Powerwall Interactions

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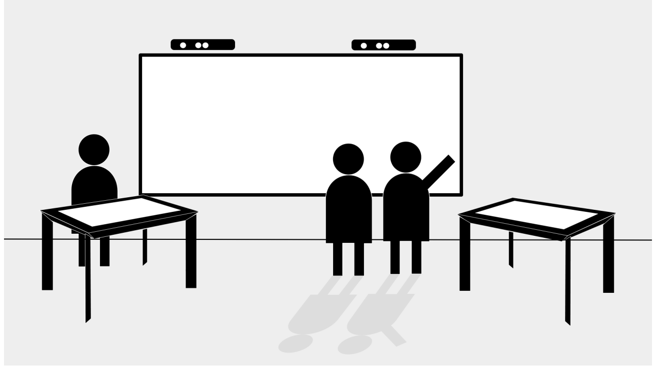

Figure 1: This position paper presents first results of a framework that connects interaction devices such as gesture recognition systems and table-top devices to interact with a high-resolution display.

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Abstract

Analyzing large data sets on ordinary computer screens can be very cumbersome as size and resolution of desktop screens are rather limited. As a potential solution, ultra-high resolution powerwalls extend the researcher's work space and facilitate the analysis of large data sets. However, the interaction with powerwalls requires new interface technologies beyond keyboard and mouse. This paper contributes an interaction concept which allows several users to collaboratively interact with powerwalls. The interaction concept uses gesture recognition and table-top techniques to control visualizations on a powerwall. To test our concept in practice we have developed a framework that connects devices, in particular table-top computers, gesture recognition devices and a powerwall with a server. This server renders visualizations on the powerwall. We briefly discuss results of a prototypical implementation in an eye-tracking data analysis scenario.

Author Keywords

Powerwall; high-resolution displays; table-top; collaboration; large screen interaction; interactive visualizations

ACM Classification Keywords

H.5.2. [Information Interfaces and Presentation (e.g. HCI)]: User Interfaces

Introduction

A large amount of data is generated and stored every day for various purposes. Visualizations are extremely helpful to graphically find patterns, interesting aspects, or to communicate information behind large data sets. As soon as it comes to analyzing large data sets through a multitude of visualizations and especially if it comes to cooperatively analyzing them, the space of ordinary computer screens quickly limits the viewer's abilities. This limitation can be overcome by using large displays with thousands of pixels in resolution. These so-called powerwalls allows several users to look at the presented content at the same time. Additionally, several high-resolution visualizations can be presented on the powerwall. However, traditional interaction concepts using mouse and keyboard devices can be cumbersome and the use of these devices complicates a multiple user interaction scenario. Therefore, additional modalities and interaction styles are necessary to control powerwalls. Thus, concepts for the collaboration on a powerwall with several devices such as tablets, table-tops, and other mobile devices must be provided.

Figure 2: High-resolution powerwall VVand at VISUS, University of Stuttgart.

In our project *Powerwall Interactions*, we aim at exploring the design space of interacting and collaborating with powerwalls. We want to build and compare different set-ups, collaboration scenarios, as well as interaction styles, modalities and visualizations using a prototypical powerwall set-up as well as one of Europe's largest powerwall installations (cf. Figure 2).

One goal of our project is to employ a user-defined approach by looking at how users naturally want to interact with these set-ups. While we will look at various scenarios, one current focus is the analysis of eye-gaze data collected during eye-tracking experiments. The first prototypical environment consists of a powerwall that can be controlled by gestures using a Microsoft Kinect sensor. Additionally, collaboration is enabled through the Microsoft Pixelsense computer which allows users to control visualization using tangible objects.

Related Work

In the domain of large displays and powerwall, much work has already been done. Since first concepts have been envisioned by Weiser [14], projects like Roomware [11] have investigated interacting and collaborating with large screens in ubiquitous environments. Today powerwalls have sizes as big as 20480×6400 pixels, respectively physical dimensions of 5.5 m×1.8 m, and resolutions of up to 100 dpi [8].

In order to interact with powerwalls, various research projects have been conducted involving different input modalities such as free hand pointing input by Vogel et al. [12] or multi-finger and whole-hand gestures from a distance by Malik et al. [6]. Alternatively, physical movement has been proposed as a navigational aid [1] as well as physical manipulation [3]. Different modalities have been compared to perform certain tasks such as for instance pan and zoom [8].

Collaboration scenarios in a powerwall environment have been studied by Vogt et al. [13]. They have used a large scale screen to allow users to collaboratively work with standard input devices on visual analytics tasks. In their work they have investigate the collaboration of multiple users. For a powerwall with touch interaction technique, Jakobsen et al. [4] evaluated the collaborative use of a powerwall for several tasks of the VAST 2006 Challenge. An example for our framework, which allows users to interact with large screen displays through multiple devices, is the Shared Substance framework [2]. This framework uses an abstract data driven approach which allows for implementing many different scenarios. A user defined approach to develop interaction styles with large scaled displays has been employed by Knudsen et al. [5]. By conducting several workshops, they have tried to find out how people use a large scaled display and how they could interact with it.

