Mixed Reality for supporting Remote-Meetings

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Abstract. Nowadays meetings are no longer physically tied to one place. Especially in knowledge work, telephone calls or Skype conferences have long since complemented classic face-to-face meetings. Various research discourses, especially computer-supported group work, have been investigating for almost three decades how distributed group work can be supported in its various forms using IT. With the increasing performance of technologies focusing on Augmented Reality (AR) and Virtual Reality (VR), new possibilities have been added that offer a high potential for supporting distributed meetings. With this prototype, we present an approach that combines AR and VR to implement a communication system with various collaboration options for the appropriate support of distributed meetings. Our prototype focuses on scenarios in which two or more people are in the same room and one or more people are absent physically, but both parties can still cooperate remotely at the same time.

Keywords: Augmented Reality, Virtual Reality, Collaboration, Remote-Meetings

1 Introduction

Remote meetings have become a common feature of everyday work in many industrial and commercial contexts where cooperative tasks are required. Supporting such remote meetings through technology has long been one of the most important discourses within Computer-Supported Cooperative Work (CSCW) and Human-Computer Interaction (HCI) [1–6]. However, the problem of the appropriate degree of immersiveness has not gone away and representing work activities at a distance is still difficult. For instance, video conferences via Skype are based on face-to-face communications and lack support for dynamic and interactive activities such as work on whiteboards or with physical artifacts, which are important parts of practical collaboration during a meeting [7]. Other approaches focus on setting up complex structures equipped with multiple screens and cameras which offer an improved immersive experience, but are not necessarily applicable for mobile or ad hoc work tasks that are typical for modern cooperation [8–10].

With the increasing efficiency of technologies focusing on Augmented Reality (AR) and Virtual Reality (VR), new possibilities for supporting distributed meetings have opened up. Research to date already shows the possibilities of AR and VR for

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improving remote cooperation [11–14]. However, the focus of current research remains for the most part either on VR as a digital meeting room or on AR as a supportive technology for face-to-face communication [15]. In our prototype we combine both technologies and contribute with insights into how to design an immersive approach that makes use of AR as well as VR to support remote cooperation within creative and object-oriented settings.

The system we present creates an immersive experience during remote meetings and offers additional collaboration options that are less fully realized in knwon video conferences. The goal is that the participants of the meeting, although they are at different locations physically, have the feeling of being together in a real room, using shared artifacts and being able to collaborate just like they would in face-to-face situations. Our prototype focuses on scenarios in which two or more people are in the same room and one or more people are absent but can cooperate remotely at the same time.

2 Description of the Prototype

In this section we present the implementation of the first iteration of our prototype. With regard to related research, we mainly focused on the topic of social presence and cooperation within remote meetings.

We built the entire system for the remote (VR) and local (AR) perspectives using the Unity game engine. For local participants, we used the Microsoft HoloLens, making use of its spatial mapping capability and hence its facilitation of free movement in the room, without being tied to a desk or immobile computer. For the remote person, we used the HTC Vive, because of its room scale tracking capability, which allows a more natural movement in the virtual environment. The remote person sees the virtual representation of an ideally well-known meeting room, which looks the same as the real room where the local participants meet. The virtual and real rooms are aligned by a visual marker, placed at a predefined position in the real room and scanned by each HoloLens user before joining the meeting session. Marker detection is done by Vuforia computer vision technology. The marker is used as a reference point to calculate the correct position for displaying the other participants and artifacts. All involved persons see a digital representation of the other participants as avatars exactly where they are in either the real or the virtual meeting room. Everyone is able to move freely and interact with each other naturally.

2.1 Creating a high sense of presence

One goal of our prototype is to involve (or at least create the illusion) the remote participants as actors in the exact same space as the local participants. We therefore try to satisfy the principal determinants of presence [16]. For further immersiveness, we created a fully virtual copy of the real room by using a combination of laser scanning and photogrammetry which, combined, delivers a highly detailed 3D model with almost photo-realistic textures. Besides visual information about the remote space, auditory cues are provided in the prototype. Therefore, the voice of all participants is transmitted as positional sound, in order to allow the users to locate people, even if they are currently not in their field of view.

We further implemented view independence for the remote person. The view independence is not limited to looking around, like in a 360-degree photo or video, because the VR-participant is also able to move independently in the virtual environment. The vividness of the environment is achieved through the presence of the other participants. Because the 3D model of the room is static, the environment itself is not interactive in its current state. With the goal to create a higher sense of presence, we therefore integrated specific elements in the room, so that all participants can interact with each other and the environment. Changes in these elements are transmitted to all other participants in real time. We assume that all these properties lead to a high degree of perceived presence, which should improve the involvement of the remote person.

