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Tele-immersive Environment with Tiled Display Wall for Intuitive Operation and Understanding in Remote Collaborative Work

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Abstract: In remote collaborative work via WAN, share various high-quality visual contents such as photography, visualization image, and real video streaming, and recognizing these contents clearly is extremely important. Supporting a high-quality display of these contents on a large-scale display system is necessary to support intellectual remote collaborative work. However, these contents are currently magnified in low resolution on a general projector using large-sized display equipment, and a sufficient quality of the contents is not obtained. In this paper, we focus on a tiled display wall using two or more LCD panels on a large-sized display system to display realistic high-resolution visual contents to solve these issues. We have constructed a tele-immersive environment with a tiled display wall, and have studied the availability for intuitive operation and understanding in remote collaborative work by implementing various collaborative applications for the effective display of high-resolution contents as well as developing interaction techniques for enormous visual contents in this environment. As a result, we have showed that the practical use of a tiled display wall is useful in the construction of intellectual remote collaborative environment.

Keywords: Tele-immersion, Tiled display wall, Remote collaborative work

1 INTRODUCTION

Remote collaborative work utilizing enormous quantity of data between multi-field researchers is very useful, and supports new intellectual discovery and knowledge-creation in many research fields. To realize intellectual remote collaborative work with participants at remote sites via WAN, sharing various high-quality visual contents is important, in addition to the existence of remote participants using video streaming to promote remote communication with high realistic sensation [1].

The use of large-scale display system with tele-immersion technology [2] is effective in order to realize the sharing of high-quality enormous quantity of visual contents with video-conference system and it is considered to use display equipment such as projectors and large-sized monitors. However, the display of video streaming and these contents with sufficient quality is difficult because the specification of a commercial projector and large-sized display equipment is low-resolution.

We have focused on the tiled display wall by two or more LCD and tried to display realistic high-resolution visual contents as effective large-sized display system in order to solve these issues. In this paper, we construct a tele-immersive environment with a tiled display wall to display realistic high-resolution video streaming and visual contents on the tiled display wall. In addition, we study the possibility of realizing intuitive operation and understanding in remote collaborative work by implementation of various collaborative applications for this environment.

2 RELATED WORKS

2.1 Tele-immersion Technique

Tele-immersion is defined as a new type of telecommunication media in which virtual reality has been incorporated into video-conference systems. In the 3D tele-immersion system, a user wears polarized glasses and a head tracker and a view-dependent scene is rendered in real-time on a large stereoscopic display in 3D [5].

Recently, Immersive Projection Technology (IPT) such as the CAVE system has become popular, and tele-immersive virtual environments have been constructed by several IPT environments [6]. Video avatar technology has been studied to realize real-world-oriented 3D human images for remote communication with high-presence tools between remote places [7]. The video avatar is a technique that represents a human image with a high-presence by integrating live video images of humans into the 3D virtual world. However, remote collaborative works in an IPT environment require deflection glasses and HMD. Under such conditions, carrying out smooth remote communication between participants is usually difficult.

Therefore, we use a tiled display wall to display higher quality visual contents which realize remote collaborative work with highly realistic sensation. In this research, we construct tele-immersive collaborative environment with tiled display wall to realize intuitive operation and understanding in remote collaborative work, and implement various applications for remote collaborative work in the environment.

2.2 Tiled Display Wall

Tiled display wall is a technology to display high-resolution visual contents on a large-sized screen with two or more LCD panels in order to construct effective large-sized display system. Much research has been done on tiled display walls and remote displays by using a distributed rendering technique for virtual walls.

For example, Chromium has designed and built a system that provides a generic mechanism for manipulating streams of graphic API commands [8]. This system can be used as the underlying mechanism for any cluster graphics algorithm by having the algorithm use OpenGL to move geometry and imagery across a network as required. In addition, Chromium's DMX extension allows execution of multiple applications and window control. However, it has a single source, and its design is not suitable for data streaming over a long-distance network.

