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The PhotoMirror appliance: affective awareness in the hallway

Abstract This paper presents the design of PhotoMirror an intra-home communication appliance for supporting informal, lightweight communication and awareness between home inhabitants. The PhotoMirror captures and displays images of trivial daily events and rituals reflecting the commotion and activities of home inhabitants.

1 Affective awareness at home

Awareness systems are communication systems that support people to maintain an awareness of the activities and the state of connected individuals or groups. Initially aimed at supporting colleagues at the workplace, awareness systems are gaining interest for leisure and social uses. At home, awareness systems can help connected people or households co-ordinate their activities through the day, e.g., the message board of the CASA-BLANCA project [3]. A good number of research prototypes and design concepts have been proposed with a less functional purpose, simply allowing individuals to convey the message that one is thought about, e.g., the Lampshade of the CASABLANCA project [3] or the Feather by Strong and Gaver [8]. Our own work has focussed on affective communication aiming to support connected individuals experience a feeling of connectedness through a peripheral and imprecise notion of each other's activities [6].

A relatively unexplored topic in this field is supporting awareness between inhabitants of the same home.

Given the prolonged and frequent opportunities for co-presence in that domain, an awareness system does not need to emulate or substitute face-to-face communication. Rather, it can capitalise on the advantages of computer-mediated communication in order to provide an extension to the wide range of media that home inhabitants deploy to communicate with each other [4].

Our interest in awareness systems for domestic use was coupled with the interest of Philips Research our industrial partner in this project. Philips produces displays mounted behind a semi-transparent mirror; the mirror is highly translucent allowing the display to be clearly visible when it is switched on, and the whole appliance to appear as a normal mirror when the display is switched off. Philips is currently marketing these mirrors for use in the bathroom of luxury hotels as TV screens. Our brief was to explore the potential of this hardware in the home and for different uses. We gradually settled for the hallway as the intended location for our appliance; the hallway is a semi-public place, it is shared by the home inhabitants and it is where one can get a good overview of the comings and goings in a home.

2 About mirrors

As a first step in the design process we decided to explore mirrors as objects aesthetically and functionally. Aiming to extend our thinking beyond the dominant paradigm of screen-based appliances and to understand the affordances of mirrors, we created a series of short video clips illustrating differences between physical mirror and virtual mirrors (i.e., coupling a camera with a screen). For example, mirrors reflect at all angles and support depth perception; video is a persistent imagery that allows one to view the back of one's head, or acts as a prosthetic memory to a space, etc.

Also, we studied examples of interactive and performance art. Some examples that influenced our thinking are mentioned below. The Smudge Time (Tamatete gallery, Rome, Italy, see http://pickledonion.com/

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smudgetime/) is a virtual mirror configuration that displays an image of pasted 'slices' taken from successive snaps of the spectator at a close sequence, thereby presenting smudged and fragmented reflection of the spectator. The cubic mirror (Salon di Mobili, Milan, Italy, see http://pickledonion.com/cubicmirror/) assembles successive snapshots of the spectator in a 3D composition of a cube visualising the passage of time in a virtual reflection. Joel Bauman's "Instant Video Grid" [see "Instant Video Grid" (2002), shown at the Onsnabrueck Media Art Festival 2004] juxtaposes successive snaps in a grid structure that is constantly updated to reflect the most recent activity in front of it. Dan Graham deploys various reflective materials giving rise to an interaction between spectators, environment and the art installation. Inspiring to us were his "pavilions" that are half-architecture and half-structure and the installation in the Van Abbe Museum in Eindhoven shown in the pictures (see Fig. 1).

3 Cultural probes

In order to enrich our ideas and to inspire the idea generation process a cultural probes study [2] was conducted. We sampled our informants widely, to include varying age groups, socio-economic status and from the neighbourhoods of our university, etc. The probes were in return a rich source of inspiration for the design teams, as some of our participants were very creative and surprising with the materials they provided to us.

The cultural probes package consisted of:

– A "Who are we?" card describing the nature and purpose of the package
– A "Who am I?" card to be filled in by informants
– Three open questions on postcards
– A package of drawing exercises and materials
– A card with images of 24 mirror designs with the request for comments on likes and dislikes
– A disposable camera with the instruction to capture pictures of reflections on mirrors at their home
– A "surprise egg" (chocolate egg containing a small toy). Informants were asked to draw what they imagined to be the right context for this surprise item to be seen in.

