Design Space for Large Cylindrical Screens*

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Abstract. The era of modern cylindrical screens, so-called advertising columns, began in the middle of the 19th century. Even nowadays they are still a popular advertising medium, which integrates well with urban environments. With advances in display technologies (LEDs, projectors) digital forms of such columns emerge and enable novel forms of visualization and interaction, which significantly differ from flat, rectangular screens due to the round shape. In this paper we present the design space for large cylindrical screens and outline design principles based on observations and experiments with a prototype of a digital column. We especially focus on the differences with flat, rectangular displays and report on challenges related to the deployment and development of applications for cylindrical screens.

Keywords: cylindrical screens, digital columns, display formats, design space, interaction techniques, screen layout, advertising displays.

1 Introduction

Cylindrical screens as means for communication already existed in ancient times in the form of decorated indoor columns and freestanding columns in open public

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spaces. The era of the modern cylindrical screen started some 150 years ago, when Ernst Litfaß invented the advertising column. Initially erected with the goal to bring order in the, at that time, wild billposting, it quickly turned out that the real advantage of those columns is their concise, elevated form making them visible from afar and providing a good placement for certain advertisements [14].

From a design perspective, the round and cylindrical shape of the column is the most interesting design element. Famous examples include advertisements showing a three-dimensional tire stack or hat fashion on the column shaft, using the form as a sculpture. However, the shape is also a challenge since the direction viewers are approaching from is unknown. Hence the column interacts towards an unknown direction and the likelihood of contact with the passer-by is low [14].

In this paper we explore the deployment of digital cylindrical displays. Digital columns differ from classical columns in the capabilities of dynamic images and interaction. However, there are also significant differences to classical digital screens. Contents on digital cylindrical screens currently often show a merely technical adaptation of classical dynamic screen content, like images and movies, without regarding the individual requirements and potentials of a dynamic or interactive cylindrical shape. The aim of our research is to provide concrete design principles that distinguish the cylindrical medium from planar, rectangular displays.

Our research is based on previous work, which describes how digital columns can be used as interactive advertising medium. We considered implications from ambience, user situation, and screen shape for interaction [3]. The contribution of our paper is twofold: First, we systematically assess the design options with regard to the column shape and the surrounding space, comparing properties of screen media and reporting on findings from qualitative user observations. Second, we derive typical usage patterns in such an environment regarding visualization and user interaction.

2 Related Work

Recently, initial concepts and products for digital cylindrical screens emerged. However, no research so far focused on investigating the design principles of such screens. In the following chapter we present related work focusing on the technical realization, classification of new screen media, research on large interactive screens and displays, sensing technologies, and interaction zones.

Most cylindrical displays use rotating LED's [6,9], where the drive system has to be well adjusted to get a jitter-free image. Other technical solutions include static mechanical designs including rings of LED modules [2] and projection-based setups like the VR Object Display developed by Fraunhofer FIRST [7]. Optical or magnetic tracking systems make it possible to use such digital columns as interactive media. Digital columns are sometimes also described as volumetric displays. For a detailed description of these displays we refer to [1]. Of special interest to our work is the classification of Sauter [15], who reports on four physical formats of screen media: desktop applications, interactive objects and installations, interactive rooms, and interactive architecture. Manovich provides a noted and useful genealogy of new screen media. Starting with the evolution of basic screen properties, he reports on modern screen's dynamics, aggressiveness, and the impact of VR [11].

Exploring the use of large electronic displays already started in the late 80s with the Colab at Xerox PARC, a meeting room to support collaborative problem solving [17]. Whereas this early approach did not support input modalities beyond mouse and keyboard, in the Tivoli project gestural commands where used [13] and in 2005, Malik et al [10] developed a technique that allows interaction from a distance.

From an interaction perspective, Paradiso et al [12] presented different input modalities for the use near interactive surfaces such as laser rangefinders, acoustic sensors, pressure sensors, and resonant tags based on RF technology. The i-LAND project [18] and the Interactive Workspaces Project (iRoom) [8] aimed at exploring how workspaces of the future could be enhanced by cooperative and multimodal interaction with large displays. Streitz et al [19] presented the Hello.Wall display, which allows for transmitting information either publicly or in a more private way using ViewPorts, and [20] refined this model to better describe the range between implicit and explicit interaction. Brignull and Rogers also focused on perceptual interaction zones around public displays [5]. Especially interesting for us is the work of Scott et al [16] who presented different types of territories when it comes to interaction on tabletop displays, dividing the workspace into directional and radial zones.

