PerspectiveTable: Blending Physical and Virtual Collaborative Workspaces

Fabian Hennecke[1]
fabian.hennecke@ifi.lmu.de

Simon Völker[2]
voelker@cs.rwth-aachen.de

Maximilian Schenk[1]
maxgschenk@gmail.com

Hauke Schaper[2]
hauke.schaper@rwth-aachen.de

Jan Borchers[2]
borchers@cs.rwth-aachen.de

Andreas Butz[1]
andreas.butz@ifi.lmu.de

[1] HCI Group
University of Munich (LMU)
80333 Munich

[2] RWTH Aachen University
52056 Aachen

CHI'13, April 27 – May 2, 2013, Paris, France.
ACM 978-1-4503-1899-0/13/04.

Abstract
Today's most common remote collaboration systems consist of a personal computer and a webcam. More advanced systems use multiple monitors installed at actual conference tables. Although this increases the feeling of 'being-there' the cooperators and their physical workspaces are inherently separated due to the system's design. To overcome this problem we present the PerspectiveTable, a remote collaboration system based on two curved displays. It seamlessly blends two personal physical workspaces with a shared virtual workspace and enables blends between the domain of face-to-face collaboration and digital remote collaboration. Users can easily exchange documents during collaboration as if they were sitting at an actual shared table. We describe how the different areas of our system blend into each other and which potentials this environment creates.

Author Keywords
Remote collaboration, shared workspaces, non-planar displays, avatar, blending.

ACM Classification Keywords
H.5.3. Information interfaces and presentation (e.g., HCI): Collaborative computing.

Introduction

Common video conferencing and remote collaboration systems such as Skype[1] work well with only one single screen. More complex systems like the SMARTdesk Boomerang[2], which offer a better integration of the remote coworker into the collaborative working environment, rely on multiple spatially arranged screens. Some show the remote collaborators while each user also has a personal display. Though this provides an illusion of 'being-there', these systems suffer from inherently separated workspaces. They do not provide a continuous collaborative workspace as in a real conference room. This can hamper a fluent collaboration in addition to the spatial separation.

Existing projects already tried to overcome these problems [5] but they still do not seamlessly blend the remote working environments. Curved displays seem to offer a way to overcome these obstacles [7]. Multiple curved displays [9, 10] were not only proposed, some were actually used for remote collaboration [1].

Based on these ideas and projects we developed the PerspectiveTable: a remote collaboration system based on two curved displays, which seamlessly blends the physical working environments with a shared virtual environment. Our implementation uses a three-dimensional avatar to visualize the remote coworker and provides four different interaction areas (see Figure 1). In this paper we describe the implemented features as well as ongoing implementations (Work in Progress) and possible new features (Future Directions) for future enhancements.

[1] http://www.skype.com

[2] http://www.smartdesks.com/video-conference-tables-boomerang.asp

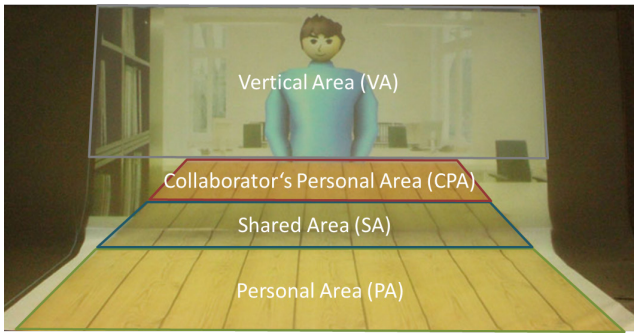

Figure 1: The PerspectiveTable has four different areas, each offering different levels of privacy and access. In order of decreasing privacy: Vertical Area (VA), Personal Area (PA), Shared Area (SA) and Collaborator's Personal Area (CPA).

The PerspectiveTable

The PerspectiveTable is a virtual remote collaboration workspace based on two curved interactive displays. Both displays show visualizations, which are similar to the work of Schwarz et al [6]. In their system they utilize a curved display to virtually extend its horizontal display area into the distance behind the curved and the vertical display area. For the PerspectiveTable we added a second curved display to the far end of this virtual area and represent the remote coworker by a digital avatar (see Figure 2). This does not only let two users look at the virtual area from opposite sides. It also allows them to interact with it. They can easily transfer documents or information from their physical horizontal display area to or even across the virtual area. This allows for a blend between the domain of digital remote collaboration on the one side and physical interactions between coworkers within the same room on the other side. Imaz et al. [3] described such blends as *actions in HCI*. To support the blend and to provide a better feeling of someone 'being there' we

animate both avatars using Kinect tracking data. This section describes the basic system setup and then explains its implemented components as well as some ongoing implementations.