We sent out ten packages and we received eight back. Some probes were meticulously and creatively worked out; others were hastily filled in. Responses ranged from the common place to inspiring anecdotes and drawings, open and frank reflections on the questions set and creative photography (see Fig. 2).

4 Technology probes

In order to find out how video capture and mirrors might be used in unconventional ways, we developed

Fig. 1 "Public Space/Two Audiences" (1976) installation at the Van Abbe Museum; photo taken during a visit by the authors

Fig. 2 The contents of a probe as returned by a participant

and deployed two technology probes, following the inquiry method of Hutchinson et al. [5].

4.1 The orange probe

The orange probe (Fig. 3) is a narrow rectangular column, with a semi-transparent mirror on its front panel at face height. It is made of wood and is covered with orange wallpaper. Inside the probe, a laptop with a webcam takes still pictures when motion is detected. The images are stored locally and can be viewed through a secure connection from a distance.

With this probe we wanted to see how people would react and experiment with a camera that is hidden behind a mirror and in a place where they pass by. We deployed this probe at the reception area of our department rather than at a home. We did this to save costs and time and because we were worried about reactions regarding privacy; clearly, more informative data would be obtained by deploying the probe at a private place like home. Below the mirror, a stack of cards was made available for the passers-by. These warned them of the filming and provided them access to the team for questions or eventually removing the footage that they objected us for keeping hold of.

We anticipated lots of comments and protests regarding the filming. Rather, we noticed that the passers-by were quite relaxed of the probe, ignoring it when they were busy and chatting comfortably in front of it. Some displayed curiosity or tried to leave a message to us. Others were playful, e.g., a gay couple who kissed for the camera, others posed as if for a souvenir photo, and others used the mirror for grooming. The passers-by interacted with the camera more than with the mirror, despite that the camera was not visible. They appeared to have 'hijacked' the functionality of the probe in order to be creative and entertaining rather than letting the probe create a record of the commotion at the reception area.

Fig. 3 The orange probe

4.2 The 7-Seconds-of-Fame probe

Whereas the orange probe explored still photos and automated picture-taking, the 7-Seconds-of-Fame was intended to test how people would react to the capture of every day moments on video, where they would initiate recording explicitly. The 7-Seconds-of-Fame is a wooden construction concealing a webcam and a laptop behind a fairground-like decoration (Fig. 4). A large button triggers the capture of a 7 s video clip from a camera mounted on top of the probe. In analogy to smudge time and the instant video grid described above, the three most recent clips are displayed next to each other, playing in a close loop.

Instructions were given to participants in a leaflet. They were asked to create different clips they would like to show at billboards at Piccadilly Square in London, to the Pope, to George W. Bush, Robbie Williams, etc. Leaflets contained also a questionnaire asking them to describe their experience with the probe.

We deployed this probe in a student's home for 2 weeks. After an initial hesitance for being filmed was overcome, students started playing with the probe, acting out sketches, creating clips (alone or in a group) that would appear as if they were talking to their double image (which was actually the previous clip they made). In the last days of the test, usage was surprisingly intense. Debriefing interviews showed that the probe was appreciated and seemed to enhance the group-spirit.

5 Concept development

Materials from the cultural probes and the technology probes inquiry were used to guide and inspire the concept generation technique. The eventual concept was the PhotoMirror appliance described below.

The PhotoMirror appliance is a large mirror that hangs on the wall of the hallway. Embedded motion sensors detect motion and trigger snapshots to be taken. These snaps are positioned on a timeline displayed as a 4×4 grid. A detachable camera is provided to let users capture video clips around the home. The camera is mounted in the frame of the mirror. When pulled out, it automatically starts filming until the camera is replaced; the imagery is streamed through a wireless connection to the mirror. The detachable video camera films both ways, filming not only the object of interest but also the face of the person holding the camera. Facial expressions can communicate emotions very reliably and efficiently; they add a personal touch to the video created and convey the intentions and mood of the filmer, as well as his or her identity. As soon as it is created, the video clip is displayed on the timeline and is played in a closed loop. Images fade away with time, making the timeline not only show the sequence of activities but also portray the passage of time; this however is done in an imprecise way leaving no permanent record as it does not allow the users to have a look at the earlier imagery. This tempers the privacy concerns of individuals who would probably resent time-stamping their entrance to and exit from their home. When enough time elapses the PhotoMirror gradually starts to resemble a mirror on the wall as the videos and stills fade away.

