

Visual Scoping and Personal Space on Shared Tabletop Surfaces

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Abstract Information is often shared between participants in meetings using a projector or a large display. Shared touch-based tabletop surface is an emerging technology. The shared display may not be able to accommodate all the information that participants want on the display. Moreover, large amounts of displayed information increase the complexity and clutter making it harder for participants to locate specific pieces of information. Key challenges are thus how to eliminate or hide irrelevant information and how participants can add information without distracting the other participants unintentionally. This study reports a novel approach that addresses these challenges by globally hiding information that is not relevant to all participants by introducing a private area on the public display.

Keywords: tabletop displays, collaboration, personal space, visual scoping, computer supported collaborative work, smart meeting room

1. Tabletop surfaces and collaboration

The shift from the paper office to the digital office has been ongoing for a long time and recent technologies has opened up new practical forms of computer supported collaborative work (CSCW) especially in the area of web technologies and cloud computing, for example Google Docs, ZoHo Office, Microsoft Office Web Apps, Google Wave, DropBox, etc (Eapen 2007; Herrick 2009) .

It is claimed that for some office workers as much as half of the working day is spent attending meetings (Kuwana et al. 1996). There are several technologies that contribute to the effective use of time in meetings and for working and sharing information among the participants. Projectors are common in meeting rooms and provide a convenient means of sharing information on the wall (Bhasker et al. 2007). Some meeting rooms are equipped with electronic white boards, capable of both displaying electronic contents and capturing freehand writing and drawing (Branham 2010). Smart meeting rooms providing services

such as automatic note-taking and meeting transcriptions are emerging (Chiu et al. 1999; Reiter and Rigoll 2004; Waibel et al. 2003).

1.1 Collaboration surfaces

Microsoft Surface provides similar functionality to the white board (Dietz and Eidelson 2009), but provides a richer set of ways to interact with the display. The surface is usually realized as a table, and the user interacts with objects displayed on the table using multi-touch hand gestures. New objects may be added using the file manager, but can also be added using the built-in camera. Touch displays are now commonplace on both public self service terminals (kiosks) (Hagen and Sandnes 2010; Sandnes et al. 2010) and handheld devices (Kray et al. 2010). C-Slate (Izadi et al. 2007) supports interaction and collaboration among remote users via touch screens for displaying and interacting with object as well as video conferencing capabilities. An overhead video camera detects hand movements and captures images that are transmitted to the other participant, making it easier for participants get a feeling for what the other participants are doing, where they are pointing, etc. There is a vast body on research on collaboration and surfaces and this is an active area of research (O'hara et al. 2011; Conversy et al. 2011; Haller et al. 2005).

A characteristic of such systems is that they are based on a common display shared by all the participants. Any information put on the display is instantly visible to all the participants. The fact that all the information is visible to all the participants is often a useful functionality. However, there are situations where it may not be desirable that all information is shown to all the participants, for example when working with personal notes or personal real-time notifications. Limited display real estate is another issue if several meeting participants want to use the shared display for their personal information.

1.2 Information sharing

Meetings often originate from the need to solve a specific problem, brainstorm to identify alternatives or discuss what decision to make. Participants typically bring their own set of tools such as papers, pens, laptops and personal organizers to such meetings. Information is shared using hardcopy handouts, whiteboards, wall

projections or large displays allowing all participants to see the illustrations, texts and slides.

One consequence of sharing a display is that everything on that display is visible to anyone watching. There may be contents on the display that should not be shared with everyone present, but may still be convenient for one participant or a subset of the participants. This is typically personal or private information such as notifications of incoming email or real time notifications. A salesman may not want to disclose what the minimum acceptable price is, and the buyer may not want to share the total budget. Information may in some instances be confidential. A medical doctor may need to consult a medical record in a meeting, but medical records are confidential and may not be shown to the other participants. In an oral examination using a tabletop display the examiners and students may want to discuss some displayed object related to a university course, but the examiners do not want to reveal their notes with their proposed grade to the student.

