Taking photographs of disaster scene

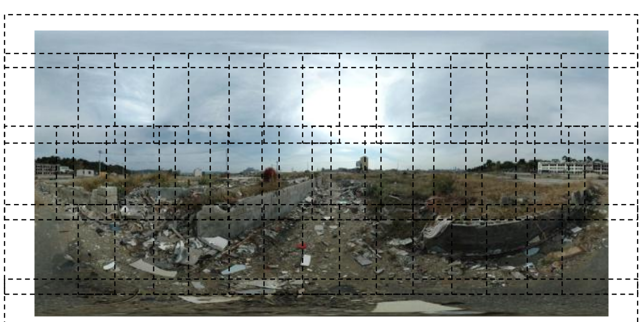

Figure 2. Panorama image created from captured photographs.

On the other hand, when the video image is captured using the video camera, the image element is segmented from the background using the chroma key or background subtraction method. This video image is stored with the position data, and the contents image is created by integrating the video element with the background panorama image.

IV. EXPERIENCE USING CAVE

In order to realize the reexperience based on the archive data of omni-directional images, CAVE type display system K-Cave was used [7]. K-Cave is a multi-screen immersive projection display that consists of front, left, right, and floor screens. The sizes of the front and floor screens are 2.63m by 2.0m, and the sizes of the side screens are 2.0m by 2.0m. The user's view position is tracked using NaturalPoint OptiTrack FLEX:V100R2 optical sensor, and the image seen from the user's view position is rendered in real time. Two NEC NP2150J LCD projectors are used for each screen, and the passive stereo image is projected through the circular polarizing filters.

As for the computer that generates projection image for K-Cave system, PC cluster that consists of five PCs of Dell Precision T7400 (Dual Core Xeon 3.33GHz, NVIDIA Quadro FX3700x2) is used. Four PCs are used to generate stereo images for each screen, and one PC is used to control the whole system. The application program is developed using OpenCABIN library and it consists of master part and renderer part programs running on each PC [8].

The virtual sphere of the archive data is located so that it surrounds the cubic screens of K-Cave, and the image for each screen seen from the user’s view position is cut out and it is rendered as shown in figure 3. Though the projected scene itself is not a stereo image, the effect of motion parallax corresponding to the movement of the user's view position or the walk-through can effectively be used. By using this method, the user can experience high presence virtual world through the interaction in the omni-directional image. Figure 4 and figure 5 show that the user is experiencing the scene of the earthquake disaster in K-Cave system.

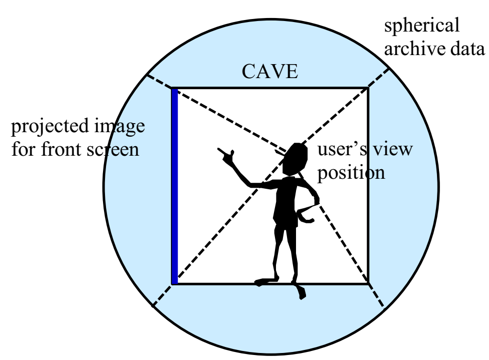

Figure 3. Principle of rendering image in CAVE system

Figure 4. Experience of disaster scene of building in CAVE.

Figure 5. Experience of disaster scene of street in CAVE.

V. EXPERIENCE IN DOME ENVIRONMENT

Next, spherical archive data was used to represent high presence image in dome environment. As experimental environment, the inclined type dome display with 30 degree inclination and 18m diameter was used. One LC projector NEC NP2000J with fish-eye lens RAYNOX DCR-CF185PRO was used to project the image with wide field of view onto the dome screen. When the fish-eye projector is used, the projected image contains distortion based on the fish-eye lens. But, in the dome environment, the overall distortion in the projected image is reduced due to the influence of the curved screen. In this study, the distortion based on both the fish-eye lens and the curved screen is corrected simultaneously using the checkerboard pattern. The horizontal and vertical angles of the image that is projected onto the dome screen by the fish-eye projector are 133 degrees and 100 degrees, respectively.

In this system, the projection image is cut out from the spherical model and the corrected image is projected using the fish-eye projector as shown in figure 6. Though the image for all direction cannot be projected by one projector, the user who is sitting at the center area can see the high presence image with wide field of view. In addition, in the case of the dome display, many users can experience the projected contents simultaneously.

Figure 7 and figure 8 show that the image of the earthquake disaster created from the archive data is projected onto the dome display. In the dome environment, it is known that the user can feel the three-dimensional sensation from the projected image without wearing 3D glasses. Particularly, the three-dimensional sensation is reinforced using the effect of motion parallax by moving the image elements or using the camera work [9]. In this content, the projected scenes were created by synthesizing several layered image elements such as the caption of explanation or the human image onto the background image. In order to use the virtual depth effect based on the motion parallax, the background image was rotated slowly so that the three-dimensional sensation is reinforced as well as the recorded image in whole direction is displayed.

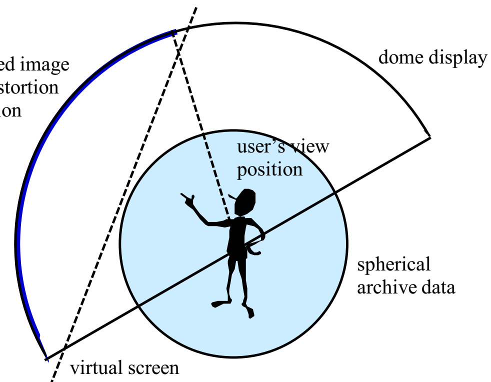

Figure 6. Principle of rendering image in dome environment.

