Electronic Glassboard – Conception and Implementation of an Interactive Tele-presence Application

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Abstract. This work presents a conception of a novel tele-presence system with an integrated interactive component. Previous solutions in this research area mainly focus on communication and do not offer sufficient, intuitive cooperation support for distributed meeting members. The Electronic Glassboard fills this gap by integrating the video display and drawing area. This allows for cooperative sketching without losing direct eye-contact with the cooperation partner.

Keywords: tele-presence, CSCW, EMS, electronic meeting support, transparency, sketching, distributed conferencing, videoconferencing.

1 Introduction

Collaboration of distributed partners gains in importance in the economy. Communities of practice span around the globe and The Global Village [1] has already become reality. Extensive travel, combined with resource management (direct travel expenses, travel time), is necessary in order to maintain and support such dynamic networks. Lost work time caused by business trips represents an immense cost factor for companies in every industry sector. In order to reduce such costs, and serendipitously to have a positive effect on climate change, more and more solutions for distributed collaboration are coming into operation.

2 Tele-presence Systems

Designing effective communication and collaboration processes across distance can be a challenging task. Olson and Olson [2] found that, in spite of the availability of advanced information and telecommunication technologies, distance in synchronous interactions cannot be rendered insignificant. Some differences will always persist, such as cultural influences, time-zones, geographical conditions and language. For the purpose of their study, Olson and Olson [2] analyzed synchronous interaction processes in collocated and distributed work settings to understand what features contribute to the success of synchronous, distributed work.

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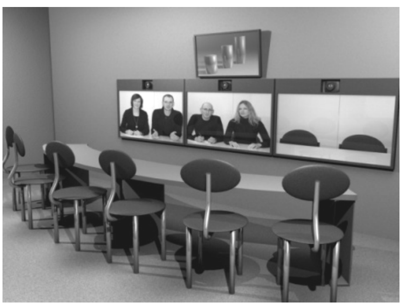
Using the 3C–classification [3], in the context of Computer-Supported Cooperative Work (CSCW), groupware systems can be classified into 4 system classes with differential emphases on communication-, coordination- or cooperation-tasks. These system classes are communication systems, shared information spaces, workflow-management systems and workgroup computing. Following the space-time matrix [4], the class of communication systems can be structured into synchronous vs. asynchronous and collocated vs. distributed applications. In this context, Nunamaker et al. [5] shaped the term of the electronic meeting system. Bly et al. [6] and Streitz et al. [7] similarly framed the development of their respective systems. The Colab meeting room system [8] has been the basis for many studies in this area (e.g. [9]).

Videoconferencing systems are synchronous in nature and have long been used by organizations in distributed situations. In the early years of videoconferencing, research work focused mainly on broadband difficulties in connection with transporting audio- and video- signals. Researchers were interested in dedicated transport channels such as ISDN-lines. However, with the massive increase in bandwidth available via the Internet and its increasing ubiquity in modern society, videoconferencing has become an increasingly popular service for individuals. The range of products reaches from simple systems, such as Skype[1] and Microsoft Live Meeting[2], to highly sophisticated systems with dedicated high-speed communication links and custom network hardware and software.



a) Hewlett Packard Halo

b) CISCO TelePresence 3000

Fig. 1. Exemplary tele-presence solutions, schematic illustrations

As videoconferencing systems have become more sophisticated in recent years, a new class of commodity systems has emerged in the market with the goal to optimize the quality of communication. Formerly reduced portraits of the communication partner evolved to life-size, high quality representations.

These systems try to create the impression that distributed workgroups all appear to be in the in the same room: they appear to be tele-present. This impression is further enhanced by a specific room layout. The experience level improves in many ways. Perceived qualitative factors, such as facial expressions and gestures, lead to an improved awareness state. At present, the two most advanced products in this context

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[1] http://www.skype.com, access on: 02/25/2009.

[2] http://office.microsoft.com/en-us/livemeeting/default.aspx, access on: 02/25/2009.

are the immersive solutions CISCO TelePresence[3] and Hewlett Packard Halo[4] (see Fig. 1).

The use of high-quality components comes at a price. These solutions quite frequently require the planning of investments up to the medial 6-digit Euro range (depending on the number of users). Although the operation itself generates additional costs for dedicated data channels providing guaranteed quality of service[5], many of the Fortune 500 companies use these products today to reduce both travel expenses and loss of work time accordingly.

