Development of Concurrent Design Environment Using Super High Definition Image

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Abstract

Though the concept of concurrent design has spread and various design tools have been used, the design environment that supports the designers' collaborative work has not been discussed enough. In this study, CDF (Concurrent Design Facility) was developed as a collaborative design environment in which designers, researchers and managers can discuss with each other while sharing the necessary data. The feature of CDF is that the users can share the intuitive, accurate and high presence information by using the super high definition stereo image projected by 4K projectors. In this study, as the mechanisms of sharing images between the center screen and each user's terminal, command capture method and screen capture method were introduced, and the effectiveness of these methods for the collaborative work was evaluated.

Key words: concurrent design, super high definition stereo image, collaborative work

1. Introduction

As the large-scale and complex system are designed and the life cycle of the products becomes shorter, the concept of the concurrent design that makes design work more efficient by sharing the design data and advancing the collaborative work among each section in the design process has spread [1]. In the concurrent design, the functions of the communications and mutual interaction among designers as well as sharing data are required. However, in the usual concurrent design support environment, though the functions of modeling or sharing data using the computer is achieved, the effective communication or interaction methods among designers have not been discussed enough. In this study, in order to meet these requirements, CDF (Concurrent Design Facility) was developed as a collaborative design environment [2]. As for the concurrent design environment that supports the collaborative work, ESA-CDF and CoDE have been developed [3][4]. Our CDF particularly aims at constructing the collaborative design environment in which several designers can perform accurate and intuitive collaborative work while sharing the super high definition image of design data. Currently, though the basic construction of the CDF system has been constructed, the functions concerning the communication or the collaborative work are being improved. This paper describes the concept, the implemented functions and the future improvements of the CDF system.

2. System Construction of CDF

In this study, CDF was installed at the Graduate School of System Design and Management, Keio University as a collaborative work environment. The CDF aims at realizing the collaborative design in which the designer, researcher and manager can conduct the system design while sharing the necessary data and discussing with each other. In this case, the design targets include not only the product design but also the design of information system or social system. Figure 1 shows the CDF room and Figure 2 shows the system configuration of this environment.

The display system of CDF consists of a 180-inch acrylic screen (Nippura, Blue Ocean) and 108-inch LCD

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monitors (Sharp, LB-1085) placed at both sides. On the acrylic center screen, super-high definition stereo image is projected using the stacked 4K projectors (SONY SRX-S110) that are main devices of CDF. 4K means a super high definition image of 4,096x2,160 pixels, and it provides more than four times of the resolution of high definition television image. The linear polarization filters are attached on the 4K projectors, and the user can see the stereo image by wearing the polarized 3D glasses. The brightness of the 4K projector is 10,000 ANSI lumens, and the brightness of the image projected on the center screen is almost equivalent to the images displayed on the LCD monitors at both sides. Moreover, the 4K projector can be used to project not only the 4K resolution image but also four divided high definition images. In this case, six kinds of high definition images can be presented at the same time on the center screen and the monitors at both sides.

As image sources, two high-end graphics workstations, five graphics PCs, video server, and video conferencing system are prepared. Two high-end graphics workstations that consist of host computers (Dell PrecisionT7400, Quad Core Xeon 3.2GHz x2) and graphics engines (NVIDIA Quadro Plex 1000 Model IV) are used to generate 4K stereo images, and five graphics PCs (Dell PrecisionT7400) are used to generate high definition images. These graphics computers have dual-boot configurations of Windows XP and Fedora8, and various applications can be executed on them. In addition, the stereo video images stored using the side-by-side format in the video server can be reproduced, and the high definition video image sent from the remote site using the video conferencing system (Polycom) can also be displayed.

In the CDF system, these image sources can be displayed on the arbitrary screen area by switching the connection through the matrix switch. This matrix switch can be controlled with the liquid crystal touch panel connected via the wireless LAN, and the users can change the displayed image freely when they are discussing with each other.

