Video Conferencing on Non-Planar Interactive Displays

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ABSTRACT
Several recent publications introduce user interface prototypes with non-planar interactive surfaces. Using our own prototype Curve featuring a large vertically curved interactive surface, we want to explore video conferencing and remote collaboration scenarios on non-planar interactive surfaces. We discuss the factors *framing*, *mobility*, *conception of space* and *interface compatibility*, which might be relevant for designing video conferencing applications on non-planar surfaces and outline our research objectives. We are especially interested in how the form of non-planar displays can be used to create spatial representations and interactions that facilitate new experiences in remote collaboration scenarios.

Author Keywords
Non-planar displays, curved displays, remote collaboration.

ACM Classification Keywords
H.5.2. Information interfaces and presentation: User interfaces – Graphical user interfaces.

General Terms
Design, Experimentation, Human Factors.

INTRODUCTION

Research about video conferencing has a long record in the HCI community. Video and audio channels can create windows showing a veridical representation of a spatially distant but coexistent space. With reference to Alberti [1], the term window can be interpreted as a rectangle on a plane surface that offers a view onto the world outside, just like a real window. In the renaissance, this metaphor helped artists to understand and employ the concept of perspective in their paintings (they had to frame their view). In a visual sense, common video conferencing applications using windows on a computer screen still refer to Alberti's conception of the window metaphor and are subject to the same principles [5]. The view onto the other world is framed (the screen border is the ultimate frame, the framing is done by the user) and discrete (the two worlds are not connected).

Recent developments of non-planar interactive displays [3,6,13,14] allow for new ways of using the display to visualize the remote collaborator. We argue that these possibilities require rethinking the metaphor of the architectural window. Some of its basic properties like framing or the mobility of the spectator seem affected by the changing form factor of such display configurations. Further, we propose to use the form of a display to enhance currently known remote collaboration, like the three-dimensional collaboration space of the MirageTable [3]. Besides such visual possibilities non-planar displays also influence the way a user interacts with the display [6, 12,13]. We argue that these approaches should be combined to facilitate remote collaboration experiences on non-planar interactive displays. In the first part of this paper we propose several factors that can be used to classify and design interfaces for remote collaboration on non-planar interactive surfaces. In the second part of the paper we discuss several interaction techniques on such non-planar displays and the effects of the display and its size on the interaction and the remote collaboration.

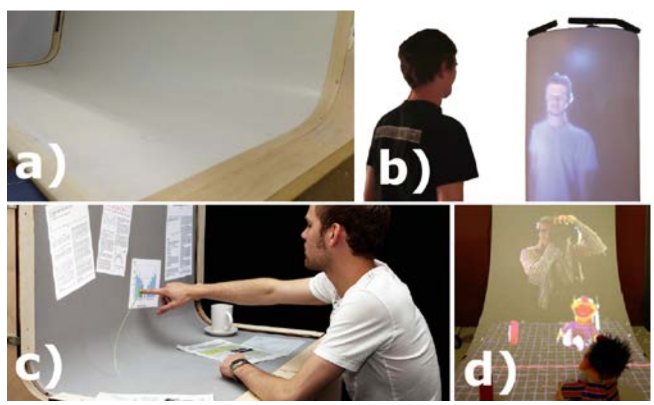

Figure 1 a) Curve [14], b) TeleHuman [7], c) BendDesk [13], d) MirageTable [3]

DESIGN FACTORS

In this chapter we introduce multiple design factors to classify and possibly design interfaces for remote collaboration on non-planar interactive displays. The design factors *framing*, *mobility*, *conception of space* and *interface compatibility* are introduced and discussed.

Framing
With the emergence of non-planar interactive surfaces, framing becomes an important aspect of applications in general. Most interaction with computer systems still seems to take place in framed settings: framed screens of different sizes hold potentially hundreds of framed windows (WIMP-paradigm). On the other hand, the dissolving of the frame in virtual reality settings can create seamless immersion into computer-generated visual environments. However, bulky hardware setups, heavy restrictions on the material space and invasive equipment like head-mounted displays or data gloves make immersive virtual realities inaccessible.

Some recent research projects show interesting tendencies concerning the framing of video conferencing applications using non-planar interactive surfaces. The prototype TeleHuman by Kim et al. [7] uses a large cylindrical display. Benko et al. [4] use a vertically curved display similar to the BendDesk [13] and our prototype Curve [14]. Although non-planar displays have borders, it might be questioned, if and how their visual presentation of content should be framed. In case of the TeleHuman [7], the ultimate goal seems to be a frameless holographic representation of a distant user. In contrast, the video conference with shared experience space in MirageTable [3] implies framing decisions – at least an aperture must be chosen. We propose to consider framing as an important aspect when building video conferencing applications on non-planar displays, since it impacts the “ontological” cut between material and immaterial space.