Some information may not be confidential, but also not be directly relevant to the discussion. Such information may be distracting and should be eliminated. Often one of the participants wants to show certain information to everyone and in the process need to go through several steps to locate and cue the information, for example finding a particular table in a 100 page pdf document. Such search and cue operations can distract other participants and it may be better to show the final result to the others when it is ready rather than the entire process.

The problems described above can be solved using personal papers, laptops and handheld devices, but the information remains private even if sharing is desirable. Also, papers and laptops clutter the conference table and may distract the participants. Some systems fail because usability and privacy has not been sufficiently addressed in the design (Grudin 1988; Kim and Kim 2006). This paper describes a strategy that addresses some of these challenges.



Fig. 1. The prototype comprises a projector mounted on a stand that projects the image onto the surface of a desk. The users interact with the table using mouse, keyboard or handheld devices (iPhone). A more complete prototype could include interaction through hand gestures using touch technology.

2. Personal space on shared displays

2.1 System setup

To illustrate the concepts discussed herein a conceptual prototype of a system for displaying and interacting with information using commonly available components was created. The display comprises an adjustable desk with a white surface, a projector mounted to project onto the table, and a computer controlling the projected image (see Fig. 1). In addition, the users of the system may connect using a handheld device such as an iPhone or other Wi-Fi enabled mobile device.



Fig. 2. The surface content shown on the handheld device. The user selects where the selected information (blue border) is to be located when displayed to the other participants.

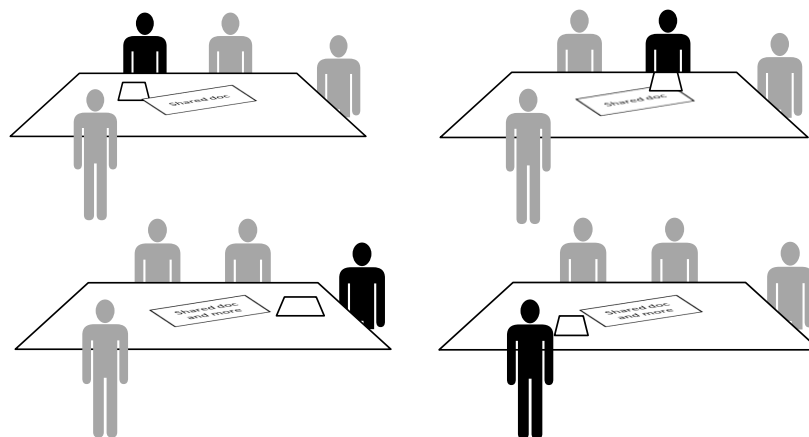


Fig. 3. Personal and public information on a collaborative tabletop surface.

2.2 Scenario: personal display space

Imagine the following scenario: Three participants are having a discussion around a table. The table shows a document they are currently working on and a Web Browser with a page relevant to the discussion. As the discussion progresses, there is a need to produce a specific illustration. One of the participants has this illustration privately available. Rather than disturbing the two other participants in their discussion, he picks up his mobile device and finds the illustration. The device shows a representation of the table with a representation of the file that can be moved and scaled (see Fig. 2). Once the group is ready to view the information

the file is uploaded to the shared surface. All three participants may now use the new information, that is, copying, pasting and changing the illustration.

2.3 Scenario: Adding private information

Imagine the same three participants sitting at a table, but this time the table shows a blueprint of an oil tanker. The three participants are trying to finish a ship design. As each participant is an expert in their respective area, there is no need for them to constantly see all the details of the blueprints. A view incorporating all the pipes, wires, beams, nuts and bolts is complex and may easily become cluttered. One of the participants who is an electrical engineer complains that due to a supporting beam being in the way, it is hard to get an electronic switchbox to fit, and asks the structural engineer if it is possible to move the beam. The changes are then quickly made. Next, the engineer responsible for the plumbing looks at the table using his mobile device which shows an augmented image of the display. The table shows the modified blueprints of the boat, and the plumbing engineer's handheld device display shows the water pipe overlay. The electrical engineer views the same blueprints through his device, but only sees the electric wiring overlay. The team of engineers can then agree on the design and verify that there are no errors. This is less intrusive than virtual reality technologies that are used for the same purpose (Raposo et al., 2006).

