MirrorSpace: using proximity as an interface to video-mediated communication

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Abstract. Physical proximity to other people is a form of non-verbal communication that we all employ everyday, although we are barely aware of it. Yet, existing systems for video-mediated communication fail to fully take into account these proxemics aspects of communication. In this note, we present MirrorSpace, a video communication system that uses proximity as an interface to provide smooth transitions between peripheral awareness and very close and intimate forms of communication.

1 Introduction

Physical proximity to other people is a form of non-verbal communication employed everyday by us all, although we are barely aware of it. We constantly use space and distance to define and negotiate the interface between private and public matter, particularly during the moments leading up to contact. By altering our physical distance from other people in a space, we communicate subtle messages such as our willingness to engage into dialogue with them, the desire for more intimacy or a lack of interest.

The term *proxemics* refers to the study of spatial distances between individuals in different cultures and situations. It was coined by E.T. Hall in 1963 when he investigated man's appreciation and use of personal space. Hall's model lists four distances which Northern Americans use in the structuring of personal dynamic space [1]: *intimate* (less than 18 inches), *personal* (between 18 inches and 4 feet), *social* (between 4 and 12 feet) and *public* (more than 12 feet). For each communication situation, there is a distance within these four categories that we find appropriate, based on our cultural background and on the particular context of the situation. If the perceived distance is inappropriate, we become uncomfortable and we usually adjust it by physically moving closer or further away, or even simply turning our head or looking in another direction.

Existing systems for video-mediated communication fail to take into account the proxemics aspects of communication. Although some of the people who designed the systems understood the importance of these aspects, they failed to fully provide the support they require. In this note, we present MirrorSpace, a video communication system that uses proximity as an interface to provide smooth transitions between peripheral awareness and very close and intimate forms of communication.

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2 Related work

Most video communication systems are based on a glass pane metaphor. VideoWindow [2] probably best illustrates this concept, displaying remote people as life-sized images on a large vertical surface, making them appear as if they were seen through a virtual window. The glass pane metaphor provides a sense of shared space and supports gesture-based communication. However, even with life-sized images, the psychological distance to someone at the other end of the system is still greater than that in a comparable face-to-face situation. In particular, the distance between the camera and the image of a remote person's eyes can make eye contact and gaze awareness a real challenge. A number of solutions to these problems have been proposed for specific contexts. ClearBoard [3], for example, supports both eye contact and gaze awareness in close collaboration situations based on shared drawing.

As a cultural artifact, the mirror has a prominent position in the creation and expression of esthetics. Throughout Western culture narratives such as the Narcissus myth, *Snow White* or *Through the Looking Glass*, it has come to many different meanings including vanity, deception, identity or a passage to another world. A number of interactive art installations, such as Liquid Views [4], have picked up on these meanings and taken advantage of the universal and irresistible fascination for self-image. A mirror metaphor offers an interesting potential to attract people to a video-based system [5]. It also helps reduce the psychological distance between local and remote participants by displaying them side-by-side, as if they were all in one room [6].

No matter the metaphor, the interpersonal distance perceived by participants determines in great part the suitability of a video communication system for a particular context. ClearBoard, for example, creates the impression of standing about one meter away from the other person, which corresponds to the personal distance of Hall's classification [3]. Although perfectly suited for use with friends and colleagues, this distance might seem too small for a formal meeting with a person of a higher rank. Another consequence is that while ClearBoard makes it easy to establish eye contact, it also makes it difficult to avoid. Users of VideoWindow experienced the same problem and "went to great lengths to avoid eye contact" when they wanted to avoid conversation [2].

ClearBoard authors suggest that the communication system could provide users with some control over the perceived interpersonal distance [3]. This distance is influenced by many factors such as the spatial distance from the display, the size and quality of the video images, backdrops or voice fidelity. The potential exists for proximity as a form of non-verbal communication to affect behavior in video-mediated interactions. Yet, very little work has been carried out on the control over perceived proximity [7].

3 MirrorSpace

While existing video communication systems create a shared space corresponding to a particular interpersonal distance, the goal of MirrorSpace is instead to create a continuum of space, to allow a variety of interpersonal relationships to be expressed. Our work focuses on the understanding of how people's interactions can trigger smooth transitions between situations as extreme as peripheral awareness of remote activity and intimate situations.