3 Characteristics of Classical Screens

To understand the requirements for the deployment and development of applications for cylindrical screens, in this chapter we introduce characteristics of classical screens to draw on them in comparison. We refer to [11] where a classical screen is defined as a flat, rectangular surface, separating the physical space from a space of representation that usually has a different scale. Examples are traditional paintings, dynamic screens (such as television and cinema), and computer screens in manifold sizes. They all have in common that they are used for frontal viewing, that the viewer is being "imprisoned" in a fixed, immobile position, and that the representation is embedded in a frame with four boundaries, usually appearing in the horizontal "landscape" or the vertical "portrait" ratio [11].

As can be seen in Figure 1 the rectangular frame determines the spatial distribution of elements displayed on the screen. Because of the reading direction, an important element, such as a website's logo, is often positioned in the upper-left corner and the navigation will be positioned either below or to the right.

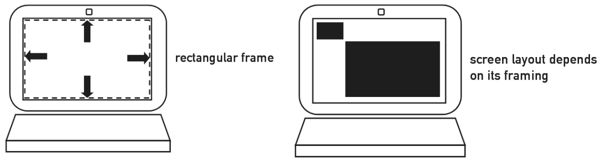

Fig. 1. Properties of rectangular screens

Rectangular screens are also characterized by a so-called "viewing regime". While the computer screen shows a number of coexisting windows that are taking turns striving for the attention of the viewer, the television screen acts as a single window into the virtual world, where the rectangular frame screens out what is outside the boundary thus helping the viewer to identify with the screen representation [11].

For huge screens, such as in cinemas, the window metaphor is replaced by the metaphor of immersion (see Fig. 2). The screen size, and in an IMAX cinema also the concave shape, cover the range of the visual field of the viewer and help him to immerge into the artificial world. A similar effect can be observed in VR (using CAVEs or HUDs), where the user is still imprisoned but experiences a higher degree of freedom (e.g. turning left and right). VR interfaces are hence enhancing the metaphor of immersion to a metaphor of total immersion where the physical space is totally encompassed by the virtual space [11].

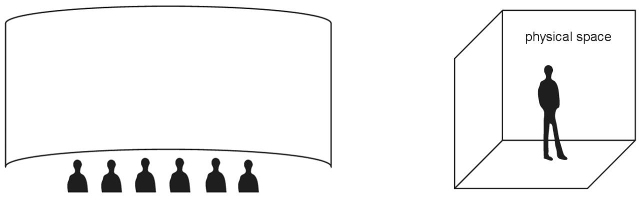

Fig. 2. Immersive screens. IMAX cinema screen (left), CAVE (right)

4 Research Design and Observations

For our research on cylindrical screens we used the VR Object Display developed by Fraunhofer FIRST (see Fig. 3). This prototype of a large cylindrical display is equipped with eight standard projectors that project the image onto a special screen. It has a height of 2.2 meters and a diameter of 1.5 meters. The 4:1 projection screen is 1.1 meters high, has a diameter of 1.3 meters and a resolution of 2048 to 512 pixels. It is equipped with a magnetic and an optical tracking system and a 4.1 audio system.

We used this prototype to investigate how users interact with such a cylindrical display. Therefore we invited employees and school classes to the lab and let them interact with different applications we developed for the use on cylindrical displays. The initial results presented in the following chapter were obtained from user observations in the lab and qualitative interviews. A deployment in the wild is currently not possible due to the complex and time-intensive setup. For the qualitative study dynamic as well as interactive sample applications were used which are described in more detail in [4].