Fig. 1. CDF room.

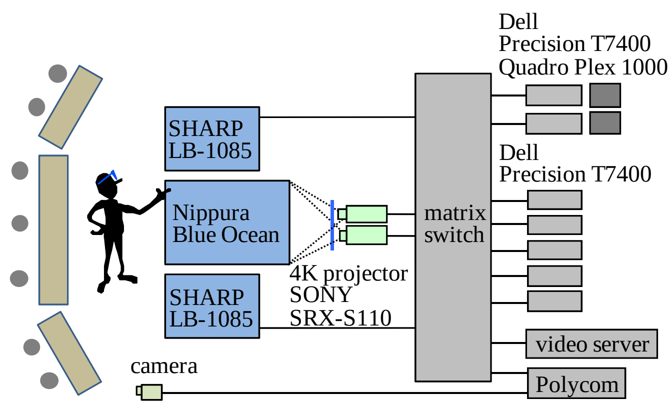

Fig. 2. System configuration of CDF

3. Sharing Visualization Image

By constructing the above mentioned configuration of CDF, basic functions of the concurrent design in which the designers in charge of each phase of the design process gather and discuss with each other while sharing the visualized data have been realized. In this environment, it is possible that the designers perform the collaborative work by switching the connection between the image sources and the display areas of CDF. As a next step, it is desired that each designer can share the super high definition images between his own terminal and the center screen, and perform the interactive operation. In order to meet these requirements, some functions were added to the CDF system and the effectiveness was evaluated.

1) Command Capture Method

First, as a function of sharing image in which the designer can transmit the visualization image from his terminal to the center screen and share it as a 4K stereo image, OpenGL command capture method was introduced. This method was developed in the CnC project that was a joint research project with Cybernet Systems Co., Ltd. and Fiatlux Corporation, and it was implemented as FusionVR software [5].

This software aims at transmitting the three-dimensional computer graphics image rendered on the user's terminal to the center screen and representing it as 4K stereo image. When the three-dimensional computer graphics monaural image is rendered using OpenGL library on the user's terminal, the OpenGL commands are captured from the rendering application and they are replaced with the commands that render the 4K stereo image. These commands are transmitted to the graphics workstations and 4K stereo image is rendered using the parameters for the binocular vision and the center screen. In this method, since the monaural image is converted to the 4K stereo image without changing the source code of the rendering program, the existing application program can be used to experience the super-high definition stereo image. Figure 3 shows the mechanism of the OpenGL command capture method, and Figure 4 shows that the 4K stereo image is presented on the center screen using this function.

Moreover, when this function is applied to several images at the same time, the three-dimensional computer graphics images rendered on each terminal of several users can be synthesized three-dimensionally as a 4K stereo image on the center screen. For example, if one user designed the body shape and other user designed the interior appointments of the car, super high definition stereo image of the car model that provides both the body and the interior can be represented by integrating the images of each model. By using this method, it is expected that the efficient collaboration between designers can be realized by using the super high definition stereo image.

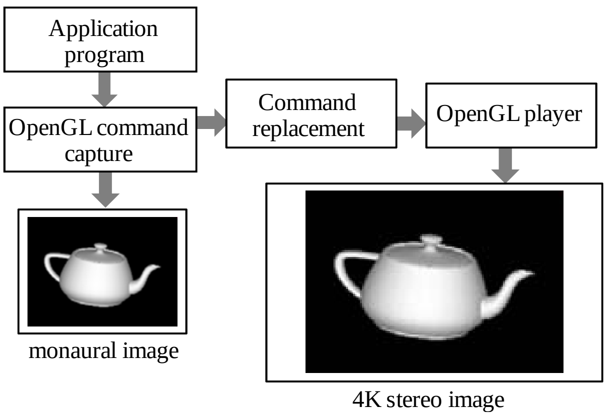

Fig. 3. Mechanism of OpenGL command capture method.