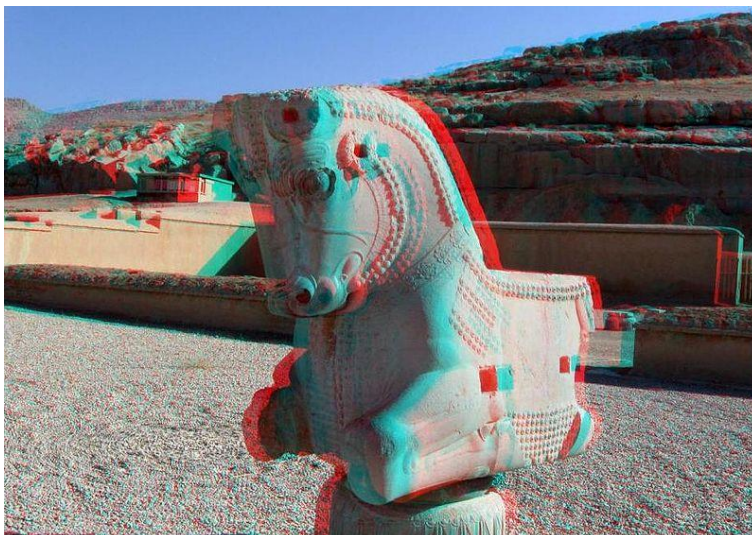


Fig. 4. Anaglyph image (by Reza Hasseli, Creative Commons).

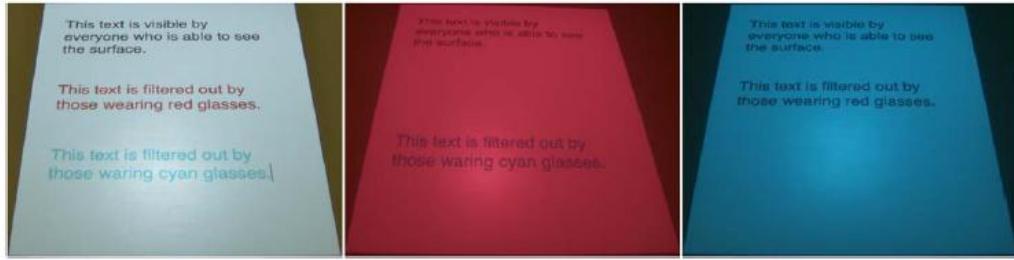


Fig. 5. Filtering information with anaglyph images. The left image shows the scene as it appears to the naked eye. The middle and right images show how the scene looks through pure red and cyan tinted eyeglasses respectively.

2.4 Anaglyph image information hiding

All participants can see all the information on the table with the setup described in the previous sections. Several strategies can be used to selectively hide information from certain observers. A technologically simple strategy is to employ anaglyph images (see Fig. 4). Anaglyph images were traditionally used to create 3D imagery and were popular in early 3D movies and 3D images (Jorke and Fritz 2006) and more recently to enhance the perception of depth cues for remote control of robots (Livatino and Privitera 2006) and ray traced images (Tibor and Mirsad 2008). Anaglyph images can be created by several layers of superimposed colored images, typically red and cyan and viewed using a set of glasses where one eye is colored red and the other cyan. If the left eye has a red glass only the cyan image will be visible as the red color is filtered by the red glass, while the red image will be visible on the right eye as the cyan glass is filtering the cyan image. Grayscale images are used to show the same visual information to both eyes. By employing certain variations in the blue and cyan image the illusion of observing a three-dimensional scene is typically achieved. Our prototype is inspired by such anaglyph images, but instead of employing glasses with different colors for each eye the same color is used for both eyes. However, each pair of glasses has a unique color. One pair of glasses will be red and thereby filter red colors and another will be cyan and thus filter cyan colors. Thus the observer using the red glasses will only see the cyan image, while the observer wearing the cyan glasses will only see the red information. The image displayed on the table contains information coded with both red and cyan colors which are only visible to the observer with certain glasses. Using this personal space a participant can for example type a new paragraph of text displayed

personally on the shared display without the other participants noticing (see Fig. 5).