Basic System Setup

The core system was implemented in Java using jME 3.0[3]. The Kinect-based tracking software was implemented in C# and communicates with the core system via the UDP protocol. The modular implementation makes it comfortable to exchange avatar animation data between the remote systems. While the basic visualization technique is similar to the work of Schwarz et al. [6], each area of the virtual conference table is also configurable in terms of length, width and angle.

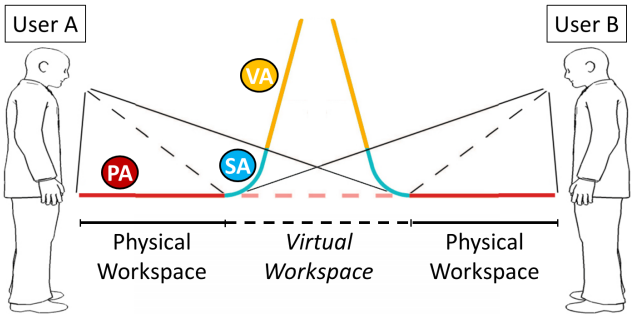

Figure 2: Concept of the PerspectiveTable: two curved displays seamlessly blend two physical horizontal workspaces ("personal areas", PA) into a virtual one ("shared area", SA) and represent the remote coworker on the "vertical area" (VA).

Implemented Components

We realized different *areas* within the PerspectiveTable with different levels of accessibility (see Figure 1). Each user has Personal Area (PA) on her physical horizontal display area. It blends into the Shared Area (SA) within the display's curve, which is also connected to the Coworker's Personal Area (CPA) on the other side of the virtual table. To support a convenient document editing position a user can also drag content to her Vertical Area (VA). Possible visibility issues in this area concerning the remote collaborator are discussed in the next section.

Another component is the animated *avatar* of the remote coworker. We opted for a 3D avatar for several reasons: a real camera image would somehow destroy the consistent virtual visualization and also introduce the problem of wrong viewing directions. They occur if the camera is not exactly mounted in the user's line of sight. This would have either lead to coworkers constantly looking downwards (camera above the display) or to a camera in the center of the VA.

To *exchange documents* users can easily drag them from their physical horizontal area into the shared virtual area located within the display's curve. This can be done without crossing any disturbing display borders. As previous research has shown users are quite comfortable with dragging through a curved display segment [2].

Work in Progress

Beside these implemented components several other ideas are only partly implemented. They will, however, help to describe our vision of the PerspectiveTable.

Storing documents on the VA opens up several *visibility* options. These documents can be 'private' (coworker only sees their shape and position) to provide an office-

[3] jMonkeyEngine, http://jmonkeyengine.com/

like scenario: the coworker cannot read digital information on a screen. A document can also be 'personal': the content of the document is visible to the coworker but it behaves like a real piece of paper: the content is mirrored. The most collaborative state of a document is 'shared'. This means that its content is correctly readable to support a better understanding at the cost of possible pointing problems [4].

Another component we are planning to implement will add support for *collaborative gestures*. One example for such gestures is what we call 'High-Five', a gesture for fast document transfers based on a blend between a real face-to-face situation (handing over a document) and touch input (tapping and holding) of our curved display (see Figure 3). A user selects a document with one hand and initializes the transfer by touching the VA with multiple fingers or the entire other hand. The coworker can then accept the transfer by touching the corresponding area on her VA and finally place the document with her second hand accordingly.

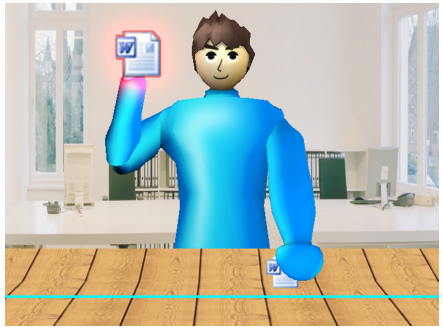

Figure 3: "High-Five" is a possible collaborative gesture for document transfer: It is based on handing over a piece of paper to somebody. It uses one hand to select a document from the PA and the other hand to transfer it to the VA.

