Telepresence Systems for Large Interactive Spaces

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Abstract

The need to analyze and manipulate large datasets and perform complex tasks with computers has increased interest in wall-sized displays and virtual reality systems. As such environments become more common, the need to support telepresence across these large interactive spaces becomes critical for remote collaboration. In this workshop paper, we present our past work on remote collaboration, telepresence and large interactive spaces as well as our ongoing projects to support telepresence in such spaces for face-to-face and side-by-side collaboration.

Author Keywords

Telepresence; Remote collaboration; Wall-sized display

ACM Classification Keywords

H.5.3 [Group and Organization Interfaces]: Collaborative Computing; CSCW; H.4.3 [Communications Applications]: Computer conferencing, teleconf., and videoconf.

Introduction

Large interactive spaces such as rooms with wall-sized displays or immersive virtual reality systems are becoming more common to help users manage the increasing size and complexity of data in science, industry, business and society. Uses of such spaces are diverse, ranging from analyzing scientific data to visualizing complex physical
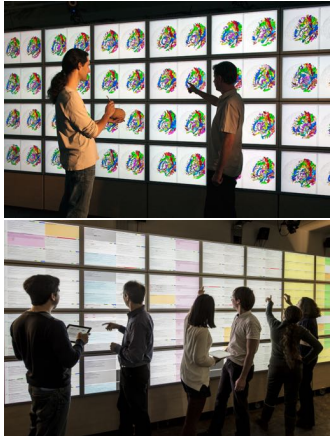
Figure 1: Co-located collaboration using a wall-sized display (comparing brain scans [3]; scheduling a conference [8])
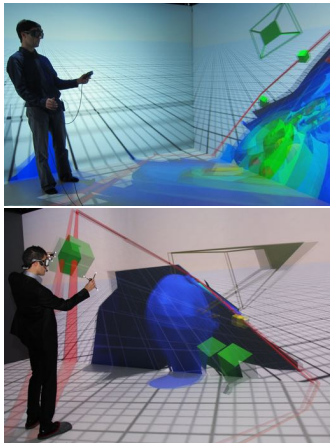

Figure 2: Remote collaboration in virtual reality systems (scientific data analysis) [6]

simulations, reviewing large CAD models (trains, aircraft, etc.) or scheduling complex events. The ability to display large amounts of information and to improve the spatial organization of this information offers new opportunities to manage extremely large and complex datasets and computations. Large interactive spaces are also powerful tools to support creativity and can be used for brainstorming and combining ideas in the context of product design, artistic creation or crisis management.

Complex tasks usually do not involve a single participant, but require strong collaborations among groups of users. Large interactive spaces naturally support collaboration among small groups of users working together in the same room. Even though participants are more and more often located remotely, remote collaboration is still poorly supported by large interactive spaces. For instance, current telepresence systems are designed for meetings where users sit around a table, omitting the case where participants move and work on shared data. As a consequence, tasks such as remotely analyzing datasets, teaching or creating dance and music performances cannot be carried out effectively today by distributed groups.

Previous Work
Our research group has worked on interaction with ultra-high resolution wall-sized displays [3]. Some of this work has addressed co-located collaboration (Figure 1). For example, we used our large wall-sized display to show the entire CHI 2013 program. Up to 10 people worked collaboratively to detect and solve scheduling issues [8].

We have also addressed remote collaboration in virtual reality, covering both technical aspects of distributed virtual environments [5] and collaborative interaction among remote users [4]. In particular, we ran experiments to study collaborative manipulation techniques for analyzing scientific data among users located in two immersive systems in Rennes and London [6] (Figure 2).

We have worked on videoconferencing and telepresence. We conducted early work on media spaces [9], including deploying the largest known analog media space, at Xerox PARC (KASMER) [2], conducting field studies of a real-world media space (WAVE) [11] and exploring novel forms of video-mediated communication [12]. We have also explored 3D head reconstruction [7] in the context of 3D telepresence systems [10].

More recently, we have started to study theoretical aspects of telepresence. We conducted a controlled experiment to assess the accuracy of users when determining remotely pointed objects on a wall-sized display [1]. The experiment consists of showing video recordings of actors pointing at shared targets on the wall-sized display. We found that showing objects using only the head can be more precise than using the head and arm, and that the relative position of the observer to the display of the video feed has almost no effect on accuracy. Based on these findings we presented implications for designing telepresence systems for wall-sized displays.