The strategy also extends to groups of people as the text may be visible to a subset of the participants in the meeting. For example, if one participant types the text displayed in red then all other participants with glasses that does not filter red will be able to read the text, while those with glasses that filter red will not be able to see the text. Once the text is ready, it may be marked as public, the color changed, into say black, such that it is visible to all the participants.

2.5 Stereoscopic technologies

The anaglyph images used in the prototype are convenient for experimenting with the ideas, but this strategy has several shortcomings. First, only a limited number of participants can be supported due to color space limitations. Moreover, the tinted glasses affect the viewing quality as the red glasses will make everything look red, and the cyan glasses will make everything look cyan. Several stereoscopic technologies have been proposed and a handful of technologies are commercially available (Kim and Kim 2005) such as passive techniques based on polarization (Kitamura et al. 2006) where images with different polarization are sent to each eye, that is, the light in the image has certain polarization. For this application glasses with different polarization but with the same polarization on each eye could be used for each participant. For instance off the shelf polarization sunglasses could be used as one set of glasses and the other set obtained by rotating the two lenses 90 degrees. This would allow the display and other participants to be viewed in full color, but only two unique simultaneous visual channels are possible with polarization. Stereoscopic technology based on active technology could be adopted where what is seen by each eye is actively controlled such that full color view and many participants could be supported. Liquid crystal shutter glasses (Turner and Hellbaum 1986) is one example of active stereoscopic technology, where the light allowed through the glasses can be actively controlled in a similar manner in which a camera shutter can be controlled. Three dimensional effects are achieved by closing the shutter for one eye while opening the shutter for the other eye and vice versa in rapid succession while each eye is fed a unique image. The active glasses are typically controlled via infrared, Bluetooth or similar communication technology. Such systems could be adopted

for the purpose discussed herein, by opening or closing the shutters for both eyes, but instead only allowing one pair of glasses to observe the display at any time (Mistry 2009). However, with many participants flicker could be an issue.

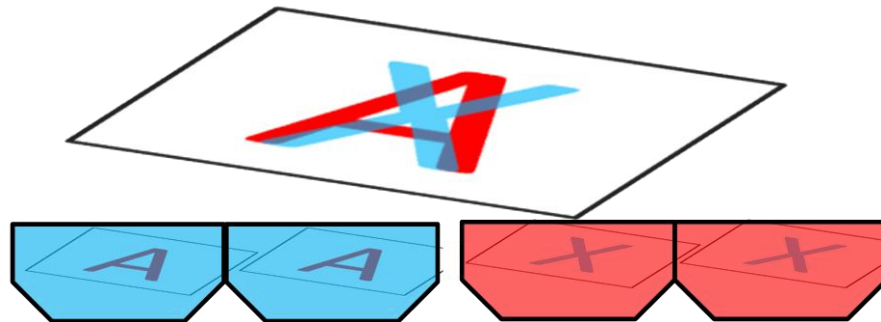


Fig. 6. Scoping information and reusing display real-estate with anaglyphs.

2.6 Scoped information

This study addresses how a surface can be shared among several participants while making certain information available to a subset of the participants. Using anaglyph images, images coded with different colors, we are able to effectively hide parts of the images. Each participant is given a pair of colored glasses. The glasses are either colored red or cyan. Using these mono-colored glasses, all information shown on the display using that color is filtered making that information unavailable to the user.

Information added to the display is initially visible only to that user, users wearing no eyeglasses and other participants with similar colored eyeglasses because the information is displayed with a particular color. Moreover, the same display real estate can be shared by several participants (see Fig. 6)

If the user wants to share the information with the other participants, the object is moved to the shared part of the display. The color of the information is then changed into a color visible to everyone, such as black. Alternatively, shared information can be moved back from public scope to private scope. We have coined this mechanism scoped information, as it makes the information available or unavailable only to the participants that are using the glasses with a particular color in a similar manner to which variables may have public or private scope in certain programming languages (Lieno et al. 2002). The color based realization of the technique does not provide privacy, as one may simply remove the glasses to see the hidden information. In fact, removing the glasses would reveal both shared

information, and hidden information for both of the two colors. It does, however, allow irrelevant information to be hidden from the view. It may be possible to also provide privacy given the right visual channel control technology.

