Towards Visual Data Exploration at Wall-Sized Displays by Combining Physical Navigation with Spatially-Aware Devices

Ricardo Langner* Raimund Dachselt†
Interactive Media Lab, Technische Universität Dresden, Germany

Abstract
We present our work on the use of spatially-aware mobile devices in front of wall-sized displays for data exploration and navigation. The basic idea behind this work is to navigate data sets by walking and moving a mobile device within an interaction space. We describe mappings of different types of information spaces and report on results of a preliminary study regarding layered information spaces. We illustrate the potential of such a new data analysis interface by describing a prototype application that both visualizes traffic data and allows for performing comparison tasks.

Index Terms: Human-centered computing—Human computer interaction (HCI)—Interaction techniques; Human-centered computing—Visualization

1 Introduction and Background
Wall-sized displays provide great potential for visual data analysis and information visualization (InfoVis). Due to their display size, they enable interfaces that can show more data, more visualizations, and support collaboration. Previous work showed that users naturally move in front of such displays in form of physical navigation [1], which can offer improved user performance. Another interesting research direction is the use spatially-aware mobile devices for data analysis [2, 3, 7], showing that device interaction and movement can support orientation and navigation of complex information spaces.

The goal of our work is to investigate the use of spatially-aware mobile devices in front of wall-sized displays for data analysis. This is mainly inspired by Spindler et al.’s research on tangible views [5, 7]: They used the physical movement of spatially-aware displays above an horizontal context display, i.e., a tabletop or interactive surface, for the exploration of different information spaces. The question is, what are the consequences and implications of bringing such concepts from setups with horizontal displays to spaces with large vertical displays? Recently, Kister et al. [4] showed how mobile devices can be used to explore graph visualizations on large displays. However, we think that this type of data analysis interface is still underexplored and little is known about how to design them in a way that supports data analysts. We therefore want to improve our understanding on the combination of physical navigation with the use of spatially-aware mobile devices in front of wall-sized displays.

2 Use the Space in Front of Wall-Sized Displays
The basic idea behind our work is to explore and navigate a data set by walking and moving a mobile device within an interaction space. A large and stationary display provides the contextual and central visualization, and mobile devices display portions or different visual representations of the data according to their location (i.e., position and orientation) in the exploration space (see Fig. 1). We extend the definition by Spindler et al. [5, 7] and describe such interaction spaces for vertical displays as a 3D real-world volume in front of a vertical reference surface with the Z-axis that is perpendicular to its surface. Fig. 1b-d illustrates variations of different types of information spaces for vertical displays (adapted from Spindler et al. [5]): layered, zoomable, and temporal information spaces.

From Horizontal to Vertical Displays When comparing setups that use horizontal [5, 7] or vertical reference displays, the following differences emerge and need to be carefully considered for the design of InfoVis applications. First, in many cases vertical displays are larger than horizontal displays. While this allows to display either more or larger visualizations, it might also increase the interface complexity or encourage sensory overload. The large size also leads to a larger interaction space available in front of the display. It fosters physical navigation, which can have positive effects on orientation and task completion times [1]. However, depending on the duration and activity of working sessions, it might also involve higher physical demands. Due to the viewing angle, vertical displays also allow for a more flexible movement as well as various distances from which users can look at it. At horizontal displays, however, users typically walk rarely but stand directly at the device.

3 Local Interaction Spaces
The interaction space mentioned above uses the complete space in front of the large display. Alternatively to this global space, information spaces can also be placed locally (see Fig. 2), especially for layered and temporal information spaces. Instead of walking through the space, the hand-held device is moved locally, most likely along an axis between its original location and the user’s head. While arm movement is less physically demanding, it allows to navigate, for example, a stack of layers from various positions in front of the large display. It would also be possible to use the global and local space independently to navigate individual data dimensions.

Preliminary Study As a first step towards the use of a global or a local interaction space, we started investigating the selection of

*e-mail: ricardo.langner@tu-dresden.de
†e-mail: dachselt@acm.org

© 2018 Ricardo Langner and Raimund Dachselt
This is the author’s version of the work. It is posted here for your personal use. Not for redistribution.
IEEE VIS 2018 Poster Program, 21-26 October 2018, Berlin, Germany
target layers of a layered information space (Fig. 1b) by conducting a preliminary study. In case of the global space, the space is divided into discrete parallel layers that are standing in front of the wall-sized display. Layer selection can be achieved by walking forwards or backwards in relation to the large display (Fig. 2a). For the local space, the stack of layers is placed at the mobile device’s 3D position (Fig. 2b). To navigate through the stack and select a specific layer, the user touches and holds a clutch-button on the mobile device, then moves the device, and finally releases the button.

For the preliminary study, 20 students (8 female, 12 male) from the local university volunteered. The average age was 26 years (M= 25.54, SD= 2.72). The study took place in a controlled lab environment. We used ASUS Nexus 7 (7” display, 330 g) as a mobile device. To track the location of the device, we used a motion capture system mounted to the ceiling. This system covered an area of approximately 5 m × 3.5 m in front of the large display, which had a size of 5 m × 2 m. Based on a previous study on multi-layer interaction [6], we ask participants to perform five sequences of 13 layer selections: 1 × 25 cm, 2 × 20 cm, 2 × 15 cm, 2 × 10 cm, 3 × 5 cm, and 3 × 2 cm. Since each participant performed tasks for both a global and a local space, this resulted in sessions of approx. 20 min and a maximum of 130 selections per person.

As first results (without full statistical analysis), we found that it was easier to complete the sequences in a global space, as people failed more often in reaching thin layers in local spaces. We also observed less overshooting for the global space. However, it seems that if thin layers could be selected, completion times are lower for local spaces. Interestingly, the physical demand reported by participants was higher for local spaces. While one reason might be the more frequent overshooting, we think this could also show that for shorter working sessions walking is less problematic than one would imagine. Finally, we found that if thin layers could be selected, completion times were lower for local spaces.

In this work, we present our ongoing investigation on the navigation of data sets by walking and moving a mobile device in front of wall-sized displays. Besides first insights on the navigation of layered information spaces, we presented a first prototype implementation, which visualizes traffic data and allows to perform visual comparison tasks. An interesting open question regarding layered interaction spaces is the layer thickness. Particularly when users need to navigate with a specific layer by moving along the large display (in parallel), the display size benefits use cases that involve multiple data analysts, we also want to further investigate collaboration and support visual comparison tasks carried out by multiple users. We hope that our work illustrates the potential of such new types of data analysis interfaces and that it can serve as a basis for further investigations and discussions.

5 Conclusion

In this work, we present our ongoing investigation on the navigation of data sets by walking and moving a mobile device in front of wall-sized displays. Besides first insights on the navigation of layered information spaces, we presented a first prototype implementation, which visualizes traffic data and allows to perform visual comparison tasks. An interesting open question regarding layered interaction spaces is the layer thickness. Particularly when users need to navigate with a specific layer by moving along the large display (in parallel), the display size benefits use cases that involve multiple data analysts, we also want to further investigate collaboration and support visual comparison tasks carried out by multiple users. We hope that our work illustrates the potential of such new types of data analysis interfaces and that it can serve as a basis for further investigations and discussions.

Acknowledgments

We thank Matthias Kalms and Lucas Recknagel for their work on the prototype, illustrations, and study.

References