2.1 Cooperation and Tele-presence Systems

Systems available on the market today mostly focus on the communication between meeting participants. These systems offer similar solutions in terms of cooperation of the participants (see [7]). On the one hand, document cameras are applied to transport picture information of non-digitizable objects, like construction parts for example. Alongside, individual laptops can be connected with a conventional display cable in order to present screen content to all participants.

Current systems also use an additional display to present picture information. The HP Halo system, for example, mounts a screen showing the digitized content above the displays showing the communication partner (see Fig. 1a, upper center image). The CISCO TelePresence 3000 system, similarly arranges an additional screen below the participant's displays (see Fig. 1, b), center, below desk board).

As the systems discussed so far are mainly focused on communication, both implementations lack advanced interaction support. Furthermore, the participants are not aware of each other's state during their interaction with shared content. At this stage of development, we present the *Electronic Glassboard* approach, which we will explain in further detail throughout the course of this paper.

2.2 Room Layout for Tele-presence Applications

Lewe [10] describes numerous parameters for the layout of electronic meeting rooms. His analysis concentrates on collocated meetings and evaluates their influence on the productivity of teams. He presents a series of design alternatives for the layout of such rooms ([10], p. 216 et sqq.). Amongst all layouts described by Lewe [10], the room layout "Classic Double" is the most significant model for tele-presence solutions.

The "Classic Double" (see Fig. 2 a) emanates from a group located between two boards or interaction surfaces i1, i2 (i.e. whiteboard or flipchart) respectively. A conference table is arranged in the center. It supports separating two groups whose persons *p* can communicate with each other face-to-face. The interactive surfaces *i1*, *i2* can be used for presenting digital content.

Given a distributed context, the room shown in Fig. 2 a) can be seen as two single rooms, separated along line l (see Fig. 2 b). The setup of the systems Hewlett Packard Halo and CISCO Telepresence, discussed earlier, overcome this separation by placing

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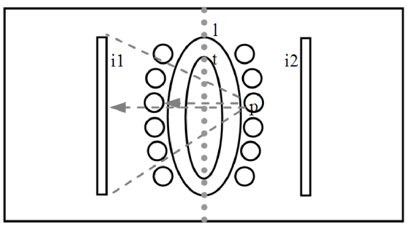
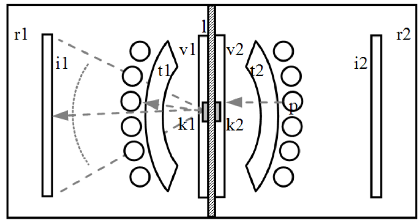
[3] http://www.cisco.com/en/US/products/ps7060/index.html, access on 02/25/2009.
[4] http://www.hp.com/halo, access on 02/25/2009.
[5] See also: IEEE Workshop on Quality of Service, http://iwqos07.ece.ucdavis.edu/, access on 02/25/2009.



a) "Classic Double"
(see [10], p. 218, [11], p. 256 et sqq.)



b) "Classic Double", distributed

Fig. 2. Room layout, top view

large LCD displays along line l. Both of these systems use the interaction surfaces only for presentation functions and also place them near the separation line l (see chapter 2.1). Hence, the remote team could follow deictic gestures (e.g. pointing to a certain part of a presentation), making the arrangement shown in Fig. 2 b) beneficial to interaction.

However, this room arrangement is not the best choice for the systems introduced earlier. On the one hand, for the viewer, the image caption is not big enough in order to record content situated behind the remote person. On the other hand, this arrangement would demand a constant re-orientation of the people in the room (constant turning of the body of approx. 180° around the vertical axis) from the presentation surface i1 or i2 respectively to the displays showing the communication partners v1, v2 and vice versa. Additionally, a camera with a very high depth of field would be necessary for focusing on both the participants sitting in the foreground and the illustration on the interaction surface situated behind them. Another challenge is to normalize the audio signal volume for both persons sitting at the table and, if applicable, for the persons standing close to the interaction surface.

Therefore, looking at the most prominent tele-presence solutions on the market today, a realization of an interaction surface being separate from the participant's displays is not the ideal solution. On the contrary, it creates additional problems regarding the communication channel. In the following section, we present a conceptual design that combines interaction surface and participant display into one integrated system.

One advantage of the systems discussed earlier in this chapter is that identical installations are not necessary in both rooms. Given that r1 is installed as described in Fig. 1, a conventional web-conferencing solution could be used in r2. Here, however, a shared whiteboard component could be shown on v2. The video signal of k1 would be shown on v2 anyway. Given a web-based training environment, this would offer substantial advantages over conventional videoconferencing systems. During a lecture, for example, students can see the instructor but cannot be aware of his interaction with the shared whiteboard or other presentation tools in use.