6 Implementation

A non-functional prototype (Fig. 5) was created to visualise the aesthetics and styling of the appliance.

A functional prototype was built from pinewood (see Fig. 6). On it we fitted a 17-inch Philips TFT screen behind the semi-transparent mirror, a motion detector

Fig. 4 The 7-Seconds-of-Fame probe

sensor on the top of the frame and a detachable camera appliance embedded in the frame.

The software for this application runs on a PC (Dual Pentium 4 3,2 GHz, 1,024 Mb RAM, FX5200 GeForce video-card). The software was written in Max/MSP, a graphical programming language particularly well suited for video (through the Jitter extension). A passive infrared sensor was built in the top of the frame for motion detection.

For the detachable two-way camera appliance we used a small wireless camera.

Inside the casing of the two-way camera we have mounted an AV colour CMOS camera that transmits video signal by wireless. This signal is received by the PC via a TV-card (Hauppauge WinTV USB 2.0). Inside its

casing the wireless camera points sideways to a pair of mirrors, each tilted by 45° to the front and back of the camera respectively (Fig. 7). The result is that at any moment the camera films both ways, merging the back and front image along a vertical axis. The mounting cradle in the frame has two functions: two spring-mounted braces detect when the camera is pulled out and will trigger the filming. A socket at the back of the frame is used for recharging the battery mounted on the camera.

7 Evaluation

The prototype went through several iterations and improvements before it was fit for field-testing. It was then deployed at two homes for 2 days each. We interviewed the participants regarding their overall communication with each other prior to and after the introduction of our prototype. The footage and the images created in the two homes were deleted, in presence of the families, to protect their privacy.

The first family played around a lot with the device and showed it to their visitors. An interesting event was when they remarked in the morning the late return home of their adult son the night before, which gave rise to discussions. They missed text and voice input accompany the images. This comment was echoed also by the second family testing the appliance, which they conceived as a message board. Unfortunately the device had been installed in their living room instead of its intended location; it proved to be too bulky to place in narrow corridors typical of modern apartments: The PC tethered to it was a problem which we intended to solve by mounting a single-board PC behind the mirror. Another problem was its weight; the large frame with the PC and the mirror are quite heavy. It is not always acceptable to hang such a weight on the wall of one's home. As a consequence, the functional prototype was more conspicuous than we had intended.

On the positive side the test participants used the PhotoMirror, experimented with it and reported relatively high feelings of connectedness attributed to its use. The bi-directional wireless camera appealed a lot to them.

8 Conclusion and discussion

The appliance we created combines the experience of a physical mirror and a virtual mirror. The virtual mirror captures and displays fleeting and perhaps mundane moments of commotion that occur at the hallway of a home. The virtual mirror combines the display of automatically captured moments, together with video clips created by the inhabitants that help share feelings about objects and situations when other house members are not co-present.

Fig. 5 The 'appearance' prototype

Related research in appliance design has explored virtual mirrors. MirrorSpace [7] supports synchronous media-rich communication, aiming to support the perception of interpersonal distance through the experience of video-conferencing and to increase the perceived social presence. The reflection [1] is another video-conferencing application where images of participants are merged into a single dynamic composition. In comparison to these works, we have focussed upon complementing face-to-face interactions rather than emulating them and in trying to match the specific needs that arise in the context of intra-household asynchronous communication.

