Tiled Display Communication Using Multiple Fish-eye Cameras

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Abstract

In this study, collaborative work environment between remote places was constructed by using tiled display system equipped with multiple fish-eye cameras. This system measures the user's fingertip position as well as transmits the user's image by sensing the space in front of the display surface. Then, the remote users can communicate with each other by using the pointing interaction. These functions enable the users to perform intuitive and natural collaboration while sharing high resolution information.

Keywords: tiled display, fish-eye camera, collaborative work

1 Introduction

In recent years, it has become possible that users in remote places communicate with each other by transmitting their live videos mutually through high speed network. As a next step, it is desired that the remote users perform collaborative work by sharing necessary information. In the current video chat or video conferencing systems, though the users' images are transmitted mutually, they cannot feel the sensation of sharing the collaboration space. This study aims at constructing effective collaboration environment in which users can perform high presence collaborative work while sharing necessary information between remote places.

In order to realize such a purpose, communication environment in which necessary information can be shared using the tiled display system [Renambot 2006] was constructed. In this system, it is expected that the users can perform effective collaboration by displaying the remote user's figure and the shared information on the high resolution tiled display. In particular, this system realizes natural interaction based on pointing gesture by using fish-eye cameras that capture the user's image and track the position of the user's fingertip. Therefore, this system can be used for the collaborative work in various application fields such as design, research, education, etc. In this paper, the concept of the tiled display communication, the system configuration, and the technological principle of video avatar and pointing interaction are explained.

2 Concept of Tiled Display Communication

In order to realize high presence communication between remote places, the following requirements are given. 1) high resolution large display should be used, 2) full scale image of the user can be displayed, and 3) natural interaction based on the user's gesture can be used. Namely, this means that not the communication on the desktop terminal but the communication in the shared space is important. In this study, in order to realize these functions, the communication method using the tiled display equipped with fish-eye cameras was developed. The tiled display consists of twelve (4x3) 20-inch LCD monitors (Dell 2007FP). Since the resolution of each monitor is 1600x1200, the total resolution of the tiled display is 6400x3600. As software for rendering images on the tiled display system, SAGE library is used.

In this system, the multiple fish-eye cameras (KEIYO SKP-R705 VHB, Minilens 1.24mm) are attached to the bezels between monitors of the tiled display system. Since the fish-eye camera can capture the scene with wide viewing angle of about 180 degrees, it can sense the whole space in front of the display wall. The sensing image can be used to measure the position of the user's fingertip as well as to capture the image of the user who is standing in front of the tiled display. By using these functions, video avatar and pointing interaction technology were implemented to realize the effective collaborative work. Figure 1 shows the concept of the remote communication based on the space sensing, and figure 2 shows the tiled display system with multiple fish-eye cameras.

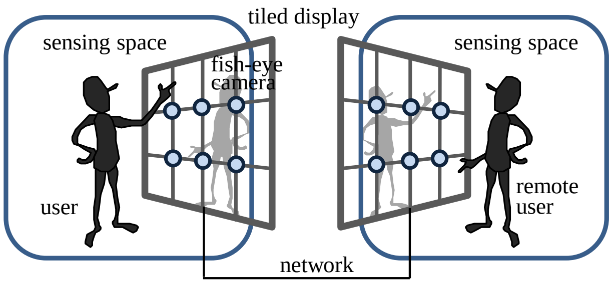

Figure 1. Concept of Tile Display Communication

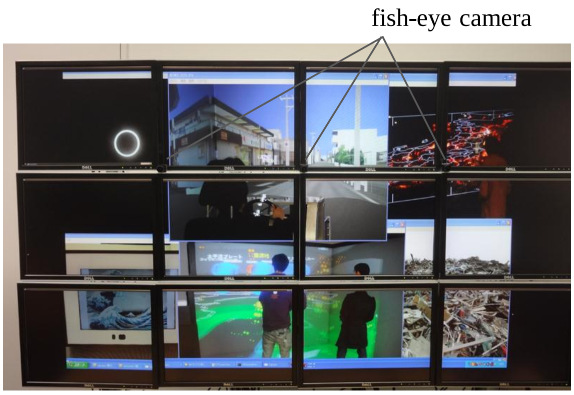

Figure 2. Tiled Display with Multiple Fish-eye Cameras

3 Video Avatar

The fish-eye cameras are used to generate a video avatar. The image of the user who is standing in front of the tiled display is captured with the wide angle background image. Therefore, it is necessary to segment only the user's figure from the background

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and correct distortion in the fish-eye image to create the video avatar image.