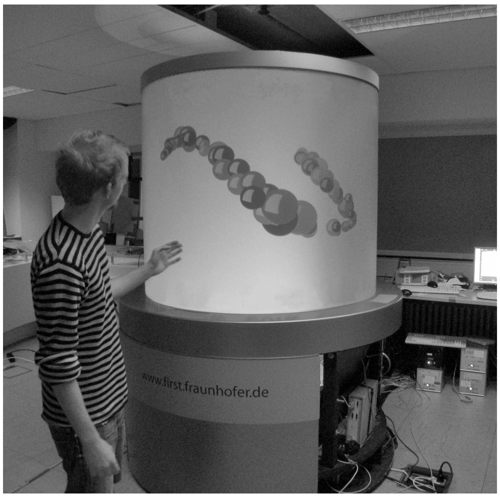

Fig. 3. Interactive column developed by Fraunhofer FIRST

4.1 The Cylindrical Screen and the Body

We started with an observation of the relationship between the body of the viewer and the solid cylinder. We were especially interested in the physical space, degrees of freedom, multi-user interaction, interaction zones, and the user position (see Fig. 4).

The Space and the User. Columns are freestanding, not integrated into the surrounding architecture (i.e. attached to a façade, wall) like classical displays. We observed that the viewers did not stay anymore in a rather fixed, immobile position, but started moving around the column in physical space and exploring the virtual space "beyond the screen", hence creating a more active environment.

Degrees of Freedom. Cylindrical screens provide more degrees of freedom. Viewers can move around the screen left and right, without stopping and losing the relation to the displayed content unlike in front of a rectangular display where viewers need to turn round at the boundary to proceed with any kind of interaction.

Multi-User Interaction. The roundness and a wide diameter support multi-user interaction. On a classical rectangular screen, space for interaction is scarce, hence, only very few people can interact with the screen at the same time. In contrast, everyone in the close-up range interaction zone of cylindrical screens can participate.

Interaction Zones. In front of classical rectangular displays people residing in the (rather small and obvious) interaction zone are exposed to the reactions of the surrounding audience, which might result in embarrassment and people stopping to interact with the display. We observed that this effect is weakened in the vicinity of round interfaces since everyone approaching the close-up range is equally exposed to the interaction, hence reducing both uncertainty and the barrier to start interacting.

User Position. Observations with ceiling-mounted cameras and face-detection revealed that the viewer position in front of a large cylindrical screen differs from the classical viewer positioning, in that no frontal positioning but only a momentary frontal viewing occurs: while walking around or along the column, test persons most of the time had a diagonal position to the screen and looked at it spontaneously only.

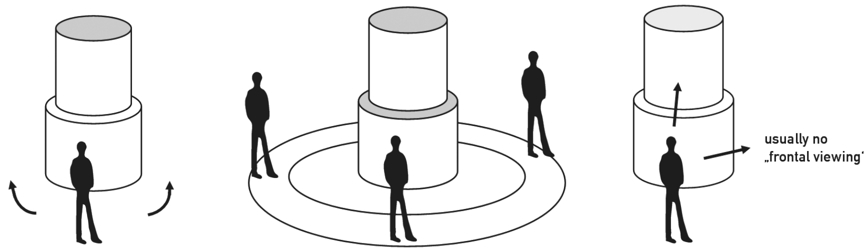

Fig. 4. Degrees of freedom (left), multi-user interaction and interaction zones (middle), diagonal viewing (right)

4.2 The Cylindrical Screen and the Viewer

Second, we explored the relationship between the viewer and the representation on the screen including the physical format, screen metaphors, the framing, the visibility and the direction of effect (see Fig. 5).

Physical Format. In a virtual room or CAVE the virtual space completely encompasses the physical space. In contrast, for cylindrical screens the virtual space is all inside the physical space. Hence, the cylindrical screen can be best described as a virtual object, and it is sometimes also seen as a kind of volumetric display.

Screen Metaphors. In contrast to wide, concave-shaped cinema screens, cylindrical screens are non-immersive due to their convex shape, not covering the entire visual field. This makes virtual things emerging out of the screen more natural than immerging the viewer into an artificial world.

Framing. Cylindrical screens are characterized by the absence of the left and the right boundary, as known from the rectangular frame. This makes aligning elements on the screen difficult. Essentially, there is an endless continuation of the layout to the left and to the right, the cylindrical screen has "no beginning and no end" [14].

Visibility. At any time viewers can only see a part of the cylindrical screen, called a "section of view". Vice versa, there is always content beyond the visible. This implies a limitation of perception, but may also be used as a design element.