Currently we are exploring further the design space of intra-household communication, especially in the direction of audio-enhanced messaging and audio-photography as this was an explicit requirement emerging from the user studies described in this paper

Fig. 6 PhotoMirror in action, showing the combined effect of physical and virtual mirrors

Fig. 7 The interior of the detachable two-way camera
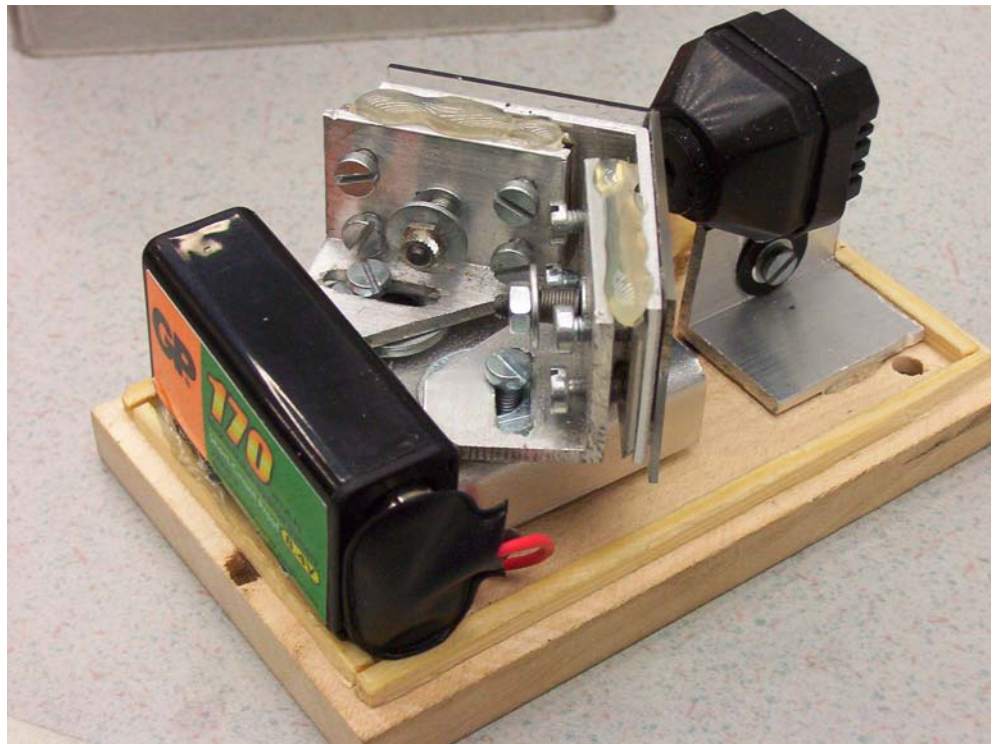
(the probes and field test). We aim to extend our evaluation of the affective benefits that can be gained by such appliances with a longer term field test. We believe that our PhotoMirror can fill an interesting niche in the range of communication appliances that populate the modern household and can be a valuable medium for social interactions among the home co-habitants.

References

1. Cullinan C, Agamanolis S (2003) "Reflexion: a responsive virtual mirror for interpersonal communication (video)," at EC-SCW 2003, Helsinki, 14–18 September
2. Gaver B, Dunne T, Pacenti E (1999) Cultural probes. ACM Interact 6(1):21–29
3. Hindus D, Mainwaring SD, Leduc N, Hagstrm AE, Bayley O (2001) Casablanca: designing social communication devices for the home. In: Proceedings of CHI 2001, pp 325–332
4. Hollan J, Stornetta S (1993) Beyond being there. In: Proceedings of ACM CHI'92 1992, pp 119–125
5. Hutchinson H, Mackay W, Westerlund B, Bederson BB, Druin A, Plaisant C, Beaudoin-Lafon M, Conversy S, Evans H, Hansen H, Roussel N, Eiderbck B, Lindquist S, Sundblad Y (2003) Technology probes: inspiring design for and with families. In: Proceedings of CHI, pp 17–24
6. Markopoulos P, Romero N, van Baren J, IJsselsteijn W, de Ruyter B, Farshchian B (2004) Keeping in touch with the family: home and away with the ASTRA awareness system. CHI extended abstracts 2004, pp 1351–1354
7. Roussel N, Evans H, Hansen H (2003) MirrorSpace: using proximity as an interface to video-mediated communication. Internal report 1363, LRI, Universite Paris-Sud, France, April 2003, pp 7. (Downloaded from http://www-ihm.lri.fr/~roussel/publications/ on Feb, 2005)
8. Strong R, Gaver W (1996) Feather, scent and shaker: supporting simple intimacy. In CHI'96 extended abstracts, ACM Press, Boston, pp 444