Enabling Remote Proxemics through Multiple Surfaces

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Figure 1: Our vision of Eery Space: a remote user controls the wall display, two users in different physical spaces collaborate and a fourth user looks at them through a virtual window.

Abstract

Virtual meetings have become increasingly common with modern video-conference and collaborative software. While they allow obvious savings in time and resources, presence is still elusive. Indeed, remote participants complain about reduced presence away from the "main meeting", whereas local participants have trouble noticing remote peoples' activities and focus. We present Eery Proxemics, an extension of Proxemics aimed at bringing the syntax of proximal interactions to virtual meetings and increasing awareness of remote participants' activities and situation. Our work focuses on virtual meetings facilitated by multiple surfaces, ranging from wall displays to tablets and smartphones. Therefore our goal is to increase mutual awareness of participants, who cannot see each other from different locations, through a shared virtual space. We call this shared realm the *Eery Space*. Through it we are able to make proxemic interaction area visible to/from far participants to afford proximal interactions and exchanges among meeting participants. Preliminary evaluations carried out with people outside our research group, indicate that our approach is effective at enhancing mutual awareness between participants and sufficient to initiate proximal exchanges regardless of physical location.

Author Keywords
Interaction Design; Remote Proxemics; Multiple Surfaces; Collaboration; Awareness; Eery Space

ACM Classification Keywords
H.5.2 [Information Interfaces and Presentation (e.g. HCI)]: User Interfaces

Introduction
When people get together to discuss, they communicate in several manners, besides verbally. Hall [9] observed - that space and distance between people (Proxemics) impact interpersonal communication. While this has been explored to leverage collaborative digital content creation [12], nowadays it is increasingly common for work teams to be geographically separated around the globe. Tight travel budgets and constrained schedules require team members to rely on virtual meetings. These conveniently bring together people from multiple and different locations. Indeed, through appropriate technology, it becomes possible to see others as well as to hear them, which means it becomes easier to communicate verbally and even non-verbally at a distance.

The newest videoconferencing and telepresence solutions support both common desktop environments and the latest mobile technologies, such as smartphones and tablet devices. Notable examples include Skype[1] and FaceTime[2]. However, despite considerable technological advances bent on bringing people together, remote users in such environments often feel neglected due to their limited presence [13]. Moreover, although verbal and visual communication may be easy in virtual meetings, other modes of engagement, namely proxemics, have yet to be explored. Yet, Reeves and Nass work [15] suggests that this is not only possible, but desirable.

In this work, we introduce *Remote Proxemics* as a tool to interact proximmally with remote people. To this end, we explore the space in front of two or more wall-sized displays in different sites, where local and remote people can meet, share resources and engage in collaborative tasks, as illustrated in Figure 1. We propose techniques that enable people to interact as if they were located in the same physical space, as well as approaches to enhancing mutual awareness. Finally, we present a preliminary user evaluation of our approach.

Related Work
Shared immersive virtual environments [14] provide a different experience from "talking heads" in that people can explore a panoramic vision of the remote location. The most suitable systems for collaboration are spatially immersive, either via large scale-, tiled- or, even CAVE-like- displays. These systems provide the necessary size for all people in a meeting to see others and support the physical space needed for collaborative work in two remote rooms. As an example, Cohen et al. [5] present a video-conferencing setup with a shared visual scene to promote co-operative play with children. The authors showed that the mirror metaphor could improve the sense of proximity between users. Following a different metaphor, Beck et al. [3] presented an immersive telepresence system that allows distributed groups of users to meet in a shared virtual 3D world. Participants could meet front-to-front and explore a large 3D model.

While most common user interfaces require active input from people to perform an action, such as the push of a button, some systems have the ability to react to the

[1] Skype: http://www.skype.com/
[2] FaceTime: https://www.apple.com/mac/facetime/

presence of users. For this, it is important to detect their presence, and to analyze the spatial relationships between people. Hall [9] stated that spatial relationships can give out information about the intentions of people to communicate and interact with each other. Laga et al [10] suggested that the concept of private space can be used as indicative of a non verbal communication and defined a mathematical model to identify these spaces. More recently, Marquardt [11, 12] proposed using proxemics interactions to mediate people, devices and non-digital objects. They demonstrated that, by analyzing distance and orientation, applications can change data displayed on the screen or react to people by implicitly triggering functions.