In this research, we apply a Scalable Adaptive Graphics Environment (SAGE) developed by EVL at the University of Illinois [3]. SAGE is a graphics streaming architecture for supporting collaborative scientific visualization environments with potentially hundreds of mega-pixels of contiguous display resolution. In collaborative scientific visualization, it is crucial to share high-resolution visualization image as well as high-quality video streaming between participants at local or remote sites. The network-centered architecture of SAGE allows collaborators to simultaneously run various applications on local or remote clusters, and share them by streaming.

We constructed a tiled display wall environment consisting of 1 master node, 8 display nodes, and 16 LCD panels (17inch, SXGA). The tiled display wall's LCDs are located at 4x4 arrays as shown in Fig. 1. Master node and all display nodes are connected by gigabit Ethernet network, and 2 LCDs are connected to 1 display node with DVI cables.

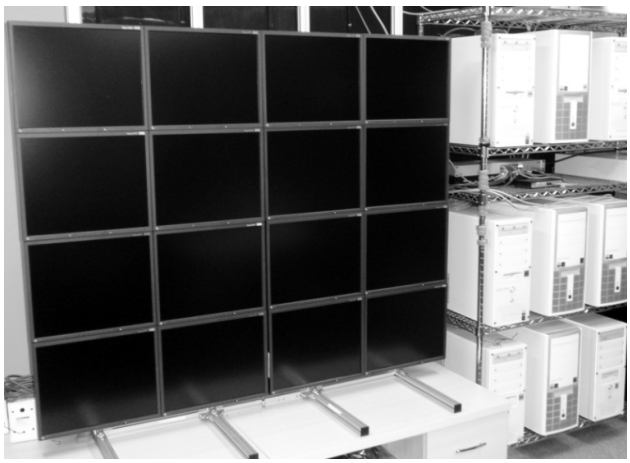

Fig. 1. Tiled display wall in this research.

3 MULTI-VIDEO STREAMING ON TILED DISPLAY WALL

We have implemented an application of high-resolution real video streaming by adding the API code of the SAGE Application Interface Library (SAIL) in a source program of application. In the application, pixel information obtained from a small camera is rendered as a video image by glDrawPixels on the tiled display wall. The video image captured by a camera located at frame of the LCDs on the tiled display wall is transmitted to remote sites, and its video image is displayed on the tiled display wall in a remote site.

We believe the display of the workspace in remote site with real video streaming by applying the ultra high-resolution display technique is an advantage of tiled display wall. We have showed that an ultra high-resolution video streaming with tiled display wall is effective to display the existence of participant and ambiance in remote place as a result from current experiments [9]. However, the video image captured by a single small camera is difficult to display with realistic high-resolution on a tiled display wall, because there is a limit in the display resolution of the video image captured by a single small camera. In addition, the magnified view of original video image on tiled display wall causes to degrade the quality of video image.

In this research, we have constructed an environment to display realistic high-resolution video streaming on a tiled display wall. In this environment, each piece of video image data captured by multiple cameras is transmitted to display nodes of the tiled display wall in remote sites from each application node. In addition, a high-resolution video which is generated by compositing these transmission video images are displayed on the tiled display wall. Fig. 2 shows that transmission multi-video streaming captured by 2 sets of small cameras (Pointgray Flea: XGA, 30fps) located at remote site in LAN. The display resolution of each video is set at 2048 1536 pixels. From this result, we showed to display a clear video image of a remote site over a wide range. As future work, we will study the technique to display more high-quality video image of workspace in remote site on tiled display wall by increasing number of captured camera.

In addition, we have measured the network throughput performance for each transmission video in the environment. The measured results, shown in Fig. 3, are the network throughput of the transmission video about for 20 minutes, and we plot the average value for measurement results for every 2 seconds. From the measurement results, the steady throughput of about 500 Mbps on average, which is considered a full performance of the camera, is gained in each video streaming. Moreover, the transmission delay between each video image is not seen in the observation of each display video on the tiled display wall.

