Efficient Tiled Stereo Display System for Tangible Meeting

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Abstract

In this paper, we present a tiled display system for tangible meeting. We built our system as a distributed system and use GPU based warping and image blending technique for real-time processing. For efficiency, we update specific area only, where the remote user exist, in real-time and blended it with static panoramic image of remote site.

1. Introduction

For immersive and tangible meeting with a remote user, it is important factor to provide large scale display with high resolution to cover up the field of view. To display high resolution image of remote environment, we must have high resolution image source. However, the transmission of high resolution images needs high network bandwidth. Although we can use gigabit Ethernet owing to the development of network device industry, we still need higher bandwidth network to transfer the high resolution image which can cover the cubical large screen environment, especially for stereo display. In this paper, we propose a new system for efficient large scale display. Figure 1 shows the conceptual view of our proposed system. According to figure 1, you can see that a user in local site can see the remote user with remote environment in our system. It makes for user to feel as if he also exists in a remote site. To do this, we first construct a high resolution environmental map for remote site in advance and then display to each wall with 4 projectors in large screen environment. However, we don't need to update the whole remote environmental map because it doesn't change dynamically except the area of around user. If we can segment the remote user from camera image automatically in real-time, we have only to synthesize it into the environmental map considering the position.

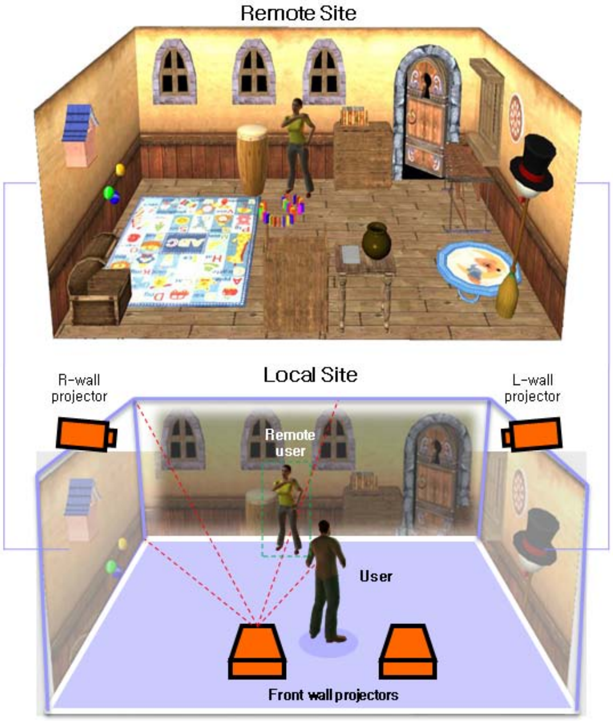


Fig.1. Conceptual view of proposed system

However, it is hard to segment an object from natural scene in real-time. Therefore we receive a whole frame, which includes a remote user, captured by remote-camera through the Ethernet. Then, we synthesize the transmitted frame to the high resolution environmental image. To do this, we have to extract the feature points and then match to find the corresponding features. After finishing the matching process, we can warp the transmitted image to align the environmental image seamlessly. The details for this process will be addressed in the following section.

2. Experimental Details

To build a tiled display, we used real-time warping and blending technique using GPU and implemented as a distributed system to support parallel processing of each projector. Since the real-time image warping requires large computational complexity, previous approaches used special hardware system to support that kind of work. However, there has been a great improvement in the performance of GPUs, we can utilize the power of GPUs to handle the real-time warping process[1,5].

As mentioned above, for network efficiency, we only update the active region of remote environment, where a remote user can occupy, with network cameras. In this case, we have to register the updated region to the static panoramic image which can cover the field of view for remote environment and was made in advance[6].