Eery Space

To explore proxemic interactions between physically apart users, we created a common virtual space, to overcome the physical distance separating them. We call this shared virtual locus *Eery Space*, where people equipped with personal handheld devices can meet, collaborate and share resources in front of a wall display, as depicted in Figure 2. Instead of placing users in front of each other, as typical of commercial applications and other research works [3, 4], we place both remote and local users side-by-side, similarly to Cohen et al. [5], maintaining their positions in front of the wall display. We consider both a user's position alongside the wall and their distance to it. Contrarily to the common interactions with remote users using the mirror metaphor, we provide for a sense of remote users being around local users in the same shared space. This creates and reinforces the model of a shared meeting area where interactions can take place. Furthermore, all wall displays show the same perspective to make shared references plausible.

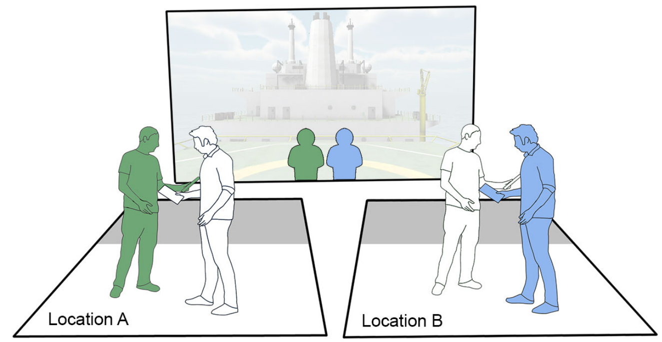

Figure 2: Two people in different locations interacting in the Eery Space. Wall displays in both locations show the same. Grey area on the floor illustrates the moderator space, in which a user can take control of what it is shown on the wall displays.

Interaction Design

By placing users in the same common virtual space, albeit being geographically apart, new ways of interaction become possible. These new interactions take into account the personal space of each user. Despite their not being in the same physical space, the locus of a remote user must be accounted for, fostering interactions with local people as if the remote user were actually there. Unlike conventional systems which strive for eye-contact we focus on proximal interactions.

Remote Proxemics

We devised remote proxemics to be able to capture the natural interactions that occur between co-located people and make them available to users who are not physically in the same room. Previous research indicated that people can respond socially and naturally to media elements [15]. Thus, we allow remote users to interact through appropriate virtual proxies, by making both the shared space and actions mutually visible.

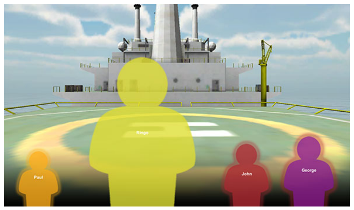

Figure 3: Users' shadows on the wall display. The larger shadow indicates that the its user has the moderator role. The two users on the right with red auras participate in the same bubble. The larger the shadow the closer a person is to the wall.

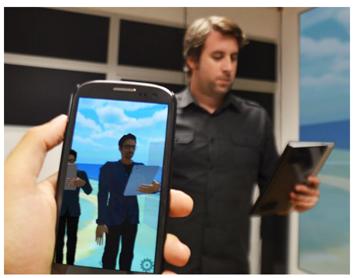

Figure 4: Virtual window offers a personal view to the virtual world, showing users' avatars with their position and orientation accordingly to the wall, from the device owner's point of view. In this case two users are shown, one local and one remote.

Within Eery Space when a user enters another person's personal space (1 meter from their position), they can start interacting in what we call an *Interaction Bubble*. This bubble can encompass two or more users, either local or remote. When located in the same bubble, users can engage in collaborative activities. In our prototype, users can create joint annotations, and have the ability to see the other's sketches in real-time.

Moderator

In Eery Space, the moderator is a person that has special authority to take control of the common visualisation on all wall displays, by mirroring actions made on the handheld device. This authority is granted to whom gets closest to the display, inside the moderator space (as illustrated in Figure 2), taking advantage of person-to-device proxemic interactions. The current moderator relinquishes their role when leaving the moderator space. If this happens and another person is standing in that space, then they become the new moderator. Otherwise, the moderator role will be open for anyone to take.