The scoped information facility allows users to use the shared display for personal use without disturbing others. Opening a new file may now be done in a way that only affects the participant initiating the operation. When the information is ready, its scope can be easily changed to public.

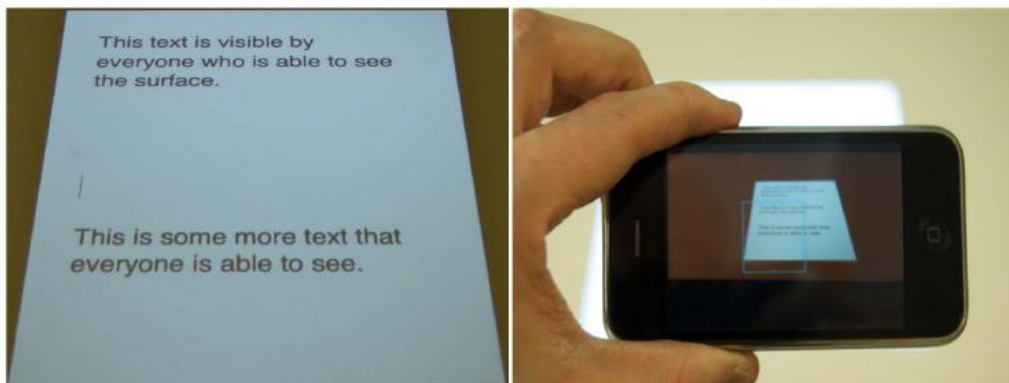


Fig. 7. The surface seen by everyone (left). The image seen through the device (right), reveals additional personal information.

2.7 Private information

Scoping of information, described in the previous section, can very useful. It will, however, not prevent others from seeing the information on the display. There may be situations which call for more privacy. One way of achieving privacy is to use a personal handheld device to display the private information.

Using a table as the main display, any information that should be viewed by everyone is shown. Using a portable device, it is possible to see supplementary information via augmented reality (Azuma et al. 1997). The iPhone is equipped with a video camera, and when the table is viewed, the supplementary information is superimposed on the table display (see Fig. 7). Another alternative would be to use an optical or video see-through head-mounted displays (HMD) (Rolland 2000; Rolland and Fuchs 2000; Rolland et al. 1994).

The mobile device, however, is not intrusive. It is possible to both interact with the information displayed on the table, as well as adding new information. By default, new information added is private, and is only visible on that particular device. When the information is shared with others, the information is moved

from the mobile device to the shared surface and the device is no longer needed to view the information. Public information can also be scoped as private. Private information may also be shared with a subset of the participants provided they have a mobile device. Such information will still remain private as it is only visible to a subset of the participants.

3. Discussion

3.1 Privacy

This paper discusses the notion of hiding information. Hiding information is not identical to making information private. Using the colored glasses, the information is only conditionally hidden as it is necessary to wear the glasses for the information to disappear. The visual channel is changed by changing the color of the glasses. Removing the glasses means deactivating the information hiding regime, and anyone is free to remove their own glasses at any time.

Information may be added to the view using a mobile device. We coined this mandatory scope. In this case, the scope is enforced, as the information is filtered using the mobile device, while no action is needed to see all the information in conditional scope. In either case, the information is not truly private. Anyone may view all of the information filtered using colored glasses by just not wearing the glasses. Moreover, in a small conference room it is easy to take a peek at their neighbor's mobile device over their shoulder.

3.2 Sociological implications

One consequence of the information hiding techniques presented herein is that the participants are unable to hide their intent, as their intent is visible through their actions. A user wearing glasses indicates intent to respect the personal space of other participants. Participants who take off their glasses signal intent not to respect the personal space of others and that they can view all the displayed information. A participant who uses their mobile device also reveals their own agenda. A participant that holds up the device indicates an interest in some information that is not currently visible on the table. The direction of the device indicates what part of the surface that is being observed. Although users have a personal space on the shared display it is transparent to everyone when this

personal space is being used. Only few studies have addressed similar issues (Strom 2002; Jafarainami et al 2005). Most research appears to focus on the synthesis of avatar body language (Levine et al. 2010).

