On the Impact of Non-flat Screens on the Interaction with Public Displays

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Abstract
With decreasing prices for display technologies and bendable displays becoming commercially available, novel forms of public displays in arbitrary shapes emerge. However, different shapes impact on how users behave in the vicinity of such displays and how they interact with them. With our research we take a first step towards exploring these novel displays. We present findings from an initial study with cylindrical displays and discuss to what extent findings can be generalized towards other forms of public displays.

Keywords
Large displays, non-planar screens, interaction techniques, content design, social interaction

Introduction
In recent years also non-flat displays have found their way into digital signage, and some of them already provide means for user interaction. The following types of non-flat digital screens have already been deployed (see Figure 1):

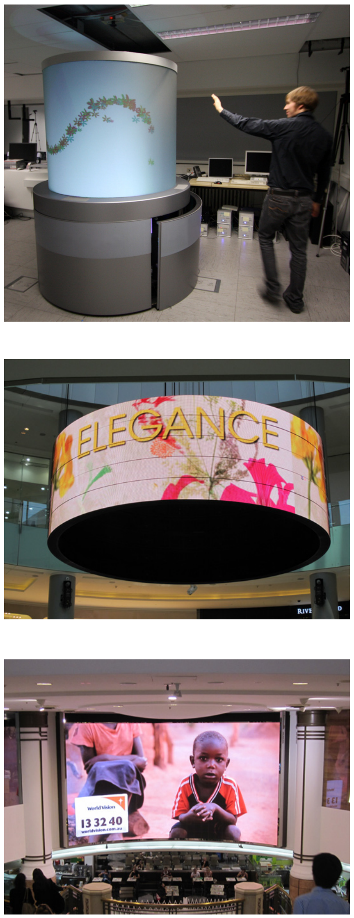

Figure 1. (a) Prototype of an interactive digital Morris Column, (b) Large cylindrical display of the Fashion Catwalk in Dubai Mall, (c) Curved display wall in Westfield Sydney Shopping Centre

- **Digital Cylindrical Screens** standing in the pedestrian precinct can be seen as the next generation of Morris or Litfaß columns.
- **Dome Projections** (halfs of a sphere) and large cylindrical screens are used in the atriums of shopping malls (e.g. Dubai Mall Fashion Catwalk).
- **Curved Wall Displays** are media façades that integrate well with existing architecture. They often have bended or wavelike shapes.

It can be assumed that more complex forms of non-flat displays will be seen in the future when low-cost bendable display technologies become available. As these displays permeate the urban space, understanding the way users behave in their vicinity and how they interact is crucial to design successful and appropriate content. To do so, we report on an initial study with a cylindrical display. We discuss how results generalize with regard to interaction, content design, and social experience.

Evaluating Different Types of Large Displays

Understanding how users move, e.g., which distances they cover, where and for how long they stop and how they position themselves, are important to understand how interactive content should be designed and where such displays are reasonably deployed. Studies on audience behavior have so far been limited to flat, rectangular displays and many designs assume that 1) people stop walking before they interact, 2) users can perceive the content of the entire screen at any time, 3) users can see what other people do when interacting with the display, 4) shoulders are usually parallel to the display, 5) the position centrally in front of the display is preferred, and 6) content is not distorted. However, these findings do not generalize for new forms of displays. To better understand the challenges of studying novel forms of displays, we studied audience behavior in front of a cylindrical display as one possible use case. Our aim was at understanding how to evaluate different display types with regard to audience behavior.

As a consequence we conducted a lab study with 15 participants with the prototype depicted in Figure 1a, comparing it to a flat display (10 males, average age 33 years, recruited in the neighborhood). The prototype uses a camera to detect body movements. We opted for a lab study as camera observations of movement patterns and interaction times are difficult to perform in public due to privacy reasons and sensible technical equipment. To make people behave in a natural way and distract from the observed objects we created a museum-like situation where people would approach a number of interactive and non-interactive exhibits in different rooms. To make results comparable the same content was used for both displays under investigation.

Audience Behavior

In the following we share observations and conclusions derived from the results of the study. For a more comprehensive overview on the results we refer to [1].

Moving Around the Column

As opposed to a flat, rectangular display, a column does not provide any boundaries left or right. This lack of borders indeed seems to have the effect of making viewers move freely around the column. Participants spent most of their time walking and covered significant distances, looking at the column from various locations and stopping quite often, but only for relatively short times. This led to much more diverse body postures as opposed to a flat display. We believe that the same holds for other forms of displays.