MirrorSpace relies on the mirror metaphor. Live video streams from all the places it connects are superimposed on a single display on each site so that people see their own reflection combined with the ones of the remote persons. A real mirror is already perceived as a surface for mediating communication with its own rules and protocols. As an example, making eye contact with a stranger through a mirror is usually considered less intrusive than direct eye contact. Since the mirror is already associated to this idea of reaching out to other people and other spaces, we believe it is the ideal enabling metaphor for establishing a new communication experience.

As we aim to support intimate forms of communication, it felt important to us that people could actually look into each other's eyes, so the camera was placed right in the middle of the screen. This setup allows participants to come very close to the camera while still being able to see the remote people and interact with them. MirrorSpace also includes a proximity sensor that measures the distance to the closest object or person in front of it. A blur filter is applied on the images displayed to visually express a distance computed from the local and remote sensor values. Blurring distant objects and people allows one to perceive their movement or passing with a minimum involvement. It also offers a simple way of initiating or avoiding a change to a more engaged form of communication by simply moving closer or further away.

MirrorSpace was originally conceived as a prototype for the interLiving project[1] of the European *Disappearing Computer* initiative. A first video mock-up illustrating its design concept was made in August 2002. Several units were then created and presented to the public as an interactive video installation in four art exhibitions, in February, May, July and December 2003.

3.1 Hardware configuration

Two MirrorSpace units were built for the first exhibition and slightly modified before the other ones. Each unit consists of a flat screen, a camera, a proximity sensor and a computer that runs dedicated software. These prototypes have been designed to minimize their technological appearance so they can discreetly blend in their environment. The computer and the wires are kept hidden from users. The screen and its attached sensors are placed into a wooden box, protected by a transparent glass partially covered with a real mirror film (Fig. 1).

The image sensor and the lens of a Philips ToUcam Pro have been placed in the center of the screen. The sensor is connected back to the logic board of the camera using hair thin isolated wires running over the screen surface. Informal tests quickly confirmed that the lens is hardly noticeable once placed onto the screen, since people are generally focused on the images displayed rather than the screen itself. The proximity sensor, a Devantech SRF04, has been placed at the bottom of the screen. It is connected to a Parallax BASIC Stamp chip, itself connected to the computer via a serial interface. The computers were initially Apple PowerMac Cubes. They were later replaced by 2.8GHz Pentium IV machines with 2GB of memory and an NVIDIA GeForce FX 5200. A 100 Mbits/sec Ethernet network was set up to connect them during the exhibitions.

[1] http://interliving.kth.se/

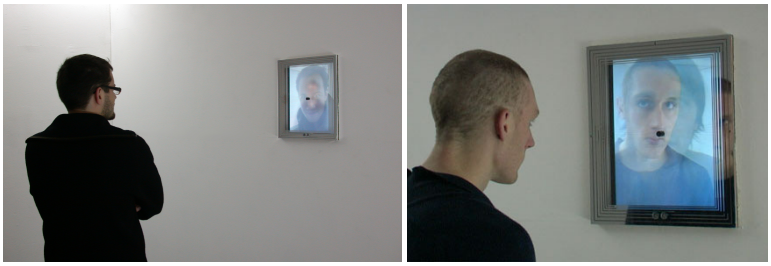

Fig. 1. MirrorSpace installation for the second exhibition

3.2 Software

MirrorSpace software is written in C++. It uses the videoSpace library [8] to capture SIF images from the camera in real-time and OpenGL to display a graphical composition created from these images and the proximity sensor values. Although only two were used for the exhibitions, the software doesn't make any assumption on the number of connected units. Proximity sensor values and images are sent on the network with a best-effort strategy (images are transmitted as JPEG data compressed to fit in a single datagram). The compositing process applies a blur filter on the image of each unit and superimposes them using alpha blending. The resulting composition is flipped horizontally before display to produce the expected mirror effect.

The blur effect is implemented with a two-pass incremental box filter. The size of the filter (i.e. the number of neighbors taken into account for one pixel) determines the blur level. The sensor values of all connected units are used to compute the size s of the filter to apply to each image. Three computation modes have been investigated so far. The first one (1) only takes into account the distance d, measured by the unit that captured the image. The two others (2 and 3) also take into account the distance d_{loc}, measured by the unit that displays the image:

$$s = f(d) \tag{1}$$

$$s = f(d_{loc} + d) \tag{2}$$

$$s = f(|d_{loc} - d|) \tag{3}$$

The software allows to choose a different mode for each unit. However, a strict WYSIWIS condition (*What You See Is What I See*) was imposed for the exhibitions.