Another advantage of the PerspectiveTable and its 3D avatar is the possibility to expand it to more than two users. Contrary to common camera-based systems the complete digital representation of a coworker and the workspace is rather flexible and users can be added or removed. To implement this, the avatars would have to be placed in a pre-assigned order around the table. The system would then know where each avatar sits and where it is represented on each display: If user A points towards user B she also has to do so from user C's point of view. While this is rather easy for three users it will become quite complex for a larger number of users.

Future Directions

We also thought about several components to enrich the interaction possibilities of the PerspectiveTable. One idea is the integration of Portals [8]. The curved display shape would allow to easily move portals to the VA and into all table areas. Portals could potentially behave differently according to their position on the table.

Another component could provide ambient information in the virtual environment to create a more immersive experience. While the implementation of a virtual clock is rather easy, the background behind the collaborator could also be used as an entire virtual conference room showing other PerspectiveTables. These tables could visualize other remote collaboration sessions and create a kind of virtual office. It would even allow users to seamlessly switch between multiple remote collaboration sessions just like moving to another table in the real world and will certainly raise issues of collaboration and social protocols.

Besides these additional components other future directions need to be investigated. During the

implementation process we noticed that the display curve is also used for spatial descriptions. Users sometimes describe an object's position using its position relative to the physical curve and not to the virtual table. Identifying reasons for this habit can help us to better understand a user's perception of blends based on non-planar displays.

Another approach for future investigations is a low-cost in-situ installation of an interactive display similar to the VA of the PerspectiveTable in an office environment. This could help to identify suitable collaborative gestures for the remote collaboration scenario. A more technical aspect is to enhance the quality of the avatar's animations using high-resolution tracking information to visualize finger movement in order to provide an even more intense feeling of 'being-there'.

Conclusion

We introduced the concept of a virtual remote collaboration environment: the PerspectiveTable. It seamlessly blends a physical horizontal workspace with a virtual one using two curved displays. To support a coherent environment without any visual flaws, such as problems with the line of sight, we opted for an animated 3D avatar as a collaborator representation. The seamless blend of the table areas allows for an easy and fluent document transfer between the collaborators. It also makes it possible to realize four different areas of the virtual table, each offering a different level of privacy and access. Besides these implemented components we described several works in progress, such as the collaborative gestures. We concluded with future directions, e.g. the possibility of extending the concept of the PerspectiveTable to virtual conference rooms with multiple virtual tables.

We believe that our insights, ideas and future directions concerning the PerspectiveTable's blending possibilities can provide useful input for the workshop. Furthermore we want to discuss the possibilities of our general setup to create new kind of blends between the physical and the digital world.

References

[1] Benko, H., Jota, R., and Wilson, A. MirageTable: freehand interaction on a projected augmented reality tabletop. Proc. of CHI'12, 199–208.

[2] Hennecke, F., Matzke, W., and Butz, A. How Screen Transitions Influence Touch and Pointer Interaction Across Angled Display Arrangements. Proc. of CHI'12, 209–212.

[3] Imaz, M., and Benyon, D. Designing with Blends Conceptual Foundations of Human-Computer Interaction and Software Engineering, MIT Press, Cambridge, 2007.

[4] Ishii, H. and Kobayashi, M. ClearBoard: a seamless medium for shared drawing and conversation with eye contact. Proc. of CHI'92, 525–532.

[5] Sadagic, A., Towles, H., Holden, L., Daniilidis, K., and Zeleznik, B. Tele-immersion Portal: Towards an Ultimate Synthesis of Computer Graphics and Computer Vision Systems. 4th Annual International Workshop on Presence, (2001).

[6] Schwarz, T., Hennecke, F., Lauber, F., and Reiterer, H. Perspective + Detail – a visualization technique for vertically curved displays. Proc. of AVI'12, 485–488.

[7] Tognazzini, B. The "Starfire" Video Prototype Project : A Case History. Proc. of CHI'94, 99 – 105.

[8] Voelker, S., Weiss, M., Wacharamanotham, C., and Borchers, J. Dynamic portals: a lightweight metaphor for fast object transfer on interactive surfaces. Proc. of ITS'11, 158-161.

[9] Weiss, M., Voelker, S., Sutter, C., and Borchers, J. BendDesk: Dragging Across the Curve. Proc. of ITS'10, 1–10.

[10] Wimmer, R., Hennecke, F., Schulz, F., Boring, S., Butz, A., and Hußmann, H. Curve: Revisiting the Digital Desk. Proc. of NordiCHI'10, 561–570.