Providing Awareness

While become and staying aware of others is something that we take for granted in everyday life, maintaining this awareness has proven to be difficult in real-time distributed systems [8]. When trying to keep people conscious of other peoples presence, an important design issue is how to provide such information in a non-obtrusive, yet effective manner. Following the collaborative guidelines proposed by Erickson and Kellog [6], we used the techniques described below to increase visibility and awareness of other users, namely for remote participants, either through the wall display or via individual handheld devices.

Wall Shadows Every person has a representative shadow on the wall display, distinguished by a name and a unique colour, as shown in Figure 3, in a similar fashion to the work of Apperley et al. [1]. The size of the shadow reflects distance from the person to the wall to give a sense of the spacial relationship between the people and the interactive surface. A larger shadow also makes it clear who is the moderator. Furthermore, each user has a coloured aura around their shadow. When two or more people share the same aura colour, this means they are in the same bubble and can initiate collaborative tasks.

Virtual Windows provide a more direct representation of other users' position and orientation. These depict a view into the virtual world, in a similar manner to the work of Basu et al. [2]. Using the combined information of users' position and the orientation of their handheld device, we calculate the user's own perspective, allowing them to point the device wherever they desire. The virtual window shows both local and remote users (Figure 4), represented by avatars within the virtual environment.

Bubble Map Whenever a user tilts their handheld device to an horizontal position, a partial top view of the Eery Space is displayed, as depicted in Figure 5. In the center of the screen, its owner is represented by a large white circle. Other users who are close enough to lie in the same Interactive Bubble as the device owner's are also portrayed as large circles, painted with the colour of each user. Users outside the bubble are considered off-screen. Resorting to an approach similar to Gustafson et al. [7], we place these circles (smaller than users in the same bubble) on the screen edge, indicating their direction according to the device owner's position.

Intimate Space We designed Eery Space keeping each person's personal locus in mind. Every user has their own

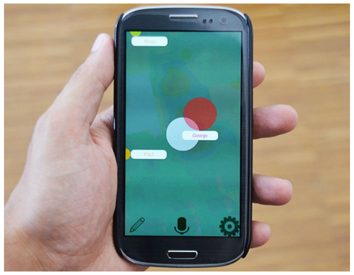

Figure 5: User's bubble map. The large white circle in the center represents the device's owner. The large red circle on its right represents a user in the same bubble. The two small circles on the screen edge are users outside the device's owner bubble.

space assured, even if they are not in the same physical room as the others. To prevent users from invading another user's intimate space, we provide haptic feedback by vibrating their handheld device, when this happens.

Preliminary Evaluation

To assess whether our techniques provide enough feedback for people to remotely interact, we conducted a small user experiment. We built our system using a multiple Microsoft Kinect-based tracker, which is able to track six users in a room, dealing with occlusions and resolving each users' position. We used Unity3D to develop a distributed system for multi-peer 3D virtual environment exploration, with support for display-walls, tablets and smartphone clients (iOS and Android). For this experiment, two participants were placed in different rooms equipped with a wall display. Our scenario is built around a 3D model design-review task. Both users were asked to take control of the wall, in turns, to navigate to a point in the model and then approach the remote user to start a collaborative annotation.

Through a qualitative questionnaire using a 6 value Likert scale (1 - very difficult, 6 - very easy), the six participants of our experiment indicated that it was easy (≥ 5) to perform the desired actions. Also, we found no significant differences on the difficulty of locating a remote user in *Eery Space* versus a local user (≥ 5 in both cases).

Conclusions and Future Work

In virtual meetings, remote participants often feel neglected due to limited presence. To alleviate this our Eery Space, brings proxemic interactions to users geographically apart. We explored both people-to-people and people-to-devices proxemics and developed techniques for providing the appropriate awareness for users' situation and actions, both local and remote. Results from a preliminary user evaluation, suggest that our solution is able to provide the means for people to engage in cooperative activities based on their location within the common virtual space and with respect to the wall displays.

For future work, we would like to learn whether photo-realistic avatars can enhance the sense of presence for local and remote users. Moreover, we intend to apply our concept to different fields, such as cooperative editing engineering models or medical data visualisation.

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