Private Focus Portals to Shared Energy Visualizations

Chi Tai Dang[1], Masood Masoodian[2], Elisabeth André[1]
[1] Human-Centered Multimedia Lab, Augsburg University, Germany
[2] Department of Computer Science, The University of Waikato, New Zealand
[dang, andre]@informatik.uni-augsburg.de
masood@waikato.ac.nz

Abstract. Large interactive displays provide potential platforms for collaborative visualizations to support groups of co-located people in interacting with shared information spaces. In these settings, it is often necessary to provide the individuals with their own private views of the shared visualizations. In this paper, we present a prototype system that allows users to get private views of their areas of interest (i.e. focus) within the larger shared visualizations (i.e. context) displayed on tabletop surfaces through portals provided on mobile devices. We demonstrate the potential of this system for visualization of collective and personal energy consumption data with the aim of supporting smart energy applications.

1 Introduction

Collaborative visualizations allow groups of people, with potentially different expertise, to combine their individual analytic power to tackle complex problems from different angles in concert or independently [11]. Various visualization systems have been proposed to support synchronous co-located collaboration [5]. These systems often use multiple displays, where a large shared display is used in combination with a number of smaller private displays (e.g. mobile devices or laptops), each belonging to one of the group members [12, 1, 8].

Collaborative visualizations need to support two different types of activities of group members, in working together (*coupled*) and working alone (*decoupled*) [9]. In their review of coupling in co-located collaborative visualizations, McGrath et al. [8] identify three problems with the use of a single tabletop display in these settings: 1) adding private views to the shared display uses valuable screen real-estate, 2) these views have to be managed as group members move around the table, and 3) such private views are always visible to others, reducing the degree of decoupling that can be achieved. Based on this observation McGrath et al. propose a *Branch-Explore-Merge* approach to supporting coupled and decoupled modes of interaction in co-located collaborative visualizations [8].

In this paper, we investigate this type of *coupled/decoupled* form of group interactions in co-located collaborative visualizations. We introduce our prototype system, called *Show-Me*, which allows individual users to focus on their own data and areas of interest using their private mobile devices, while sharing a common visualization context displayed on a public tabletop display. Our scenario of use is that of colleagues working in various offices in a building who view, share, and compare their personal energy usage data with those of others using a visualization designed for comparing temporal energy consumption data.

2 Energy Usage Visualization Scenario

As mentioned, co-located collaborative visualization tasks often involve coupled and decoupled activities with seamless transitions between them. In such visualizations, it is necessary to provide individual users with their own personal view of the public information space shown on the large shared display. We assume that the public visual space in its entirety acts as the context, while the views provided to individual users act as their own personal area of focus. This area of focus may have a different level of magnification to the context (visual zooming), or it might have a different level of information detail or content (semantic zooming)[1].

Our demonstrative scenario here is based on visualizations used for comparison of energy consumption data. We use a visualization called *time-pie* [6], designed to support comparison of personal and collective energy consumption data. Time-pie is an example of radial visualizations, which have been successfully used on mobile devices to motivate energy awareness [10]. Figure 1-left provides a sketch of the time-pie visualization, showing the amount of energy (in percentages) used by three types of devices during a 24-hour time period. The entire 24-hour period is divided into twelve 2-hour time slices, and the size of each slice is proportional to the amount of energy used during that time period in relation to the entire day. Similarly, within each slice, the amount of energy used by each device is represented as a percentage area of the entire slice. Time-pie also shows contextual information (e.g. outside temperature, the number of people in the office, etc. for each time slice) around its circumference.

We use this visualization to allow people working in different offices in a university building to compare the energy consumption of their own offices

1 For a detailed review of focus and context interfaces, see [2].

(or devices) against those of others. The time-pie visualization of the offices in a building is shown on a tabletop surface placed in a communal place in the building (e.g. coffee-room). People working in various offices in the building can view energy consumption of all the offices on the tabletop. Individuals may also wish to compare and share their own energy consumptions, in terms of their entire office or individual device types, with others. We consider this type of comparison to be a private activity, at least initially, or until the individuals are prepared to share their views with others. In this case, one could imagine individuals using their own mobile devices (e.g. tablets) as physical portals to view and focus on their own personal energy consumption data in the context of the collective energy usage visualization shown on the public tabletop display.

Multiple users could also share and compare visualizations of their personal usage data with each other, in the context of the visualization for all the offices or devices in the building. This would allow them, for instance, to discover patterns, identify interesting usage behavior, etc. in an attempt to collectively, as well as individually, make sense of their energy consumption data.

We consider the radial form of the time-pie visualization (and its Cartesian variation, called *time-stack* [7]) to be more suitable for a tabletop display, where different group members in a co-located collaborative setting will view the same visualization from different orientations. As Isenberg and Carpendale [4] point out (with reference to a study by Wigdor et al. [13]), for collaboration around tabletop displays care must be taken in choosing visualizations that are less susceptible to distortions due to changes of orientation.