Fig. 2. Multi-video streaming on tiled display wall.

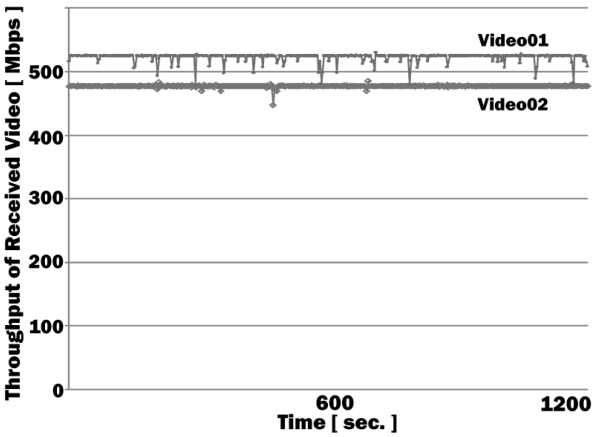

Fig. 3. Network throughput of each video streaming.

4 REALISTIC DISPLAY OF HIGH-RESOLUTION OBSERVATION DATA

We have applied this environment with tiled display wall to the field of astronomy as an effective application to realize a realistic high-resolution display of observation image data on a tiled display wall. Recently, Space Weather Forecast research has been able to predict flares, which occur on the sun's surface and influence the environment globally. In order to establish a high-precision forecast model, it is necessary to analyze a large amount of phenomena with high-resolution observation image data. We have executed realistic display processing of high-resolution astronomical observation image data.

In general, the Flexible Image Transport System (FITS) is used as standard image format for astronomical observation images. FITS is now used as an universal image format which can handle ordinary data in the field of astronomy. In this research, the observation data (resolution of image: 4,096 4,096 pixels) by the Solar Magnetic Activity Research Telescope (SMART), located in Kwasan and Hida Observatories, Kyoto University, is used as image data. The astronomical observation data saved in the local site is transmitted via WAN, and displayed on the tiled display wall in remote sites. An example of observation data by realistic resolution on a tiled display wall is shown in Fig. 4.

These results allow to observe the entire image of the high-resolution observation data on the tiled display wall. It may possible to promote new discoveries from the observation data through remote collaborative work because the data can be observed by multiple users at the same time in this environment. In addition, this environment can display a large amount of observation data that can be expanded and reduced in scale at free positions on the tiled display wall. Therefore, an analysis for these observation images by various techniques can be expected. The construction of a new environment according to user requirements will be examined in the future work.

5 COLLBORATIVE LEARNING USING TILED DISPLAY WALL IN GROUPWORK

As an example of practical use for a remote collaborative environment with the tiled display wall in this paper, we have executed collaborative learning using multi LCDs , and the tiled display wall in discussions to display student materials (Fig. 5:(top)). In addition, distance learning with the tiled display wall has been used in cooperation with classes given at the same time in other buildings, as shown in Fig. 5:(bottom).

From this approach, we understood that additional study on an effective display method for visual contents such as video streaming and presentation materials is important, even though each student used it effectively for the presentation and the discussion through the collaborative environment. In addition, we recognized that the demands for effective tech-

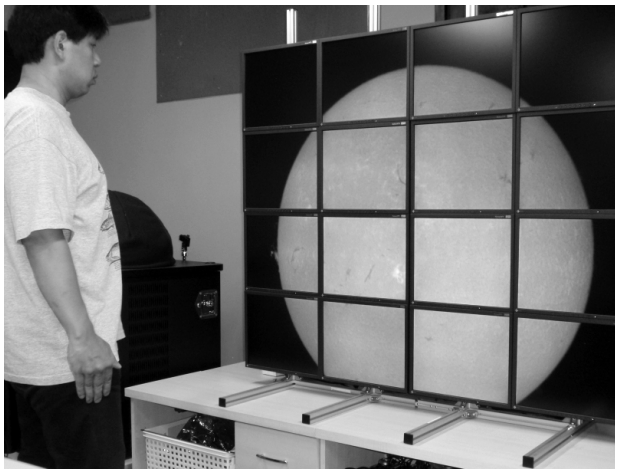

Fig. 4. Realistic display of astronomical observation image (4,096 4,096 pixels).

