Demonstrating David Meets Goliath: Combining Smartwatches with a Large Vertical Display for Visual Data Exploration

Tom Horak¹

Interactive Media Lab
Technische Universität Dresden
Dresden, Germany
horakt@acm.org

Raimund Dachsel

Interactive Media Lab
Technische Universität Dresden
Dresden, Germany
dachsel@acm.org

Sriram Karthik Badam¹

University of Maryland
College Park, MD, USA
sbadam@umd.edu

Niklas Elmqvist

University of Maryland
College Park, MD, USA
elm@umd.edu

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Abstract

We explore the combination of smartwatches and a large interactive display to support visual data analysis. These two extremes of interactive surfaces are increasingly popular, but feature different characteristics—display and input modalities, personal/public use, performance, and portability. With this demonstration, we present our conceptual framework and its implementation, which enables analysts to explore data items using both devices in combination. Building on a analysis scenario for convicted crimes in Baltimore, our demonstration gives an impression of how the device combination can allow users to develop complex insights more fluidly by leveraging the device roles.

Author Keywords

Cross-device interaction; visual analysis; data exploration; multi-display environment; large display; smartwatch.

ACM Classification Keywords

H.5.2. [Information Interfaces and Presentation]: UI.

Introduction

This demonstration aims to illustrate the concepts and prototype of our fully refereed article *When David Meets Goliath: Combining Smartwatches with a Large Vertical Display for Visual Data Exploration* [3], which is part of the CHI

¹The first two authors contributed equally to this work.

Figure 1: We propose cross-device interaction workflows that allow for an interplay between a large interactive display and smartwatches. For instance, (a) multiple analysts can extract data from views on a large display, (b) store them on their smartwatches, and (c) compare the data on other visualizations at the large display. This pull/preview/push interaction metaphor can be extended to many visualization tasks.

Figure 2: Sets are represented by labels and a miniature view.

Figure 3: Connective Areas (CA) provide the context of an interaction in a visualization.

2018 main program. More specifically, we combine smartwatches with a large displays to allow the watch to serve as a personalized analysis toolbox during the exploration of multivariate datasets on a large display. As the devices represent two extremes—like David and Goliath—of interactive surfaces, several fundamental design challenges arise for their combination. We address these challenges through general considerations about the interplay of devices and a conceptual framework in our main article. To evaluate our concepts, we also implemented a web-based prototype of the framework, which drives this demonstration.

Conceptual Framework

At the core, our cross-device interactions are incorporating two concepts: collections of data points or configurations called *sets* and context-providing elements of visualizations called *connective areas* (CA). Sets are collections of multiple entities of a certain type on the large display, which can be stored on a smartwatch. Sets allow the watch to act as personalized storage (Figure 2). Currently, we consider two different set types: data items (i.e., points in the dataset) and configuration properties (e.g., axis dimension, chart type). We define connective areas as four zones in each visualization that provide the context of an interaction: the marks, canvas, axes, as well as a special element close to

the origin (Figure 3). Connective areas define the set type and control the functionalities accessed on the two devices. In the context of the task topology from Brehmer and Munzner [2], the combination of these two aspects—data and context—represents the *what* of an interaction, and enables the smartwatch to act as mediator defining the *how*.

The unique combination of these two device types based on the above concepts supports an interaction flow as follows (Figure 4): The analyst can **focus on a CA** of interest by performing a double tap or a touch-and-hold on the CA, or by tapping or circling marks. Afterwards, the analyst is able to **pull** (i.e., create) a set based on the chosen focus or selection by performing a swipe gesture towards herself on the smartwatch. The stored sets can be **previewed** in other visualizations by switching the focus onto these. As long as the focus stays active, it is possible to switch through the stored sets on the watch by swiping vertically

Figure 4: Our conceptual framework allows for an interaction sequence that builds on a strong interplay between the large display and a smartwatch.

Figure 5: (a) Pulling, (b) previewing, and (c) pushing of sets.

or rotating a physical bezel, and preview these other sets for comparison. To permanently **push** the changes to the view on the large display, a horizontal swipe towards the large display, i.e., the visualization, can be performed on the watch. As an extension to storing sets, the smartwatch also offers the possibility to **manipulate** and combine sets on the watch. By performing a long tap on a set, these operations are shown in a menu. For a complete and detailed description of the conceptual framework, please see our main article [3].

Prototype Implementation

We developed a web-based prototype to instantiate our conceptual framework for demonstrating and evaluating our ideas. We deployed the prototype to two large display setups—a 84-inch Promethean ActivePanel and a 55-inch Microsoft Perceptive Pixel—where both setups used the Samsung Gear S2 smartwatch. All devices connect to a Python server that serves the front-end files, handles communication, and performs data operations.

In the current version, we focused on the interaction with data points and sets to test the core principles of our framework. The large display shows multiple D3-based visualizations [1] showing different attributes of the crime dataset. This dataset contains roughly 250,000 crimes in Baltimore, Maryland, USA between 2011 and 2016, where each crime is characterized by location, date, time, type, weapon, and

geographical district. Users can select marks by touch in any visualization. On the smartwatch, it is possible to pull a set from the large display onto the watch as well as preview and push it onto other views on the large display (Figure 5). Furthermore, the watch allows to combine sets and to remotely selecting views by scrolling through the displayed views on the large display. This setup allows users to work flexibly in front of the large display, through direct touch and remote interaction, and utilize the device combination to explore and compare data items of interest on different visualizations to develop insights, while maintaining their corresponding sets on their smartwatch. The current implementation is not capable of distinguishing multiple users, remote pointing, and changing visualization configurations.

Conclusion

With our conceptual framework, we have presented a way to support visual analysis tasks in a multi-device environment consisting of a large interactive display and smartwatches [3]. This accompanying demonstration illustrates the interplay between the two devices and how their respective advantages can be incorporated. Based on connective areas as well as sets (of both data items and visualization properties), we propose specific interaction techniques exploiting the large screen estate of the *public and shared display* and the personal nature of the smartwatch as an *user-specific storage, mediator, or remote control*.

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