Figure 7. Experience of disaster scene in dome environment.

Figure 8. Projection of earthquake disaster scene onto dome screen.

VI. Experiment on Virtual Depth Effect

In this study, in order to verify the virtual depth effect that can be felt from the layered photographs or video images in the dome environment, the experiment using magnitude estimation method was conducted. In the experiment, the layered human image was synthesized onto the background image of the real world as shown in figure 9, and the depth sensation felt by the subject from the human image was evaluated. In this case, the size of the human image was changed among the viewing angles of 40 degrees, 55 degrees, and 65 degrees, and the rotation speed of the background image was changed among 4deg/s, 6deg/s, and 8deg/s. In addition, the human image synthesized onto the background image was changed between static image and video image with the human motion. Figure 10 shows the condition of this experiment.

Figure 9. Layered human image synthesized on background image.

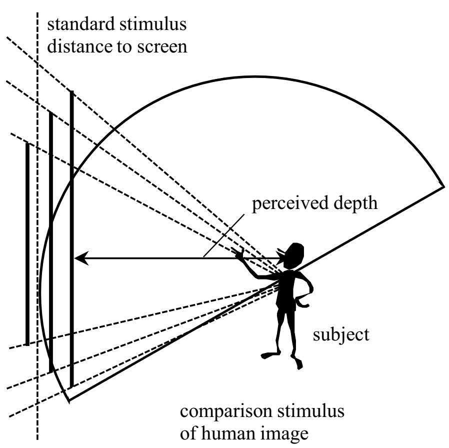

Figure 10. Condition of experiment on virtual depth effect.

Before displaying the images of each condition, the desktop screen of PC was displayed without distortion correction for 10 seconds as standard stimulus. After that, the images of the comparison stimulus were displayed in random order for 10 seconds. The number of subjects was six, and the images of each condition were displayed twice. The subjects were asked to answer the numerical value of the distance sensation felt from the human image by comparing it with the standard stimulus of the value of 10. When the subject felt the human image nearer than the screen surface, the answer would be smaller than 10, and when the human image was felt farther than the screen surface, the answer would be larger than 10.

Four-way analysis of variance was used to analyze the data with the factors of “subject”, “size of human image”, “rotation speed of background image”, and “motion of human image”. The result indicated the significant effect in the factors of "subject" (p=0.00), "size of human image" (p=0.00), "subject * size of human image" (p=0.00), and "motion of human image * rotation speed of background image" (p=0.05). Figure 11 and figure 12 show the relationship between the perceived depth sensation and “size of human image” or “rotation speed of background image”, respectively. Namely, we can see that the subjects felt the change of the distance of the human image when the size of the human image was changed though the individual difference among the subjects was large. Moreover, this distance sensation was changed due to the influence of the relationship between “rotation speed of background image” and “motion of human image”.

From these results, we can understand that the three-dimensional scene can be represented by controlling the depth sensation of each image element in the synthesized scene.

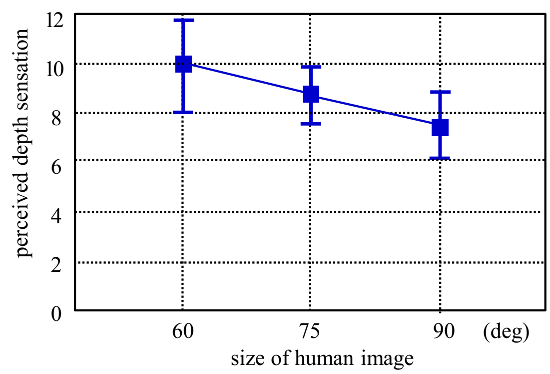

Figure 11. Relationship between size of human image and depth sensation.

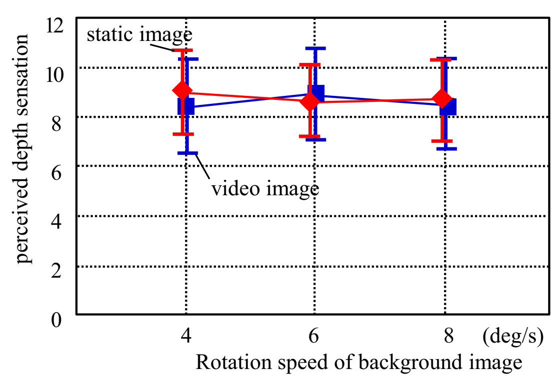

Figure 12. Relationship between rotation speed of background image and depth sensation.

VII. CONCLUSIONS

In this study, as a method of recording the experience of disaster and keeping it in our mind, the technique of high presence digital archive was proposed. In this method, the user can reexperience the scene of the earthquake disaster in the immersive displays such as CAVE or dome environment by using the spherical archive data. In this paper, the effective representation method utilizing the features of each display such as the interaction or motion parallax was discussed.

Future work will include developing the method of archiving real world scene using the high resolution and wide field of view video. Moreover, the design of social system in which people can experience high presence archive image in daily life will also be examined.

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