Based on existing work in this domain, the goal of our ongoing work is to further extend interaction and collaboration concepts with powerwalls.

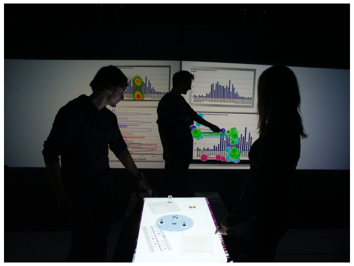

Figure 3: Three users are working with the powerwall interactions prototype.

Interaction Concept

As a general concept, we envision an environment consisting of at least one powerwall and additional devices (cf. Figure 3). The powerwall is used to show various contents, such as an overview about data items or various visualizations. Different *interaction techniques* can be implemented and used to allow interacting with the visualizations either by a single or by multiple users. Additional devices like table-tops or tablets can be integrated. The visualizations which are shown can be manipulated on the powerwall as well as on connected devices. If additional devices are connected, these devices may not only present a powerwall view (public space) but also provide private spaces that are only visible on the devices. These private spaces can be used to prepare visualizations for all users in the powerwall environment or to perform personal investigations on the data. Visualizations can be moved between private spaces and the public space. The view of the powerwall is intended to be interactive and thus allows user to remotely interact with visualizations on the powerwall.

Important for a success of a powerwall interaction environment for multiple users is that the interaction styles are intuitive and are easy to learn for the users. Additionally, the technical set-up has to be scalable, easy to configure and should be generic with respect to data types and visualization techniques. Therefore, we envision a *framework* which facilitates distribution and visualization of different kind of content and which additionally allows for manipulating the graphical representation across different devices. We propose, that the framework should consist of a server component which provides the communication between various clients representing the different interactive devices (powerwall, tablets, table-tops, smart phones), data providers, and clients. Except for data providers, all clients should be able to show visualizations which represent different views of the data. The communication components of the framework represent an abstract structure of the data that is manipulated and visualized. As the data size of visualization data is typically very large, data storage shall be handled by the server instead of storing it on each device. Visualization techniques are realized using a plug-in system on every device.

Implementation

Low-Fidelity Interactive Prototype

A first prototype was implemented using a back-projection powerwall which consists of two full HD projectors providing a resolution of 3840×1080 pixels. If 3D vision is required, two additional projectors can be used for a stereoscopic viewing. An off-the-shelf depth camera (Microsoft Kinect[1]) is positioned on top of the projection wall and is used to interact with the powerwall by performing gestures. A Microsoft PixelSense[2] table-top allows users to select data items or to change visualization parameters.

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[1] http://www.microsoft.com/en-us/kinectforwindows/

[2] http://www.microsoft.com/en-us/pixelsense/

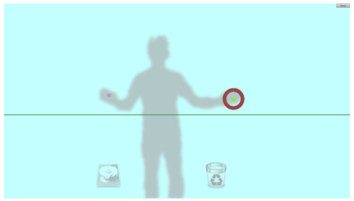

Figure 4: Interacting with the powerwall using a Kinect sensor and virtual items.

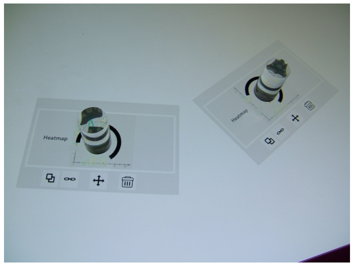

Figure 5: Tangibles allow users to select data items or to change visualization parameters.

The prototype is developed using .NET. The communication framework uses an extensible and server-based message system. Within the framework, data containers are used which can contain various types of visualization data. The framework uses webservices based on the SOAP protocol for a platform independent design.

To provide an easy access to visualization data, we have implemented an interface for data providers on the server. Every data provider provides data for a number of disjunct types of data. Each device is able to present all public visualizations. The status and position of the visualizations are synchronized using the communication framework. The PixelSense computer additionally has a private space for visualizations which are not shown on the powerwall.

Each interaction device is connected to the framework as a client. The first version prototype has a client for the Kinect sensor and the Pixelsense table-top. The Kinect's client has a direct connection to the powerwall. For the interaction input it is mainly using the built-in skeleton tracking system from the Kinect SDK. We have implemented several additional virtual items positioned around the rendered real time image of the user which allows the user to interact with the visualizations (cf. Figure 4).
The Pixelsense client uses the Microsoft Surface SDK. We have implemented a private space and a view of the powerwall for a direct interaction with presented public visualizations. The interaction is done using standard touch gestures and tangible interaction. There are different kind of tangibles which allow users to select data items or to change visualization parameters (cf. Figure 5).