4. Summary

This study explores a shared surface prototype for collaborative work that allows information hiding and personal space for individual participants. The approach allows the participants in a meeting or conference the ability to remove information of no interest, or add information as it becomes relevant. Hence, the information load and noise on the display can be minimized.

Anaglyph images were used to hide information. The participants either wear red or cyan glasses, thus filtering out the information displayed in the same color. Using this technique, two or more participants can work together on the same surface, without being disturbed by the actions of the other participants.

Portable devices are used to reveal more information than what is currently visible on the surface. Supplementary information is superimposed on top of the image captured by the device camera. The device tracks the table and use techniques from augmented reality to add the supplementary information. As the technique allows certain display areas to be used for personal space simultaneously by the participants, the overall available display real estate is exploited more efficiently.

Future work

One possible extension of this approach is teleconferencing where several participants are allowed to share and work with the same data using different surfaces and at different locations. Furthermore, one could add functionality similar to that of C-Slate (Izadi et al. 2007), thus to see the hands of other participants as they are interacting with the surface.

Another extension of this work is to explore the possibility of tiling several smaller touch screens into one large surface in a similar way to which tiled displays are composed (Majumder and Stevens 2005). Thus, instead of employing one single and expensive surface technology, several smaller inexpensive touch screens are used instead.

References

- Azuma R et al (1997) A survey of augmented reality. *Presence-Teleoperators and Virtual Environments* 6: 355-385
- Benko H (2009) Beyond flat surface computing: challenges of depth-aware and curved interfaces. In: *Proceedings of the 17th ACM international conference on Multimedia*, ACM Press, pp 935-944
- Bhasker ES, Juang R, Majumder A (2007) Advances towards next-generation flexible multi-projector display walls. In: *Proceedings of the 2007 workshop on Emerging displays technologies: images and beyond: the future of displays and interacton*, ACM Press
- Branham S, Golovchinsky G, Carter S, Biehl JT (2010) Let's go from the whiteboard: supporting transitions in work through whiteboard capture and reuse. In: *Proceedings of the 28th international conference on Human factors in computing systems*, ACM Press, pp 75-84
- Chiu P, Kapuskar A, Wilcox L, Reitmeier S (1999) Meeting capture in a media enriched conference room. *Lecture Notes in Computer Science* 1670:79-88
- Conversy S, Gaspard-Bouline H, Chatty S, Vales S, Dupre C, Ollagnon C (2011) Supporting air traffic control collaboration with a TableTop system. In: *Proceedings of the ACM 2011 conference on Computer supported cooperative work*, ACM Press, pp 425-434
- Dietz PH, Eidelson BD (2009) SurfaceWare: dynamic tagging for Microsoft Surface. In: *Proc. 3rd International Conference on Tangible and Embedded Interaction*, ACM Press, pp 249-254
- Eapen BR (2007) Collaborative writing: Tools and tips. *Indian Journal of Dematology Venereology & Leprology* 73:439-441
- Grudin J (1988) Why cscw applications fail: problems in the design and evaluation of organizational interfaces. In: *Proc. 1988 ACM conference on Computer-supported cooperative work (CSCW '88)*, ACM Press, pp. 85-93
- Hagen S, Sandnes FE (2010) Toward accessible self-service kiosks through intelligent user interfaces. *Personal and Ubiquitous Computing* 14:715-721
- Haller M, Billingham M, Leithinger J, Leitner D, Seifried T (2005) Coeno: enhancing face-to-face collaboration. In: *Proceedings of the 2005 international conference on Augmented tele-existence*, ACM Press, pp 40-47
- Herrick, DR (2009) Google this!: using Google apps for collaboration and productivity. In: Izadi S, Agarwal A, Criminisi A, Winn J, Blake A, Fitzgibbon A (2007) C-slate: A multi-touch and object recognition system for remote collaboration using horizontal surfaces. In: *Proc. Horizontal Interactive Human-Computer Systems, 2007. TABLETOP '07*, IEEE Press, pp. 3 –10
- Jafarinaimi N, Forlizzi J, Hurst A, Zimmerman J (2005) Breakaway: an ambient display designed to change human behavior. In: *Proc. CHI '05 extended abstracts on Human factors in computing systems*, ACM Press, pp 1945-1948
- Jorke H, Fritz M (2008) Advanced stereo projection using interference filters. In: *Proc. 3DTV Conference: The True Vision - Capture, Transmission and Display of 3D Video*, IEEE Press, pp 177-180