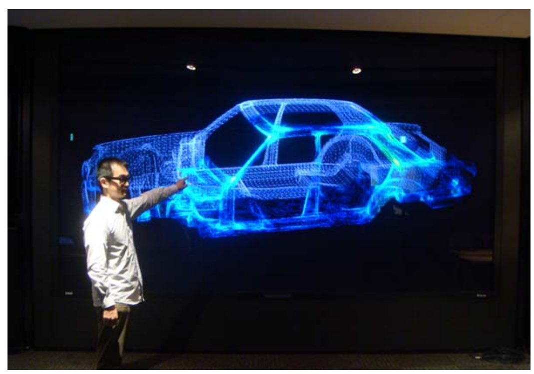

Fig. 4. 4K stereo image rendered on center screen.

2) Screen Capture Method

As an opposite form of sharing the image, the method in which the image displayed on the center screen is transmitted to each designer's terminal and they can interact with the image on the center screen from their terminals can be considered. In this study, the function of delivering image from the large screen to each terminal was implemented using the screen capture method [6]. In this method, the image rendered by the graphics workstation for the 4K stereo image is captured and it is delivered to every terminal using the broadcast. In this case, though the high-end graphics workstation is used to render the 4K stereo image, low-end computer such as a net book is often used as the terminal at the receiving side. Therefore, in this method, the resolution of the image data is reduced before transmitting it to the users' terminals so that the data processing load at the receiving side and the network load would be decreased.

In this method, since the received screen image is merely represented at the user's terminal side, it is necessary to construct the mechanism in which the input command is sent to the graphics workstation to realize the interactive operation between the user's terminal and the center screen. Moreover, since this method captures every frame of the screen image and delivers it to each terminal, the performance of the process has limitation. However, this method would have an advantage that the information can be shared among multiple users at the same time. Figure 5 shows the mechanism of sharing the image by using the screen capture method, and Figure 6 shows that the 4K image is delivered to the terminal by using this method.

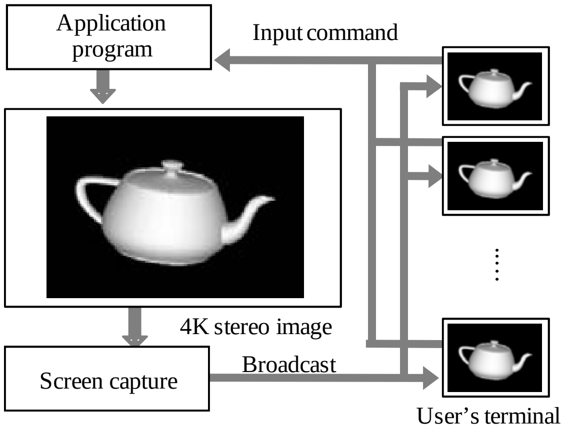

Fig. 5. Mechanism of screen capture method.


Fig. 6. Sharing image between center screen and terminal[6].

5. Conclusions

In this study, as a concurrent design environment in which designers can perform the collaborative work sharing the necessary data, the CDF room was developed. This system aims at realizing the intuitive and accurate collaboration among designers using the super high definition stereo image projected by the 4K projectors. Particularly, in order to share the visualized image among designers, the image sharing function between the center screen and the user's terminal was implemented.

In the current status, the basic functions for sharing image data have been implemented. Future work will include improving the function of interactive operation and applying it to the practical collaborative work to evaluate the effectiveness in the collaborative design.

Acknowledgement

This study was supported by Keio University Global COE (Center of Education and Research of Symbiotic, Safe and Secure System Design) Program. And we would like to thank Yasuaki Nishida (NHK Media Technology, Inc.), Hideo Miyachi (Cybernet Systems Co.,Ltd.), Taiki Tanimae and Takehiro Matsuo (Fiatlux Corporation) for their supports.

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