Mobility of the user
Like renaissance paintings or the cinema, WIMP-interfaces are based on the assumption of the user’s immobility [5]. Common video conferencing is a good example: in order to sustain visual contact, users have to stay within the field of view of the camera that produces a continuous stream of two-dimensional images.

The highest mobility in video conferencing might one day be provided by true holographic telepresence systems that allow users to experience common presence in their particular spaces. An approach to holographic video conferencing is the above-mentioned prototype TeleHuman [7]. It uses multiple Microsoft Kinect cameras to track the user orbiting around the cylindrical display and a stereoscopic projector rendering a realistic three-dimensional model of the remote user. That way, the visual presentation can adapt to the position of the user, who can freely move in space and view his vis-à-vis from all sides.

Mobility is also promoted by small devices like smartphones or tablets that can be carried around. However, the mobility of the users during video conversation seems restricted, since readjusting the frame (e.g. placing the tablet further away to increase the aperture) must be done manually.

Conception of space
The clear distinction between material and immaterial spaces that common video conferencing applications inherited from perspectival painting and cinema seems to get blurred by the recent works that also do not fit in the categories of virtual (total immersion into a virtual world) or augmented reality (material world with virtual overlays), but form a situation where material and immaterial space do not simply coexist but seamlessly merge at one position (e.g. table surface).

Immersion seems to be closely connected to the conception of space. Due to the two-dimensionality of video, the change of viewing position will not result in changes of presentation in classic window-based conferencing applications. Cheap and accessible sensor technologies employed by gaming consoles like the Nintendo Wii or the Microsoft Kinect allow a large number of developers to create applications that track users in space. That way, simulating motion parallax and changing fields of view become feasible. For instance, the MirageTable [3] uses head-tracking in combination with a stereoscopic projection and creates a seamless task space that can contain both physical and virtual objects. Another consequence of the availability of depth cameras is the possibility to spatially register people and objects. The visual presentation of the spatially registered space can range from annotated video [4] to a fully three-dimensionally modeled world.

Interface Compatibility
A limiting factor for a wide usage of the introduced non-planar interactive surfaces seems to be their size. Prototypes from the field of organic user interfaces give an idea how mobile devices could make use of flexible display technology in the future. We think, that especially the interoperability of differently sized but topologically equivalent interfaces might be a promising topic to investigate the potential of non-planar interactive surfaces for sharing experiences beyond workspace scenarios.

A SPACE FOR SHARED EXPERIENCES
In many cultures, the table is a well-established task space: For millennia, it has been used for dining, as workspace or as storage space. In order to create shared experiences, the table metaphor has been used in different systems. For instance, Völker [11] used Skype as well as cameras and projectors integrated into lamps hanging over two dining tables to create a shared table space and to promote a feeling of relatedness over distance. In Telematic Dinner Party [2], Barden et al. experiment with a technology setup allowing the experience of togetherness in a dinner party setting that consists both of physically and virtually present people. In general, tabletop displays have been used in different collaboration settings. In this chapter, we introduce our research objectives based on previous works in the field of non-planar interactive displays.

As shown by the MirageTable [3] and Perspective+Detail [10], vertically curved displays can be used to create seamless transitions from the physical horizontal display area into a virtual one. This concept has been used for example in a visualization prototype for public transport supervision [10]. An overview showing a map is presented on the horizontal tabletop display and continues into the depth on a virtual extension of the horizontal display plane (see figure 2). We want to have a closer look on how such an interface can facilitate shared experiences in video conferencing by investigating its interactive potential.

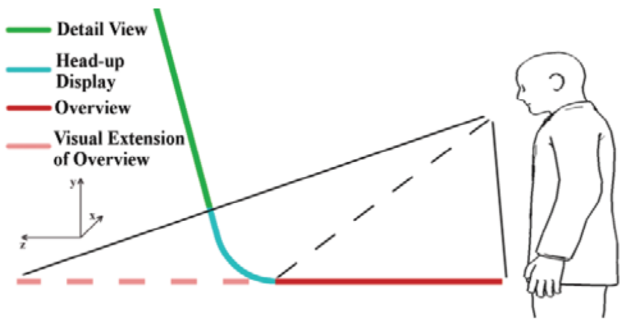

Figure 2 Virtual extension of the physical horizontal plane in Perspective+Detail [10]

A conversation across the table

It will be interesting to investigate how users conceptualize a shared space as proposed in [3] and how it can influence their communication. For instance, the above-mentioned question of framing seems unclear: The discretion of the window seems replaced partly by the visual continuity of the table but stays intact at the borders of the display.

