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Position Paper: Perceptual Affordances of Wall-Sized Displays for Visualization Applications

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MOTIVATION

Wall-sized displays engulf viewers in large high-resolution information spaces and form intriguing environments for data visualization and monitoring due to several inherent benefits: (i) physical rather than virtual navigation affords a natural pan-and-zoom in the information space to see overview from afar and details up-close; (ii) an enlarged physical space in front of the display enables collaborative viewing; (iii) and millions of pixels support viewing large amounts of data.

Nevertheless, when used outside research settings in a work context, wall displays are largely treated as big desktop monitors, both in the type of information we view on them and in how we interact with them. For example they often act only as summary and information sharing tools seen from afar (e. g. to enhance situation awareness), with interaction being inexistent or limited to mice and keyboard. Thus the full potential of interactive large wall technology, such as high resolution or direct-touch interaction are not fully leveraged, despite research work on interaction and visualization guidelines.

This lack of adoption can be due to the fact that we still need to learn more about (i) **what** information should be placed on wall displays (replicated information from personal screens, different information, or summaries); and **where** (how to layout the information); (ii) **who** interacts and updates this information (real-time feeds, a group leader, everyone); (iii) **how** to share and more generally interact with them (from a distance using mouse/keyboards or up-close using touch).

The Where

Our current work focuses on **where** to lay out visual information. To answer this question we need to consider the tasks users perform and identify the important information to place in optimal locations. But beyond that we can provide initial guidelines to data visualization designers to help determine this optimal location by examining the perception of visual representations on wall displays. This is challenging as viewers' perception is affected by their position around the wall.

Elementary graphical items such as points, lines, and areas are the building blocks of information visualizations. They possess properties such as position, color, orientation, or size which are the visual variables defining them [2]. Information visualizations consist of an assembly of these items and their variables. Thus, work studying how visual variables are perceived, quantitatively measured, and compared, has built a basis for how these "assembled" visualization are perceived. Nevertheless, the unique viewing environment of wall-sized displays requires a re-assessment of these studies [1].

Recently, we conducted a set of comparison tasks of three visual variables (length, area, angle) across different locations of the wall, to assess their visual perception from different viewing positions [1]. Understanding perception discrepancies and where and when they occur is important as fundamental data analysis tasks involve the correct assessment and comparison of elementary visual variables. To read a bubble chart, for example, one has to compare the sizes of circles to one another and to a legend, as well as relate their positions in a 2D coordinate space. The question arises whether comparisons such as these are affected by the oblique viewing angles which occur when viewing data from different positions in front of a wall-sized display. We found that an increase of the horizontal displacement of items on a wall display can lead in some cases to estimation errors up to 60% when viewers are close to the wall. Our participants consistently overestimated items, even in the case of the traditionally robust or underestimated visual variables. Finally we found that some parts of the wall are perceived differently than others.

Our work, and that of others on how changes in viewers' distance and viewing angle affect visual perception (e.g. visual aggregation of information [3] or text readability and color perception [4]), can help suggest which locations on the wall are optimal for given visualizations, ensuring effective information monitoring and a shared understanding between collaborators working at different positions around the wall.

Some concrete recommendations

We present here some concrete recommendations based on ours and previous studies:

- If visual information is spread across the width of a wall display it is likely to be distorted (perceived differently) based on where different viewers are seated, especially if they are seated fairly close to the display.
- Viewing a wall display close to its center and from a distance of 2-3m reduces distortion across the entire display. Of course it may not be a good position for other tasks (e.g. looking at details). In this case periodically walking around the display is encouraged.
- Some visual variables are known to be visually harder to perceive and compare, such as angles, even in traditional monitors. Angles are also greatly affected by visual distortion in wall displays, more so than lengths, positions and areas. If viewers need to compare visualizations placed at different locations across the display, avoid ones that are based on angle comparison (e.g. pie charts). Bar-charts, for example, are more robust.

- If visual items need to be compared across distances on the wall display, e.g. two pie- or bar-charts, try to either (i) bring them close to the viewer with interaction, (ii) place them as close as possible even if they are not close to the viewers, (iii) or encourage viewers to move to see both items.
- There is evidence that screens below and above the visual field are perceive differently. It is thus advisable to place items to compare (e.g. legends and visualizations) close together not only in width but also in height.

We hope these recommendations will help create more robust visualizations for wall displays.

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