2.2 Collaboration tools

As simple tools like a whiteboard help solving simple problems that are hard to articulate verbally, we implemented a virtual whiteboard. It is a simple white area in the size of classic whiteboards and it is placed at the same position where the real whiteboard is placed in the meeting room. The virtual whiteboard is visible to all participants, both remote and local, and everyone can draw on it. The drawing is transmitted in real time, so one can draw and explain his drawing at the same time. For our first iteration of the prototype we limited the functionality of the whiteboard to draw in four different predefined colors (black, red, blue and green), erase and to clear it completely. To select another color or to erase and clear, we placed six buttons on the left side of the board. The interface is looking the same locally as well as remotely, but the actual use differs through the interaction concepts of the hardware.

We also implemented a shared agenda for the current meeting. This agenda is placed on an empty wall of the room and is visible for all participants. The agenda is designed in a way that all participants are informed about the topics of the meeting. The agenda looks like a to-do-list where every user is able to check the tasks on the agenda.

An important factor of meetings is an appropriate time management. Schneider et al. [17] observed that the perception of time alters while being in a VR experience. To reduce this effect, we added an analog clock above the door of the meeting room, which is visible for all participants. Although our prototype has limited elements of this kind, we feel, that it carries some important implications with respect to the need to identify exactly what tools and implements need to be shared in what collaborative contexts. Our aim over time is to provide a library of virtual artifacts which can be used to construct a usable meeting room regardless of purpose.

2.3 Representation of the participants

In order to reach the goal of a more natural communication, all participants have to see each other or at least a representation of the participants. To keep the hardware setup simple, we chose three-dimensional avatars as a representation format. There is a wide range of different options for avatars. As Greenwald [18] pointed out, even very abstract avatars can enhance the perceived degree of social presence. We decided to use abstract avatars, which only consist of a head, a generic torso and hands. The head and hands are not connected to the torso. For the head we used two different abstract and low-poly 3D models of animal heads - a panda and a raccoon. Both models have clearly recognizable faces with eyes, but no mouth. Matching this, we implemented paws as hands. The pose of the HMDs is transmitted immediately to the head of the avatar. Even small motions like nodding are represented by the avatar. One is also able to recognize where someone is looking. This should lead to a more fluent and natural communication in the remote setting. This natural communication is supported by transmitting gestures. For the remote VR-participant, the poses of the controllers are transmitted to the paws of the avatar, but there is no animation for every single finger. On the local AR side, we use the hand tracking technology of the HoloLens. Unfortunately, the HoloLens only reports the position of the user's hand if it matches one of the predefined HoloLens gestures. The rotation of the paw is fixed and aligned to the yaw of the user's head because the HoloLens does not provide the rotation of the tracked hands. When the hands are not tracked by the HoloLens, the paws will disappear. The following figures give a short overview of the system:

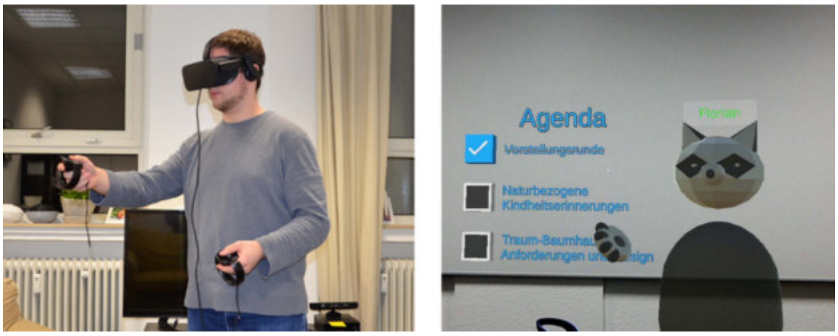

Figure 1: Left: Remote participant in his living room, right: his representation for the AR users.

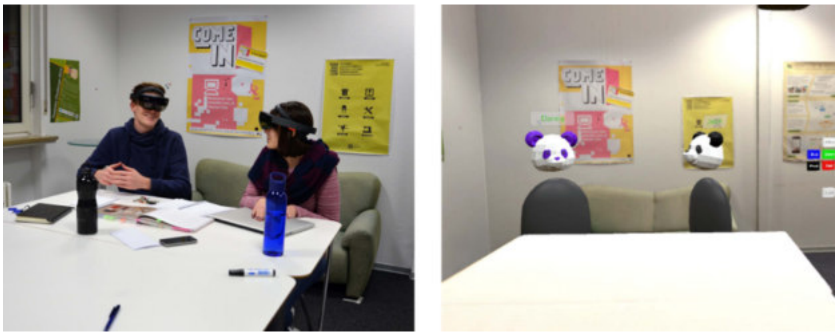

Figure 2: Left: Local participants in the meeting room, right: their representation for the VR users.

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