3 An Interactive Video Wall for Tele-presence Applications

Many CSCW systems that focus on dynamic collaboration processes across distance aim for the closest possible resemblance to face-to-face communication. Hollan and

Stornetta [12] argue that face-to-face communication provides a way to work collaboratively in a seamless manner. The goal should be to develop systems that people would rather choose to use instead of face-to-face communication. Systems should add to the experience of "just being there" [12]. We follow this approach with the introduction of the *Electronic Glassboard* system.

The approach of the *Electronic Glassboard* interprets the viewer's screen as a combination of glass panel and video wall. Glass panels are put to use in the military sector, for example, in control centers for documentation and planning of tactical maneuvers. Their advantage is that they can be written on from both sides with light pens, as well as read from both sides. In military contexts, e.g. in control centers, all participants or viewers respectively are in the same room. It makes no difference on which side the viewer is situated as the viewer can project gestures in reference to the board's content, thereby associating parts of the illustration to facilitate comprehension. The systems described in section 2.1 do barely support this interpretation of gestures.

The *Electronic Glassboard* utilizes the concept of a glass panel and exchanges the backside from the viewer's point of view with a video image. It thereby virtualizes the backside. By layering glass panel and video image (see Fig. 3), the user can create sketches in cooperation with a communication partner and discuss them while maintaining direct, eye-to-eye contact.

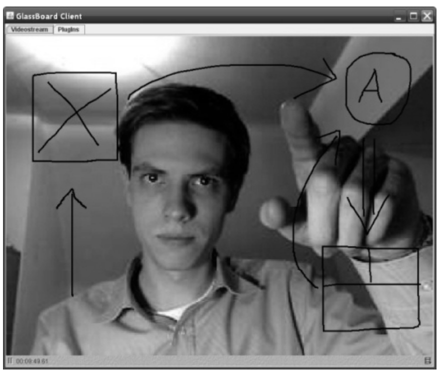


Fig. 3. Software prototype

3.1 Fundamental Layout

The systems described in chapter 2.1 are based on a fixed distance between the participants and the video display. This distance is approximately 3 meters, according to the observation of the authors. The cameras used to record the persons sitting at the tables are focused accordingly. Additionally, they are pointed in such a way that the participants have to be situated in fixed positions in order to allow unproblematic recording.

The goal of the *Electronic Glassboard* is to extend large-sized video screens with an interactive component. As opposed to the systems available on the market, we aim for a completely integrated solution. The user should be enabled to directly step towards the video image and to use an application, e.g. a sketching tool, layered above the video image in an intuitive way. A distance of 3 meters, as observed in conventional systems, cannot be bridged by the human arm. In order to interact with the screen, the user has to be able to stand within a distance of one arm's length, at most, much like a blackboard. This leads to questions regarding suitable hardware for interactivity and an adequate camera position that allows recording the persons situated in front of the display.

The *Electronic Glassboard* is more advanced than the ClearBoard approach of Ishii and Kobayashi [13] since it doesn't have to deal with problems of not being able to erase the partner's marks and double hand images. This is achieved through a novel design of hardware and software. Systems such as HP Halo or Cisco Telepresence use camera systems which are mounted directly above the video displays, at eye level (see Fig. 1). The Halo system features a separate camera above each video display; Telepresence 3000 arranges 3 cameras above the central video display. Given a distance of approximately 65cm (arm length), this camera position would not be suitable, as assumed in Fig. 4, to record a distortion-free image of the participant situated in front of the display. Given a distance of 3m between video display and participant, the camera position above the video displays is unproblematic as this would result in a very small angle between optic vector v1 generated by the camera k and actual optic vector v2 (parallel to the normal vector of the display area). Eye point a2 of the distant observer and eye point a1 resulting from the camera position are different. However, this only has an effect if the user is positioned directly in front of the screen, which is the case with the *Electronic Glassboard*. Therefore, the camera should be placed on vector v2, as close as possible to the eye point of the remote user. In other words, *behind* the display.

Full-size LCD displays available on the market today offer so called "Touch Overlays" for implementing a touch-sensitive surface. However, they cannot be considered for a realization of the *Electronic Glassboard* because a camera positioned at a2 would not be able to "see" through it. Therefore, a touch-sensitive rear projection surface area is necessary. This screen shows the projected image only, while allowing the camera to record the viewer standing in front of it.