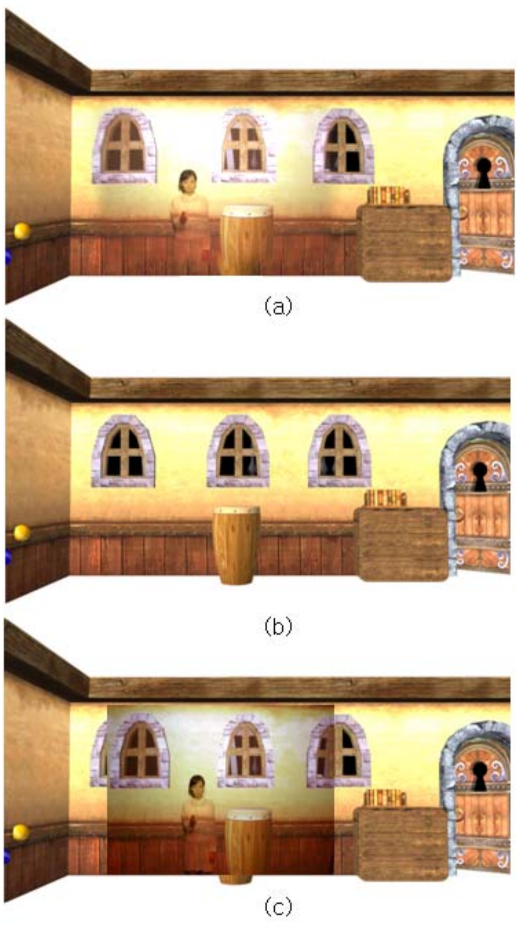


Fig. 2. Update active region of remote environment

Fig. 2 shows the process of updating active region of environmental map in local site. Fig. 2(a) shows the scene captured when the remote user appears. Fig. 2(b) shows the reconstructed scene of remote environment in local site. We can express the Fig. 2(b) is a static panoramic image of remote environment. Fig. 3 shows the composition between transmitted image from remote camera and a static panoramic image in local site before alignment process. As shown in Fig. 3(c), the transmitted image does not synthesized with background seamlessly. To make a seamless composition, we have extract feature points from both static panoramic image and transmitted image. We apply Lukas-Kanade feature tracking method to extract candidate feature points from images[2,3]. After extracting feature points, we find matching points and calculate homographies[4]. It is redundant process to apply feature extraction and matching process for every frame. After those processes, we apply optical flow method to track the extracted feature points. This process can reduce the computing complexity. Finally we can apply warping and blending process with calculated homographies[4].

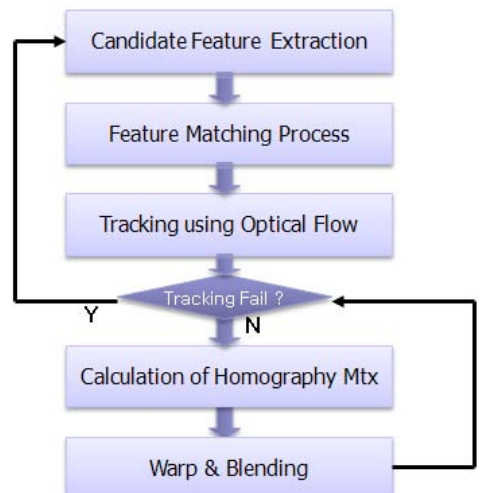


Fig. 3. Flowchart of aligning process

In Fig.4, we show the alignment result with process mentioned above and blending results in (a) and (b), respectively.

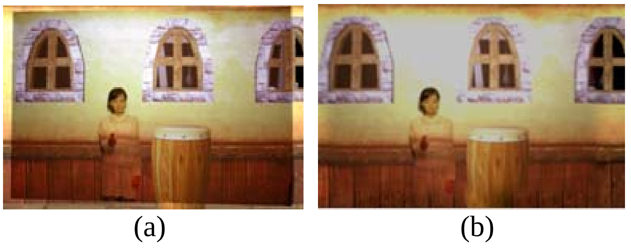


Fig. 4. Warping and blending process

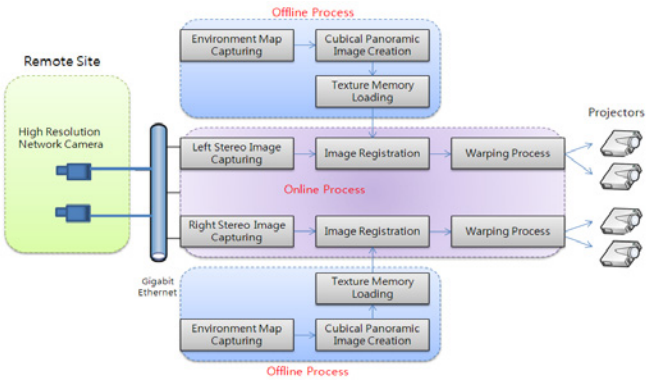
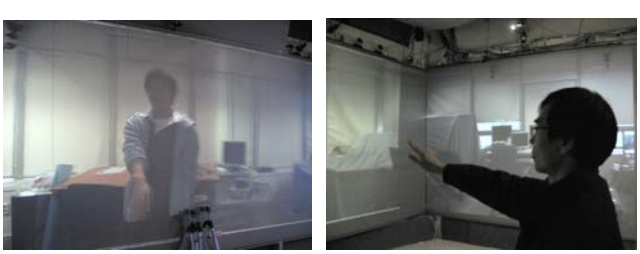


Fig. 5. Extension to stereoscopic display

In Fig.5, we show the flowchart for the extension of our system explained above to display active region stereoscopically. The overall system architecture is similar to the system with single remote camera, however, we need two high resolution network cameras to capture the stereo images from remote site and two more projectors and processing computers. In offline process, we build each environmental map for left and right view from remote stereo cameras. After building environmental map, we register to each map with transmitted frame for each view in real-time.

Fig. 6 shows the display example of rendering the reconstructed remote world. In fig. 7, we show the picture taken from the real demonstration of telemeeting between remote user and local user.

Fig. 6. Example of environmental map display



(a) (b)

Fig. 7. Meeting example between local and remote user

4. Summary

In this paper, we propose an efficient tiled display system for tangible telemeeting. For tangible telemeeting, we must support immersive environment such as large screen, haptic devices and surround sound system. Among them, we focus on the immersive large display system in this paper. To display high resolution image of remote environment, we must have high resolution image source. Even though we can have high resolution images of remote site with several cameras, the transmission of high resolution images needs high network bandwidth. This can be a critical condition to build a real-time system. For network efficiency and reducing computation complexity, our proposed system only updates the region changed actively by user. For seamless synthesis, GPU based warping and blending technique is applied in our system. More robust feature extraction and matching algorithm is essential to improve the synthesized image quality. Currently, we focus to develop robust and fast feature matching and tracking algorithm, especially under the occlusion state.

5. References

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