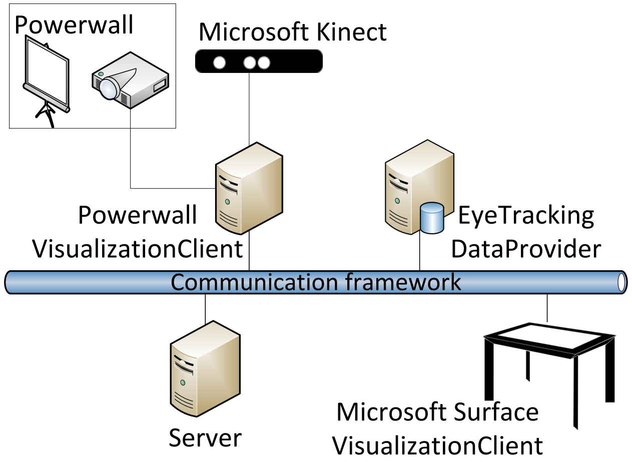

Figure 6: Our framework connects server and clients such as a Kinect device and a Pixelsense computer.

High-Fidelity Prototype: 3D Powerwall
For more complex scenarios as well as for research on interactive computer graphics and visualizations, we want to test our prototype using the VVand at the VISUS, University of Stuttgart (cf. Figure 2) in future work. This high resolution display is using ten VC DLA SH4K projectors to provide a screen resolution of 10800×4096 pixels (about 44 million pixels per eye) respectively a physical dimension of 5.97 m×2.26 m. This means that each pixel has a size of about .55 mm. More information about this powerwall can be found in [7].

Exemplary Scenario

In this section we will briefly present the application of the prototype in an eye tracking data analysis scenario since many eye tracking experiments are conducted in our institute (cf. Figure 7).

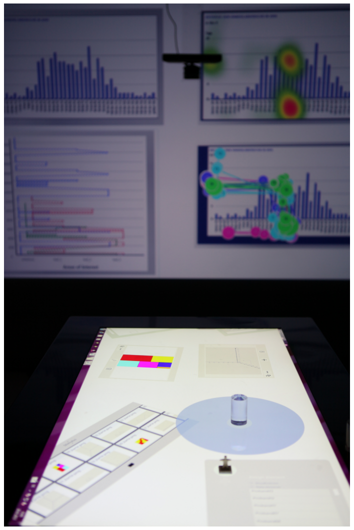

Figure 7: Application of the prototype in an eye tracking data analysis scenario with powerwall and Kinect sensor in the background and Pixelsense computer with tangible objects in the foreground.

During the last decade eye tracking experiments have become a state of the art technique to test the usability of graphical user interfaces. Eye tracking allows researchers to evaluate their software with respect to metrics such as number of fixations, fixation rates and duration. These metrics can be used to provide information about the cognitive workload of a given task using a software or a visualization. In eye tracking experiments a large amount of data is recorded. For example, a typical user study with 30 participants and three blocks of tasks, each consisting of 30 subtasks, leads to 2.700 scan paths. These 2.700 scan paths have to be compared with each other. During the analysis of an eye tracking experiment the following elements have to be selected: tasks, participants, group of participants and time segments. Using different visualization techniques such as scan path, heat map and parallel scan path visualization techniques [9] the user can analyze the recorded data. Since state of the art analysis software is developed to be used in single user mode, but eye tracking experiments are often analyzed by a group of HCI researchers, a collaborative interaction concept for eye tracking data is desirable.

The work flow for the analysis of eye tracking data was developed based on the Visual Information-Seeking Mantra (overview first, zoom and filter, details on demand) by Shneiderman [10]. Overview about the recorded data is realized with visualizations on the Powerwall. This allows the users to view all recorded data or selection of data at one glance in a high resolution. If several stimuli, tasks or participants have to be compared with each other, they can be shown in different windows on the powerwall. For each window an appropriate visualization technique can be selected performing a wipe gesture. This overview about all recorded eye movements can be discussed by all present users.

Next, filtering and zooming can be done via direct gesture interactions on the powerwall or via the table-top computer. From this moment, the analysis can be continued in different groups of users. These groups concentrate on different classes of stimuli or participants. During this details-on-demand step new visualizations can be created in private spaces both on the table-top or tablet devices or on dedicated areas on the powerwall. Results of this analysis can later be moved back to the public space to continue the analysis with all present users.

Current Status and Future Work

In this paper we have presented an interaction concept which allows several users to collaboratively interact with visualizations on powerwalls. To test this concept in practice we have implemented it in a prototype. We are using a Microsoft Kinect sensor for gesture recognition and a Pixelsense table-top computer to select data sets and change visualization parameters. A communication framework connects all devices including the powerwall with a server that provides the data. We briefly presented the application of the framework in an eye-tracking data analysis scenario.

Future work will be to evaluate our interaction concept in user experiments to find user-defined interaction styles [15] for different kinds of scenarios. Additionally, we are planning to implement further visualization techniques beside eye tracking visualization techniques such as for scientific data.

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