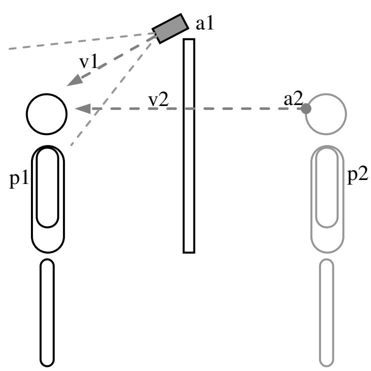


Fig. 4. Camera position, side view, schematically

3.2 Holographic Projection Surface

To allow for a frontal recording of the actor at the *Electronic Glassboard*, a special projection component is used that combines both interactivity and display functionality while still remaining translucent. This combination becomes possible by the application of a holographic projection display. Companies offering such products include Sax 3d[6] or G+B Pronova[7].

Holographic technology, also known from the field of photography, was adapted by some manufacturers in a novel way. Here, holograms that make up holographic projection surfaces are not used for saving and displaying three-dimensional objects any more, but for the exact redirection of projected light. These holographic elements can be embedded into glass, like plastic films for example. A holographic projection surface consists of many thousands holographic elements that transport the projector's light to the viewer in an optimal way. This way, the projector's beam is not directed perpendicular to the panel, but at an angle of 36° to the surface normal.

The holographic projection panel is transparent. Fine structures can only be seen when the panel is observed from a very close proximity. Looking at the front, only areas of the panel with displayed content become opaque. Looking from the back, almost no projected image information can be perceived. The holographic elements reflect the projector's light, for the most part, to the front. Given the good transparency level these panels provide, this technology is predestined for positioning the camera behind the panel in order to record persons in front of it.

Initially, holographic projection panels represent pure output mediums. However, the manufacturers mentioned above also offer panels that are touch-sensitive. This allows panels to perform as input mediums as well.

3.3 Software Application

Alongside the hardware architecture, the *Electronic Glassboard*'s application software is essential for cooperation between distributed communication partners. In our approach, the software primarily implements a special whiteboard component for cooperative sketching tasks. Fig. 3 shows the actual software prototype.

Cooperative sketching describes the cooperative creation and annotation of drawings and sketches that support the information exchange during meetings. The concept is based on writable boards in conference rooms. Cooperation systems today offer shared whiteboards that rudimentary follow the WYSIWIS-principle[8] [14]. Applied to the *Electronic Glassboard*, such a sketching area is layered directly on top of the video image of the remote partner.

Sketches are drawn with a touch screen that is invisible to the user, which is layered on top of the transparent projection film. Additionally, free-hand drawing is implemented for creating sketches. The application allows the setup of line strength and -color. Actual drawings can be deleted to start a new sketching process.

The two participating endpoints transmit the drawings as mouse events, which are captured by the software during drawing input. During that process the inputs from

[6] http://www.sax3d.com, access on 02/25/2009.
[7] http://www.holopro.de/en/index/, access on 02/25/2009.
[8] "What you see is what I see".

both sides are combined. The format of entries is also transmitted. Menu options give insight into real-time information regarding the data transmission and conversion. In the background of the drawing area, the video-stream of the remote partner is embedded. Control functions allow pausing and restarting the incoming video stream.

This software follows the classic client-server model. A central server application administers the video data streams along with the user entries at the connected *Electronic Glassboard* clients.

The software was implemented in Java. For multimedia handling, the Java Media Framework API (JMF), version 2.1.1e, from Sun Microsystems[9] was used. The Java Media Framework is a library for processing video and audio signals. The actual JMF version 2 is an expansion of the software which was formerly built for playing multimedia data and its control only. Here, the most important addition is the possibility to process data from audio-visual capture devices using Java in real-time.

For later versions of the application, the implementation of additional drawing tools and more advanced administrative functions is planned. This includes switching between different sketching areas as well as saving and loading of created sketches.

4 Conclusion

Tele-presence solutions are increasingly appealing to distributed workgroups. Unfortunately, the products available on the market today do not offer sufficient interactivity for intuitive cooperation of meeting participants. Here, the *Electronic Glassboard* concretely contributes with a new approach. The video display becomes the drawing area, in a self explanatory way.

The system is suitable for meetings that require a high degree of cooperation. It allows the cooperative creation of sketches without losing eye contact with the dialog partner during the process. The gestures involved in sketching content are consistent with the content visible to all participants.

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