The Sweet Spot

The data shows that for flat displays, there is a relatively small area in front of the display where participants get themselves in a frontal position ("the sweet spot"). This area was positioned centrally in front of the display, about 1.5 meters away from it. Participants seemed to approach this area quickly after entering the room, and stopped in this position with their shoulders parallel to the display, facing the display frontally. From this position, they could see the entire screen from the best perspective, while the entire frame was still in the visual field. In contrast, people in front of the cylindrical display rather seemed to move on a narrow circle around the column. We believe that all displays have an area where users position themselves in order to best perceive or interact with the content. This area might vary depending on the type of content and interaction techniques used – but we cannot yet provide evidence.

Time Spent for Interaction

Participants spent significantly more time with the flat display than with the column, almost twice as long. This is an interesting finding, which we believe is worthwhile to be investigated in more detail. Knowledge on the average interaction time for certain display types is valuable as this information can be used to choose suitable display types for different purposes (e.g., whether interaction times should be maximized or minimized).

Designing Content for Non-flat Displays

To put different display types to their best use, content for non-flat displays should follow requirements that are deduced from their shape and may differ from design principles for classical flat displays. For example, in our study comparing classical flat and cylindrical screens we found out that the latter, due to their round shape and as they are semi-framed, have the following qualities compared to flat displays (see [1,2]):

- Columns and their content should be designed for walking, as cylindrical displays are most suitable to keep people in motion.
- As users move more when interacting with cylindrical screens, less complex content should be used than with flat screens.
- We found out that frameless content is ideally suited for cylindrical screens due to the diverse positions of viewers.
- As cylindrical screens are semi-framed they have no left/right boundary for aligning content. Instead, to create meanings or layout hierarchies, the screen's upper/lower boundary can be used.
- Columns are more suited for non-immersive content due to their convex shape, not covering the entire visual field.
- Different shapes allow for using different screen metaphors. For example we observed that it confuses users to watch a movie on the screen that is distorted due to the screen shape, or to push a ball around the column, from which we know that it is flying straight on in the real world.

Generally speaking, for each type of non-flat display the specific requirements of its shape have to be considered. In contrast to a cylindrical screen where the viewer is standing "outside the column", a screen where the viewer is standing "inside the column" (i.e. a 360° panorama or also a dome shape) might be best suitable for content that requires the viewer to stand in a fixed position instead of walking, or for displaying immersive content instead of non-immersive content. Slight differences in shape and setup of the display can mean that quite different types of content have to be designed to produce effective user experiences.

Social Interaction around Non-Flat Displays

Display shapes can have a substantial influence on how multiple people engage with interactive content. In our study on audience behavior around cylindrical screens we discovered the following qualities:

- As there is no sweet spot, multiple users can approach the display on equal grounds and do not need to take turns. Appropriate content can help here to attract users towards non-crowded areas around the display.
- We observed that if groups of people approach the column, users have fewer inhibitions about starting to interact than with flat displays. With flat displays usually only one or few persons are exposed to the interaction in the sweet spot and thus are exposed to possible reactions of the audience, while around a column users feel less observed as if standing in an exclusively occupied spot.

Not-flat Displays in Public Environments

Just as with any flat type of display, the way users interact and how they experience displays also depends on their place of installation and how they are embedded in their environment. For cylindrical screens we found out, that they are best placed in the way of users to support passing-by interaction. What people expect on public displays also depends on the immediate surroundings (compare [3]). This may be different for each type of non-flat display. For example, as columns are usually freestanding, we assume expectations of what shall be displayed may differ from flat displays integrated into a shop window.

Conclusion

Non-flat, digital displays have the potential to change the experience of public displays in urban spaces. Presenting content on such displays, creating an engaging user experience, and exploiting the new properties of these screens requires us to rethink the way we design content and applications. Observations of users' behavior are a necessary first step to develop guidelines to design interactive non-flat displays.

We found that users may move differently when interacting with non-planar displays and that they may spend different amounts of time with such displays. The sweet spot of flat displays, where users tend to position themselves, does not exist for cylindrical displays and the same might be true for other types of displays.

We believe that future studies should also cover multi-user scenarios. Further, our experimental setup enabled the detailed investigation of motion behavior comparing different types of displays. A next step is to more closely investigate interaction with each of these displays in the wild.

References

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