Visualizing a remote person sitting at a table vis-à-vis requires several design decisions. One way to display the remote person could be based on conventional video technology. Although this solution might result in the most lifelike presentation, it also poses the known problem of camera placement which in this case is crucial for constructing a convincing table situation. Another solution could use depth cameras to spatially scan the space and create a 3D-model of it. Constructing the continuous horizontal plane is easy in this case and the layout and visualization of the space are independent from the actual material space. By using a transparent display it even seems possible to dismiss framing and only show the table extension and the remote person augmenting material space. However, a lifelike visualization of people and real-world objects, which can be placed on the horizontal surface (e.g. smartphones), might be challenging and users might eventually not accept a visual representation that exhibits visual artifacts. A compromise worth investigating could be the usage of avatars that disclaim a veridical visual representation.

Interaction in the depth

The visual continuity of a seamless shared space is an illusion that can be increased by technical means. However, physical access to this space is limited by the display, resulting in a tension between materiality and immateriality. Searching for a real-world analogy, one might think of two people sitting across each other on opposite sides of a table separated by a glass panel like visitor booths in jail or a teller's window in a bank. We want to investigate this space in terms of its interaction possibilities and are interested in how files as well as material and immaterial objects can be integrated into the table space and how they can be shared, viewed and edited by the people sitting at the ends of the table.

In [12], Voelker et al. have investigated flicking gestures on vertically curved surfaces. Users had to flick virtual pucks in order to hit randomly placed target pucks. Their findings imply that users have less trouble to hit targets on a vertically curved display compared to settings, in which the horizontal and the vertical displays are connected with a bevel or not connected at all. However, the study was focused on the display topology and did not address a three-dimensional representation of space. In such a case, flicking might be more useful for moving objects to the virtual end of the table than interacting on the physical surface, since due its curved form, most areas of the display are supposed to be reachable and might serve as additional interaction space (e.g. as head-up display [10]).

Depending on how files and virtual objects are visualized, viewing and editing files collaboratively might reveal the orientation problem known from tabletop computers [8]. Let us assume two people studying a large map spread on the table. How do they view the map? What happens if both pull the map at the same time? Building on the teller's window as a metaphor, it might be useful to not only consider the horizontal, but also the vertical plane. Can it be understood as a transparent glass panel that can be used to attach virtual notes? Or might it be segmented into different display areas framing the visual communication?

We are interested in including physical objects and devices into our research. A special form of file sharing might be to exchange data between mobile devices placed visibly on the table. Furthermore, we plan to explore table configurations with more than two users.

Possibilities of the Display Size

Even if the dimensions of prototypes like Curve [14] or BendDesk [13] might be reduced significantly in the future, the size of their displays will probably imply a stationary use at specific workspaces. On the other hand, research in the field of organic user interfaces has demonstrated small mobile devices with flexible displays. Concepts like iFlex [9] show, that a future mobile device might also take a vertically curved form. Therefore, we think that the interoperability between differently sized vertically curved displays seems to be a topic worth investigating. It will be of special interest, if user interface concepts like the shared table space can be employed across different interface sizes. As flexible display technology is not available right now, we are currently evaluating different approaches for building a small version of the curve.

CONCLUSION

In this paper we proposed several design factors, which can be used to classify and design user interfaces on non-planar interactive displays. These factors are *framing*, *mobility*, *conception of space* and *interface compatibility*. We also discussed some influences of the display's shape on the interaction in a remote collaboration scenario. Interactions in a seamless shared space enabled by vertically curved displays are of special interest to us. Further, we want to investigate interface concepts that work across differently sized curved displays. Finally we think that non-planar displays can influence how remote collaboration works and even introduce new possibilities. We are looking forward to interesting workshop discussions based on the initial ideas within this paper.

AUTHOR BIOGRAPHIES

Henri Palleis is a PhD student at the chair of mediainformatics at the University of Munich (LMU). He is interested in remote collaborative interaction beyond the workspace and is focused on vertically curved interactive surfaces.

Fabian Hennecke is a PhD student in the HCI group at the University of Munich (LMU). His main research is about the combination of differently oriented interactive surfaces and its potentials and implications.

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