Challenges in Personalized Multi-user Interaction at Large Display Walls

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Abstract

Computing devices such as desktop PCs and mobile phones assume a single user at the interface and present an interface personalized to this individual. In the case of large interactive display walls, simultaneous interaction by multiple users becomes possible and consequently, the system needs to adapt to each user at a more fine-grained level. This paper considers the challenges that follow and examines proposed solutions. We first look at requirements for a system that technically identifies the different users and compare existing systems to these requirements. Second, we discuss how to adapt the interface to multiple, possibly collaborating, users: How do we display personal or private data? How do we adapt to users that move around? In a collaborative environment, there is often a need for personal views of data in addition to a shared view. We consider both lens-based user interfaces and the use of additional personal mobile devices as mechanisms for enabling personalized interfaces.

1 Introduction

Falling display prices have made very large vertical interactive surfaces feasible. Today's display walls often support multiple interaction modalities in addition to touch, and they are large enough to facilitate multi-user interaction and thus collaboration. They have successfully been used in multiple application cases, including scientific visualization (Andrews et al., 2011; Beaudouin-Lafon et al., 2012), meeting support (Bragdon et al., 2011; Haller et al., 2010), and games (Zadow et al., 2016). Display walls generally have a very high resolution (e.g., INRIA's WILD room with 131 million pixels). At this resolution, users cannot perceive the display's entire contents at one time. Instead, physical navigation – moving around to access data, with both distal and close work – becomes feasible and beneficial (Ball et al., 2007).

Most current computing devices assume a single user at the interface and adapt to this user: A login prompt identifies her, preferences are set accordingly, appropriate personal data is displayed, and display contents change globally in reaction to interactions. In contrast, the large size of wall displays invites multi-user interaction and collaborative scenarios, making it

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necessary to adapt the interface to the individual users at a more fine-grained level. Therefore, the research question we consider in this article is: How can we provide personalized interfaces in the context of multi-user interaction with large display walls? A necessary prerequisite is that the device can determine who is interacting. Therefore, we determine requirements for a system that delivers the user's ID and ask: How can we identify the user at a per-interaction level? Which existing solutions handle this? Further, we examine the user interface: How does it need to change if multiple users are interacting with one wall display? How do we display personal data, possibly in combination with a shared global view? If users move around, how does the interface need to change?

The remainder of this publication discusses the above questions in more detail, describes the current state of the art and considers possible future research directions.

Figure 1: User-identification using an RGB+Depth camera. Left: Debug view showing user IDs. Right: Application context with user-specific brush settings (Zadow et al., 2016)

2 Identifying the User

Personalized interaction is only possible if the system can correlate each interaction with a user and provide a per-interaction user ID to application software. Several additional requirements follow: To support physical navigation, both close and distal input modalities should be supported. In general, this means tracking users' positions in front of the wall. A system for general use should also avoid an explicit registration step and custom hardware. Finally, depending on the usage context, an ID that persists between sessions can be important.

A number of works have presented user ID solutions for tabletops, for instance by giving the users identifying devices (e.g., IR Ring, Roth et al., 2010), by building custom display hardware (Fiberio, Holz and Baudisch, 2013), or by using biometric classifiers (e.g., Carpus, Ramakers, 2012). These works generally need custom hardware (identifying devices, custom displays) or a registration step (classifiers). They are also limited to identifying touch interactions. YouTouch! (Zadow et al., 2016) is one of the few wall-specific works and identifies users by using an RGB+Depth camera facing the wall (Fig. 1). However, since the ID is based on the users' appearance (and thus clothing), it is not persistent. In research settings, marker-based optical tracking (e.g., OptiTrack) is the norm, but this is expensive and requires attaching markers to users. Therefore, we conclude that reliably, inexpensively, and persistently identifying users interacting with a display wall is still an open research question.

3 Multi-user Interfaces for Large Wall Displays

Assuming a system that can identify the user, the research question then becomes: How do we design user interfaces that support multiple users sharing (and possibly collaborating at) one very large display? A good starting point may be found in the concept of Single Display Groupware (SDG, Stewart et al., 1999): SDG is based around the concept of multiple input devices for a single desktop display. In terms of the Model-View-Controller architecture, SDG assumes shared model, view and controller for all users. In collaborative use of wall displays, the situation is less clear. On the one hand, we can assume that a shared global model and view are the basis for collaboration. On the other hand, personalized interaction also requires per-user controllers. In addition, there might be per-user (sub-)views if users are interested in different aspects of the data, and even per-user models – for instance, if users have differing access restrictions.

As an example, consider the scenario of a geographic information system (GIS) used for the planning of high-voltage overland power lines on an interactive display wall. A shared global view shows the area that the power lines would be deployed in. Different collaborating users may be interested, e.g., in the area occupied by the pylons, in the impact on wildlife population, or in the resulting costs. In consequence, the system needs to present each user with an appropriate view, even if the users move around. Additionally, the information on costs could conceivably be classified, thus requiring access to restricted data and a user-specific model.

Lenses that move with the users (BodyLenses, Kister et al., 2015) provide per-user views and are a possible solution here. Further, mobile devices (smartphones, tablets, wearables) can provide personal views and access to personal data, as well as assuming the role of a personal controller. At the same time, the shared global view is not disturbed, facilitating collaboration. Instances of this principle include per-user clipboards (Rekimoto, 1998), distal pointing (e.g., Peck et al., 2009), offloading UI elements (e.g., TUIP, Spindler, 2014), as well as using an arm-worn device for this purpose (SleeD, Zadow et al., 2014). The overarching question that these works address is how to present differing views – some user-specific, some not – and seamlessly support interaction with them.

4 Conclusion

Multi-user interaction and collaboration at a single large display presents unique challenges. These include identifying users on a per-interaction level and designing user interfaces that enable multiple users to share one very large display. In this publication, we gave an overview of the problem space and sketched possible solutions.

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