Figure 1. Sketch of the time-pie visualization (left), from [6]. A co-located collaborative visualization session using *Show-Me* (right).

3 Prototype System

The current *Show-Me* prototype utilizes a tabletop display to show the shared visualization of the context, while individual group members use their mobile tablet devices as portals to view visualizations of their own areas of interest (i.e. focus). Figure 1-right shows a co-located collaborative visualization session with three people using *Show-Me*. In this setting, various modes of coupled/decoupled group interactions are supported. These are:

1. *Coupled interaction around the tabletop without tablets* (Figure 2-left). In this mode the tabletop display is used to provide the shared visualization of the context, with the usual zooming, panning, and other forms of interaction possible.

2. *Decoupled interaction around the tabletop with tablets* (Figure 2-middle). In this mode the tabletop display provides the shared visualization context, while individual tablets provide private visualizations of the areas of focus. Group members may "hover and move" their tablets over the tabletop to get focus+context type visualizations (person *A* in Figure 2-middle). Alternatively, they may also move away their tablet from the tabletop (after the two have been

synchronized by simply placing the tablet on the tabletop), to get overview+detail type visualizations (person *B* in Figure 2-middle).

3. *Coupled interaction around the tabletop with tablets* (Figure 2-right). In this mode the public visualization is shown on the tabletop display, while individual tablets are used to share private visualizations of the individual areas of focus. The individual group members may "place and drag" their tablets on the tabletop display to share a focus+context visualization of their private views over the public view.

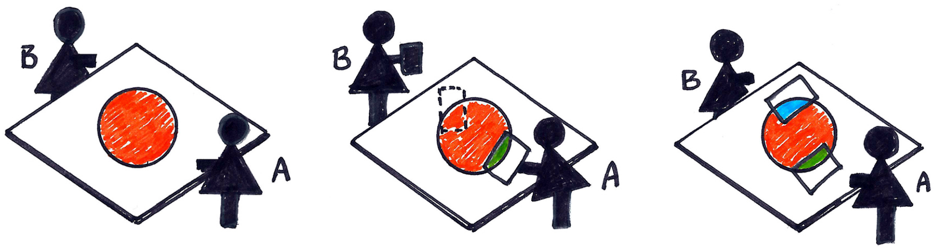

Figure 2. Coupled interaction around the tabletop without tablets (left), decoupled interaction with tablets (middle), and coupled interaction with tablets (right).

Although in this section we present these three coupled/decoupled modes of interaction separately, other combinations of them are also possible. For instance, in a modified coupled variation of the decoupled mode (Figure 2-middle) the group members may show each other their private visualizations using their tablets in the context of visualization shown on the tabletop.

It should also be noted that the type of focus provided on the individual tablets, in both coupled and decoupled modes, in most cases is likely to be a semantic focus (e.g. using semantic zoom). This would allow viewing private visualizations at various levels of semantic detail (as well as visual detail) over the shared public visualization.

3.1 Coupled Interaction around the tabletop without tablets

In this coupled mode of group interaction two or more people would use a shared visualization of collective energy consumption data shown on the tabletop display to view and compare energy use by different types of devices (Figure 3-left) or different offices (Figure 3-right) in the building. *Show-Me* allows selection of different visualizations of public data sets, as well as allowing users to zoom, select, and interact with different sections of the shared visualization.

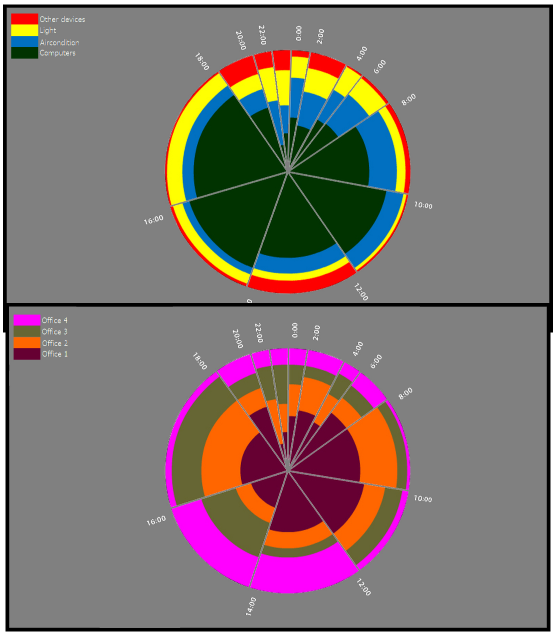

Figure 3. Public time-pie visualization of energy consumption by all the devices (left) and by all the offices (right).

3.2 Decoupled Interaction around the tabletop with tablets

In this decoupled mode of co-located interaction different group members will use their mobile devices (tablets in this case) to view and interact with visualizations of their personal (or even collective) energy consumption data. The visualization shown on the tablet will be considered the focus of the user, while the visualization shown on the tabletop will act as the context.