Fig. 5. Collaborative learning using tiled display wall in group work.

niques to display enormous quantity of experimental data and visualization images simultaneously to realize more intelligent collaborative work has risen from the collaborative learning approaches.

On the other hands, an advantage of tiled display wall is that multiple users can look at information at the same time. To utilize the advantage, we have developed a Graphical User Interface (GUI) for a mobile PC to control the enormous quantity of visualization contents on the tiled display wall by multiple users at the same time [10]. However, the GUI is difficult to execute while viewing various contents data on the tiled display wall when users operate the interactive control with a mobile PC. As a result, the use of GUI is expected to interfere by confusing the operation in collaborative works while viewing contents data on tiled display wall among some users.

Therefore, we need to develop a new user interface system to operate interactively with enormous amounts of content on the tiled display wall by some users while viewing the screen of the tiled display wall. An example of the user interface system that allows users to control for each piece of content on tiled display wall are functions such as movement of display location, scaling of window size, and hand-written annotation for each contents by holding or wearing the user interface in a natural state. For the future work, we propose an implement a mechanism to achieve these functions to support intellectual collaborative work using the tiled display wall.

6 CONCLUSION

In this paper, we have constructed tele-immersive environment with tiled display wall, and have studied the possibility of realizing intuitive operation and understanding in remote collaborative work by implementation of various collaborative applications such as the effective display of high-resolution visual contents and the interaction techniques for enormous contents in the environment. As a result, we have showed that the practical use of tiled display wall is useful in the construction of intellectual remote collaborative environment.

REFERENCES

[1] Finn, K. E., Sellen, A. J., Wilbur, S. B. (1997), Video-mediated communication. Lawrence Erlbaum Assoc Inc

[2] Sadagic, A., Towles, H., Holden, L., et al (2001), Tele-immersion portal:Towards an ultimate synthesis of computer graphics and computer vision systems, 4th Annual International Workshop on Presence, 21-23

[3] Renambot, L., Rao, A., Singh, R., et al (2004), SAGE: The Scalable Adaptive Graphics Environment. Workshop on Advanced Collaborative Environments

[4] Nirnimesh, H. P., Narayanan, P. J. (2007), Garuda: A scalable tiled display wall using commodity PCs. IEEE Transactions on Visualization and Computer Graphics, 13(5):864-877

[5] Gibbs, S. J., Arapis, C., Breitender, C. J. (1999), TELEPORT-towards immersive copresence, Multimedia Systems, 7:214-22

[6] Kukimoto, N., Nonaka, J., Ebara Y., et al, (2005), Scientific visualization in collaborative virtual environment with PDA-based control and 3D annotation, JSME International Journal Series B, 48(2):252-258

[7] Ogi, T., Sakai, M. (2006), Communication in the networked immersive environment. ASIAGRAPH 2006, 67-72

[8] Humphreys, G., Houston, M., Ng, Y., et al, (2002), Chromium: A stream-processing framework for interactive rendering on clusters. The 29th Annual Conference on Computer Graphics and Interactive Techniques SIGGRAPH '02, 693-702

[9] Ebara, Y., Kukimoto, N., Leigh, J. et al, (2007), Tele-immersive collaboration using high-resolution video in tiled displays environment, IEEE 21st International Conference on Advanced Information Networking and Applications, 2:953-958

[10] Ebara, Y., Kukimoto, N., Koyamada, K., (2008), Tele-immersive environment with tiled displays wall system for remote collaborative work. ASIAGRAPH 2008 in Tokyo, 2(2):130-133