Direction of Effect. A major challenge when designing for cylindrical screens is the indefinite direction of effect: Cylindrical Screens interact towards an unknown direction, i.e. the side from which the viewers are approaching is unknown.

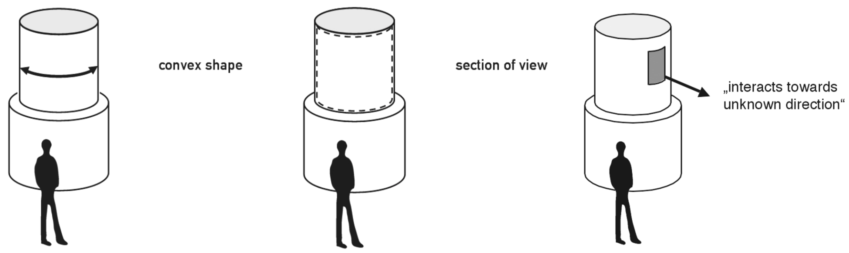

Fig. 5. Relationship between the viewer and the representation on the screen

5 Usage Patterns

Based on our previous findings we derived several usage patterns with regard to visualization and interaction, which impact on the design for cylindrical screens.

5.1 Visualization

The properties of cylindrical displays lead to the following design guidelines:

Screen Layout. Cylindrical screens have no left or right boundary for aligning elements. To arrange screen elements spatially, we suggest using the upper and lower boundary and the decoration of elements by size, color, shape, or animation.

Multi-Usage. To provide content to many viewers in different positions around the column, interactive and personal contents should be regionally limited.

Images and Movies. We observed that the merely technical adaptation of common image and video formats does not conform to the viewing requirements since the absence of a left and right boundary makes it difficult to receive information and track dynamic content. Hence we propose to use images in a smaller scale so that a frame is visible, or where possible, to use cut out or regionally limited graphics instead.

Panoramic Images. When using panoramic images the viewpoint of the classical panorama shifts outside the column, so that the viewer perceives a distorted image. Since we are not used to such a perspective, the panoramic images are losing their effect. We recommend not using panoramic images on column screens.

Typography. Since the viewer may move both to the right and to the left the reading direction is not predefined on cylindrical screens. We developed a reactive animated typography that follows changes in the position of the passer-by on a visual step-curve, thus allowing for reading text while moving in any direction. In order to prevent that the viewer looses the text flow, we use the concept of visual moderation and announce the position of the next word by an animated dot (see Fig. 6).

Fig. 6. Typography on Cylindrical Screens

5.2 Interaction

In order to understand as to how interaction on cylindrical columns could be designed, we experimented with different interaction techniques. We found out that implicit interaction based on tracking the viewer's position and movements are most suitable to get the passers-by involved into interaction with the screen. Once users engage, more explicit interaction techniques may be considered.

Multi-touch. Though our prototype does not support multi-touch we believe, based on our observations, that this interaction technique does not adapt well to the viewers' motion patterns (walking around the column, only short time in the vicinity, not task-oriented). However, more research is required to backup this assumption.

Face Detection. Our examinations show that face detection does not work well with the column since it requires a frontal viewing. However, viewers rather spontaneously face the cylindrical screen frontally while moving around the column.

Hand Gestures. We developed several applications to understand the effect of gestures as interaction techniques. We found out that the characteristics of the column have a strong influence. Whereas drawing on the column's screen was quite intuitive, pushing a ball around the column turned out to be difficult due to the shape.

Overall our observations revealed that, explicit interaction techniques only work in close proximity of the display. Hence we believe that it is crucial to first try and engage the user before applying those interaction techniques.

6 Conclusion

In this paper we presented the design space for large cylindrical screens. We deployed a prototype system and observed users in a lab environment while interacting with the screen. Based on these observations we reported on usage patterns and explored how they impact on the visualization and interaction design for large cylindrical displays. The results of our examinations indicate that cylindrical screens embody a distinct medium with specific requirements and qualities. Because of their shape, they significantly differ from planar rectangular screens and from VR since they neither follow the window nor the immersion metaphor. Instead, we see the potential of the column in its bent, round shape and in the increased degrees of freedom. Digital cylindrical screens enhance classical, analog columns not only by dynamic images but also by their potential to interactively engage with the user. In particular, knowing the position of the viewer helps to not interact towards an unknown direction.

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