Once a tablet has been synchronized with the tabletop, it can then be used as a physical private focus portal to the public visualization shown on the tabletop display. As mentioned earlier, the focus can be changed by panning and zooming visually (i.e. change of magnification), or semantically by overlaying other visualizations or changing levels of information detail. Each tablet (and its user) are associated with a particular office, and as such, they are allowed to only view their own personal usage data in detail, or use other visualizations on their assigned tablets.

Also note that users can put their tablets on the tabletop, or lift, hover, and move them above the tabletop, to get their own focus+context views. Lifting the tablet completely and moving it away from the tabletop allows keeping its view in synch with the tabletop, and provides an overview+detail mode of operation.

3.3 Coupled Interaction around the tabletop with tablets

Coupled interaction around the tabletop could also include the use of tablets to share details of personal energy consumption, which are not available through the collective visualization of the tabletop display. For instance, individuals may wish to view and share visualizations of their personal energy consumption data with the aim of comparing and identifying interesting patterns of use.

Figure 4-left shows one such case, in which two people from offices 1 and 4 are using their tablets to compare their private energy consumptions by different devices between 8:00 and 10:00 in Office 1 with those of Office 4 between 12:00 and 14:00.

Note that although in the current version of our prototype it is not possible to layer tablets on top of one another to combine their areas of focus through physical layers, this is something that we are intending to investigate in the future. For now, if two tablets need to focus on different parts of the same area of the shared tabletop visualization (e.g. offices 1 and 4 between 12:00 and 14:00), then one or both of the users need to lift their tablets off the tabletop and interact with the tablet surface to move their base of focus to the same region.

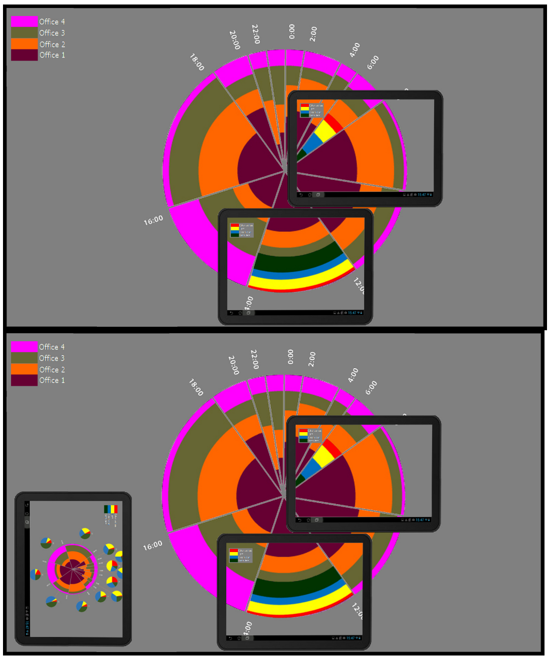

Figure 4. Public time-pie visualization of energy consumption by all the offices in coupled interaction around the tabletop with tablets. The left picture shows details of devices for Office 1 between 8:00 and 10:00, and Office 4 between 12:00 and 14:00. The right picture shows a combination of tablets, each with a different type of details for one of 3 of the offices.

Clearly it is not necessary to have the same type of focus visualization (e.g. semantic zoom) in all the tablets used in this form of coupled interaction. Figure 4-right shows an example of a case where the tablet on the left is providing a different visualization of the details of energy consumption by all the devices in one of the offices for the entire day.

4 System Implementation

The current *Show-Me* prototype has been designed as a distributed multi-surface (multi-display) system, consisting of application components for the Microsoft PixelSense tabletop, and Google Android-based tablets. The tabletop application was developed using the PixelSense Surface SDK (WPF) and shows the shared public visualization on the tabletop display surface. Tablet application, on the other hand, was developed using the Java programming language for the Android platform and provides the private focus views.

Both applications utilize a multi-platform MSE (Multi-Surface Environment) framework, called *Environs* [3], as a software layer integrated into the *Show-Me* applications for each participating device. By means of this framework, the devices span a so-called application environment, which is similar to a Peer-to-Peer network wherein the devices are loosely coupled together and communicate with each other directly.

To create and show the private focus views on the tablets, *Show-Me* leverages interactive video portals between devices provided by the *Environs* framework. Those video portals can be overlaid, with multiple static or dynamically changing content, before streaming to destination devices. Our prototype makes use of this feature to provide additional private visualizations (e.g. usage data for different offices) to individual users in coupled and decoupled interaction modes.

In order to track the mobile devices, our prototype makes use of the Byte tags[2], which are natively supported by the PixelSense tabletop.

5 Conclusions

Here, we have presented our prototype *Show-Me* system which utilizes a shared tabletop display with a combination of mobile tablet devices, to create a multi-surface environment for comparing and analyzing personal and

2 http://www.microsoft.com/download/en/details.aspx?id=11029

collective energy consumption data using the time-pie visualization. We intend to evaluate the effectiveness of *Show-Me* in supporting our proposed co-located collaborative energy usage visualization and analysis tasks. We will then modify and extend our system based on the results of this study.

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