4 Interacting with MirrorSpace

The first mode of operation of MirrorSpace (1) is quite intuitive: objects and people close to the mirror are better perceived than those far away. It is the one we used for all the exhibitions. It allows people to slowly get into focus as they move closer to the unit (Fig.2) and out of focus as they move away from it. The second mode introduces the notion of relative distance between participants. By moving forward or backward, people alter not only their own image but also the image of the remote persons. By

moving away from the mirror, one can still slowly disappear. However, in this case, the other people can follow that person to a certain extent. The third mode should allow multiple ”islands” of communication aligned in front of the sensor. However, a lot of space and more than two units are needed, which is why it hasn’t really been tested yet.

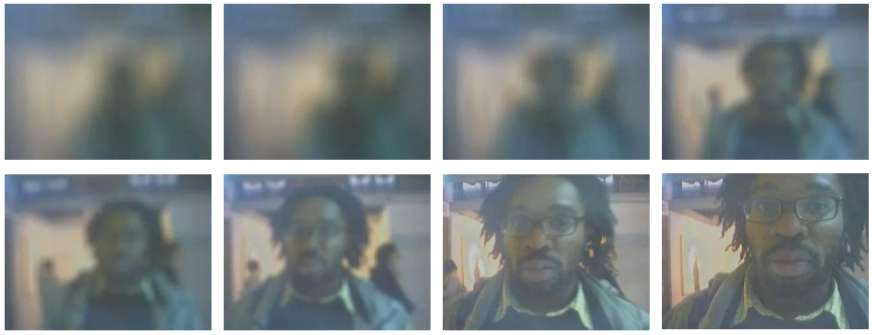

Fig. 2. Moving from peripheral awareness to focused communication by approaching the mirror

Almost all visitors of the exhibitions agreed on one point: interacting with MirrorSpace is fun. Proximity sensing helps creating an intimate relationship between users and the system. Many of them played with their own image and the blur effect. People didn’t hesitate to make a fool of themselves and many took pictures or recorded video clips of themselves and other people interacting through the system. When they saw another person appearing next to them on the screen, many people turned over, looking for that person behind them. This shows that the superposition of the images creates a sense of sharing the same space. It also shows that MirrorSpace is perceived as a mirror and not as a remote video communication system. In fact, the majority of the people didn’t think about the camera at all. Only after playing with the system for some time, they suddenly asked surprised ”where is the camera?”.

The superposition of the images allows not only to share space but also to become one. People who were visiting the exhibitions with friends or relatives immediately understood that and tried to overlay their faces (Fig. 3). Some went as far as kissing each other. At the same time, other persons were surprised and even disturbed to find strangers able to come so close to them. In that case, they simply backed away, which made their own image disappear smoothly with the blur effect. This strongly differs from systems such as ClearBoard or VideoWindow where eye contact is difficult to avoid. It shows that MirrorSpace can be used as an intimate communication device and, at the same time, supports at least part of the body language we are used to.

5 Conclusion

We hope that MirrorSpace will help researchers and practitioners realize the importance of the understanding of proxemics for the design of video-mediated communication

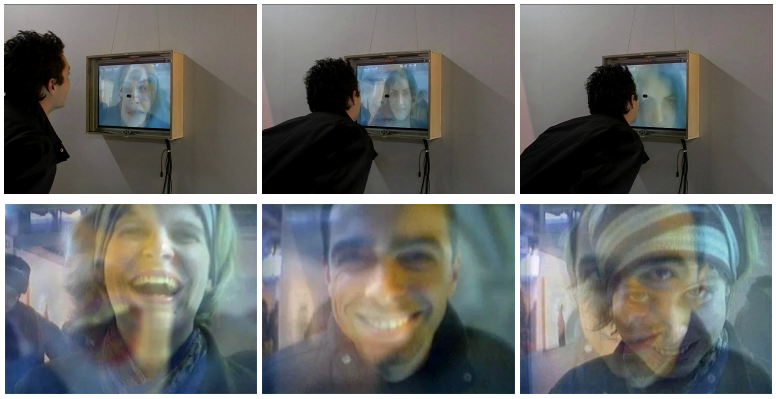

Fig. 3. Close and intimate communication through MirrorSpace

systems. The design concept of this system as well as some details of its implementation have been described. We have also described some user reactions to presentations of the system that were made during several art exhibitions. These initial reactions show that MirrorSpace supports smooth transitions between peripheral awareness and very close and intimate forms of communication. We strongly believe that the use of proximity as an interface to computer-mediated communication is a promising research direction. We plan to continue this work on image-based communication and to apply the ideas described in this paper to other forms of communication as well.

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