Kim M, Kim H (2006) Awareness and Privacy in Groupware Systems. In: Proceedings of the 10th International Conference on Computer Supported Cooperative Work in Design (CSCWD'06), pp. 1-5

Kim SC, Kim KE (2005) A new liquid crystal display-based polarized stereoscopic projection method with improved light efficiency. *Optics Communications* 249:51-63

Kitamura Y, Nakayama T, Nakashima T, Yamamoto S (2006) The illusionhole with polarization filters. In: Proc. ACM symposium on Virtual reality software and technology, ACM Press, pp 244-251

Kray C, Nesbitt D, Dawson J, Rohs M (2010) User-defined gestures for connecting mobile phones, public displays, and tabletops. In: Proc. 12th international conference on Human computer interaction with mobile devices and services, ACM Press, pp 239-248

Kuwana E, Yana E, Sakamoto Y, Nakamura Y, Horikawa K (1996) Computer-supported meeting environment for collaborative software development. *Information and Software Technology* 38:221-228

Leino K, Rustan M, Nelson G (2002) Data abstraction and information hiding. *ACM Trans. Program. Lang. Syst.* 24:491-553

Levine S, Krahenbuhl P, Thrun S, Koltun V (2010) Gesture controllers. *ACM Trans. Graph.* 29:124-135

Livatino S, Privitera F (2006) 3D visualization technologies for teleguided robots. In: Proc. ACM symposium on Virtual reality software and technology, ACM press, pp 240-243

Majumder, A, Stevens R (2005) Perceptual photometric seamlessness in projection-based tiled displays. *ACM Trans. Graph.* 24:118-139

Mistry, P (2009) ThirdEye: a technique that enables multiple viewers to see different content on a single display screen. In: Proc. ACM SIGGRAPH ASIA 2009, ACM Press, pp 29

O'hara K, Kjeldskov J, Paay J (2011) Blended interaction spaces for distributed team collaboration. *ACM Trans. Comput.-Hum. Interact.* 18:1073-0516
 Proc. 37th annual ACM SIGUCCS fall conference, ACM Press, pp 55-64

Raposo A, Corseuil ETL, Wagner GN, dos Santos IHF, Gattass M (2006) Towards the use of cad models in VR applications. In: Proceedings of the 2006 ACM international conference on Virtual reality continuum and its applications, ACM Press, pp 67-74

Reiter S, Rigoll G (2004) Segmentation and classification of meeting events using multiple classifier fusion and dynamic programming. In: Proc. International Conference on Pattern Recognition, pp. 434-437

Rolland J, Fuchs H (2000) Optical versus video seethrough head-mounted displays in medical visualization. *Presence: Teleoperators & Virtual Environments* 9:287-309

Rolland J, Holloway R, Fuchs H (1994) A comparison of optical and video see-through head-mounted displays. In: Proc. SPIE, vol. 2351, pp. 293-307

Sandnes FE, Jian HL, Huang YP, Huang YM (2010) User Interface Design for Public Kiosks: An Evaluation of the Taiwan High Speed Rail Ticket Vending Machine. *Journal of Information Science and Engineering* 26:307-321

Strom G (2002) Mobile Devices as Props in Daily Role Playing, *Personal Ubiquitous Comput.* 6:307-310

Tibor S, Mirsad T (2008) Comparison of stereo displaying techniques in POV-Ray 3D generated scenes. In: *Proc. 10th International Conference on Information Integration and Web-based Applications & Services*, ACM Press, pp 659-661

Turner TL, Hellbaum RF (1986) LC shutter glasses provide 3-D display for simulated flight. *Inf. Disp.* 2:22-24

Waibel A, Schultz T, Bett M, Denecke M, Malkin R, Rogina I, Stiefelhagen R, Yang J (2003) SMaRT: The smart meeting room task at ISL. In: *Proc. 2003 IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP'03)*, IEEE Press, Vol. 4, pp 752-755