First, in order to segment the user's figure from the captured image, background subtraction method is used. In this method, the background image without users is captured beforehand. And when the user's image is captured, the difference between the captured image with the user and the background image without the user is calculated and only the user's figure is segmented [Ogi 2009]. Next, the fisheye distortion that is contained in the captured image is corrected. In this process, the camera parameters and the distortion values in the captured image is calculated beforehand from the deformation of the checkerboard pattern using OpenCV library, and they are used for the distortion correction of the captured image. However, since the surrounding area of the fish-eye image cannot be completely corrected due to the restriction of the checkerboard size, a portion of the image in the center area (260 by 260 pixels) is cut out and it is used for the communication. Figure 3 shows the process of making a video avatar of the user. By using this method, it has become possible to represent the remote user's figure overlapped on the shared information.

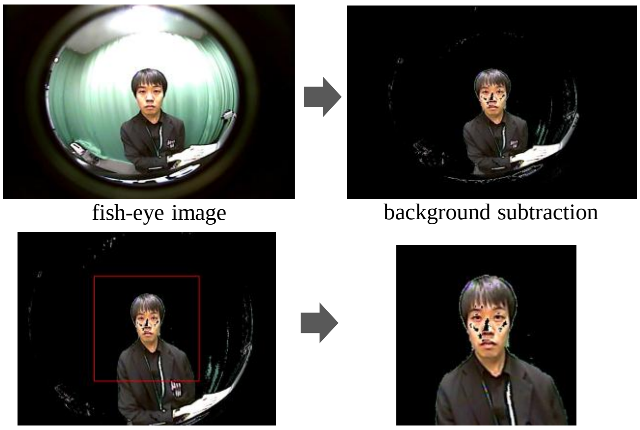

Figure 3. Process of correcting user’s image

4 Pointing Interaction

Since the viewing angle of the fish-eye camera is about 180 degrees, it can capture wide image up to monitor surface. Therefore, when the user points at the monitor surface, the fingertip position can be recorded in the peripheral area of the fish-eye image. The direction of the fingertip seen from the camera position can be identified by the interrupted point on the circumference of the fish-eye image. When the direction of the interrupted point is identified by two fish-eye cameras, the fingertip position on the tiled display wall can be calculated as the intersection point. Figure 4 shows the method of measuring fingertip position from the images captured by fish-eye cameras.

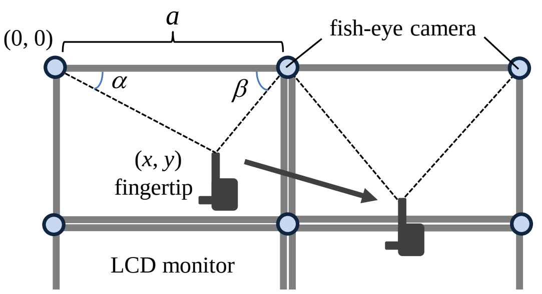

Figure 4. Measurement of Fingertip Position

Since the actual positions of the fish-eye cameras are already known, the fingertip position of the user can be calculated from the directions of α and β as follows.

$$x = \frac{\cos\alpha \sin\beta}{\sin\alpha\cos\beta + \cos\alpha\sin\beta} a$$

$$y = \frac{\sin\alpha \sin\beta}{\sin\alpha\cos\beta + \cos\alpha\sin\beta} a$$

By installing this function in each monitor, the fingertip position on the whole surface of the tiled display can be measured and it can be used for the pointing interaction on the large display surface.

5 Information Sharing

By using the above mentioned video avatar and pointing interaction functions, intuitive and natural communication in the high resolution shared space between remote places can be realized. Figure 5 shows that the remote users are conducting communication while sharing the information of photograph data. In this application, the images on the local PCs are captured at constant time intervals and they are transmitted to the tiled display system to share them between remote places.

Figure 5. Tiled Display Communication Sharing Photograph Data

6 Conclusions

In this study, in order to realize effective collaborative work between remote places, the concept of space sensing using fish-eye cameras was proposed. In this method, the segmented user's image is used for the communication, and the measured fingertip position is used for the pointing interaction. By using these techniques, high presence and intuitive communication between remote users becomes possible and this system is expected to be used in the intelligent collaboration environment. Future work will include developing a concrete collaborative work support system by applying this technology.

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