Telepresence across Large Interactive Spaces
We have started a large project, called DIGISCOPE, to create a high-performance visualization infrastructure for collaborative interaction with extremely large datasets and computations in the context of scientific data analyses, design, engineering, decision-support, education and training. DIGISCOPE consists of ten interconnected large interactive spaces, including virtual reality systems, 3D display devices, large wall-sized displays and a variety of interaction devices such as motion trackers. One of the
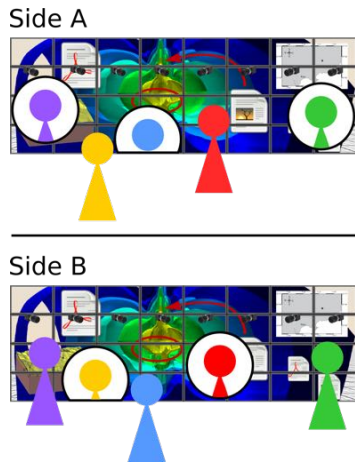
Side A

Side B

Figure 3: Telepresence system for face-to-face collaboration based on a camera array

main goals of DIGISCOPE is to create a unique infrastructure to develop and study telepresence systems for large interconnected interactive spaces. At the time of this writing, nine of the ten rooms are operational and the telepresence system interconnecting them is being created.

In the context of DIGISCOPE, we want to create novel collaborative systems that support remote collaboration within and across large interconnected interactive spaces. We will explore cases where users interact together either in the digital world, e.g. collaborative interaction on the same dataset, or in the physical world through the computer, e.g. remote design and fabrication of physical objects. In particular, we want to develop telepresence systems that support a collective sense of co-presence (feeling of "being together"), non-verbal cues, turn-taking and shared understanding of the situation in settings where users can move freely in the rooms.

The main challenge is to find solutions for capturing videos of several users who can freely move in the room, and showing these captured videos on large display surfaces. A camera with a wide field of view that can cover the entire room is not an option because we need to have a close view of the users to be able to perceive eye-gaze direction, facial expressions, etc. Similarly, using the entire display to show video feeds at fixed positions is not possible because users need to display other content and to move in front of the display. The proposed systems will have to maintain direct eye contact even if users move in the room. We plan to study two solutions that correspond to two remote collaboration scenarios.

Face-to-face collaboration
The first system is based on a camera array and supports virtual face-to-face collaboration (Figure 3). Camera arrays are usually used for 3D reconstruction or image

processing, but they are still not widely used for real-time video acquisition in telepresence systems. We plan to design a system with multiple cameras attached to the screens that will allow to select the most appropriate camera to capture the view of a particular user. We also want to explore different ways to show remote users such as moving the video to follow the remote user's location or the position of the local observer.

Side-by-side collaboration
The second system is based on a mobile screen located on the side of the main display (Figure 4). This additional screen displays the remote users and thus supports side-by-side collaboration. Tanner and Shah [13] showed that side-by-side collaboration can be more appropriate than face-to-face depending on the task, but studied it only with laptops. We believe this way of collaborating is especially relevant in the context of large interactive spaces, and we want to use independent mobile screens to implement it in such environments.

Conclusion
As the need for remote collaboration in distributed working environments increases, we want to develop telepresence systems suitable for large interactive spaces. We have conducted a number of studies about co-located collaboration on a wall-sized display and remote collaboration in immersive virtual reality systems. We have also investigated media spaces and 3D telepresence systems. More recently, we have studied the use of deictic instructions for shared objects on a wall-sized display. We plan to continue our exploration of telepresence systems across large interactive spaces in various scenarios, including face-to-face and side-by-side collaboration. This workshop is an unique opportunity to discuss how telepresence systems can better support non-verbal cues
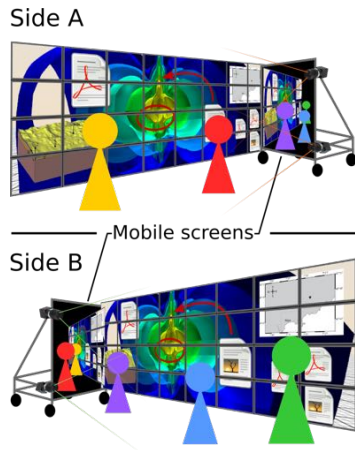
Side A

—— Mobile screens ——

Side B

Figure 4: Telepresence system for side-by-side collaboration based on mobile screens located on the side of the display

such as gaze awareness and deictic gestures, how new collaboration scenarios can benefit from side-by-side collaboration, how telepresence robots can be used in large interactive spaces to capture mobile users and display them appropriately, and how the social aspect of group communication is affected when using large displays.

Acknowledgements

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