Can You See Where I Point at?

Sebastian Boring
University of Munich
Amalienstr. 17, 80333 Munich, Germany
sebastian.boring@ifi.lmu.de

Dominikus Baur
University of Munich
Amalienstr. 17, 80333 Munich, Germany
dominikus.baur@ifi.lmu.de

ABSTRACT
Pointing on public displays is usually done in a relative and indirect fashion. However, such techniques have two drawbacks: first, a personal pointer is shown on the public screen which decreases the users' privacy in selection tasks. And second, when multiple displays are present, users need to connect to the one they want to interact with a priori. In this paper we review the strengths of Touch Projector as an absolute and direct pointing device in terms of spontaneously interacting with large public screens in a semi-private fashion. We briefly describe the infrastructure to allow spontaneous interaction through the display and discuss the use of both the local and remote display to distribute information according to the necessary privacy.

Categories and Subject Descriptors
H.5.2 [**Information interfaces and presentation**]: User interfaces: Input devices and Strategies, Interaction Styles.

General Terms
Design, Experimentation, Security, Human Factors.

Keywords
Mobile device, input device, interaction techniques, through the display interaction, multi-display environments.

1. INTRODUCTION
Today's pointing techniques on large, public screens are mostly carried out in a relative and indirect fashion. However, such pointing techniques show a personal pointer on the remote screen allowing others in the environment to follow what a person is doing. This holds true for both absolute as well as relative pointing as long as they have an indirect nature. Hence, selecting information from a nearby public display using a mobile phone is only possible if such information is not sensitive.

Relative and indirect pointing further requires the user to connect to the target display in the first place. However, the more displays exist a public space, the more time-consuming this task gets. Absolute pointing techniques (partly) overcome this limitation as pointing at a display naturally reveals the target display. It seems obvious that relative and indirect pointing does only allow for spontaneous interaction with an a priori connection procedure. Hence, spontaneous interaction (i.e., immediately interacting on a screen) is only possible when absolute pointing is used.

In summary, absolute and direct pointing allows both spontaneous interaction and the selection of sensitive information at a distance. We have developed a system called *Touch Projector* that allows this kind of interaction on distant displays through the user's mobile device [1]. Users aim at a remote display and can interact on it immediately through the live video image shown on the personal display (see Figure 1). In this paper, we review the strengths of this interaction technique in terms of spontaneously interacting with large public screens in a semi-private fashion.

Figure 1. Touch Projector: interacting through the display.

2. RELATED WORK
Several relative pointing techniques have been proposed for interacting on remote displays using mobile phones. Ballagas et al. use optical flow analysis which turns the phone into a mouse-like interface [2]. Accelerometers or the mobile device's joystick can also be used to control a remote pointer [3,4]. All of these techniques, however, show a personal pointer on the remote screen allowing others to observe the user's actions (especially when control elements are placed on the public display).

Recently, absolute pointing techniques have been studied widely. Jiang et al. present a system that employs the mobile device's camera to track a pointer on the remote screen [5]. Similarly, Pears et al. demonstrate how the phone can be tracked in 3D [6]. Both techniques still rely on visible pointers leading to the same limitations as the ones mentioned before. Ballagas et al. overcome this by using temporarily superimposed markers on the remote screen to determine the phone's position [2].

In contrast to these tracking methods (i.e., the phone tracks itself with respect to the display), Miyaoku et al. show how the mobile device's display can be recognized using a camera mounted at the remote display [7]. Their solution, however, requires that the mobile display faces the public display during the interaction. Thus, the phone's display is not visible to the user during the interaction raising potential privacy threats.

3. THROUGH THE DISPLAY
To allow spontaneous interaction in a way that others cannot see what a person is doing, absolute and direct pointing seems to be the key. However, existing solutions rely on pointers shown on the remote screen which decreases the user's privacy [6]. We extend the concept of *Shoot & Copy* [8] to allow continuous interaction on various displays in the environment while preserving the user's privacy. We further want to discuss how the information can be distributed between both the local and remote layer.

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3.1 Spontaneous Interaction

While other systems focus more on the interaction itself, we wanted to create a system that allows for *impromptu use*. To do so, users aim at the target display which is then being shown in the live video image on their mobile device. They can now start interacting on it as if the content would reside locally. The system thereby knows which display the mobile device is pointed at and can route (and transform) local input to be executed remotely.

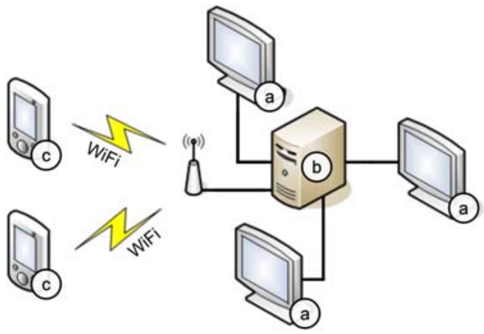

Figure 2. Infrastructure for spontaneous interaction: each display (a) connects to the *environment manager* (b). Mobile devices (c) communicate with the centralized instance.

To allow this theoretical scenario, we implemented a system called Touch Projector [1]. As shown in figure 2, we rely on a centralized instance – the *environment manager*. This component is responsible for (1) identifying the target display each mobile device is pointed at and (2) routing input from mobile devices to the corresponding remote screen. This architecture allows for *absolute* (i.e., the current input location is not based on the previous one) and *direct* (i.e., feedback is given at the location the input occurred) interactions. The resulting interaction is similar to such known from interactive surfaces such as tabletops. However, as the input is physically (but not logically) decoupled from the interaction canvas, the interaction may remain private.

3.2 Personal versus Public Content

The original idea of Touch Projector uses the mobile device as input canvas only. However, the local display can also be employed as output area. Information that is of interest for the interacting person only should hence be distributed to the local display. For example, control options regarding one item (e.g., *create a local copy*) can be displayed next to the item on the local screen. Such additional information can either remain fixed with respect to the mobile screen (*device-centric*) or fixed at the remote item (*content-centric*). In any case, users do not interfere with each other even while interacting with the same item. This is a huge difference compared to direct interactions on interactive surfaces such as tabletops. Even if permanent feedback is shown on the external display (e.g., different options for a single item), users can still interact with them in a semi-private way by selecting them in their personal viewfinder.

The local layer can further be used to show sensitive feedback. For example, when users enter sensitive information (e.g., a sequence of numbers for authentication), the system can show feedback on the personal (see Figure 3b) device even though the numbered keypad is shown on the remote display (see Figure 3a). Naturally, other modalities of feedback (e.g., vibrations) may be given in an individual way. Nevertheless, users have to trust both their personal device as well as the underlying architecture – namely the *environment manager*. While a user most likely trusts a personal device, the centralized instance remains a problem of our prototype. However, we believe that the connection and communication between both displays may turn into a peer-to-peer fashion, e.g., by using hidden markers on each screen.

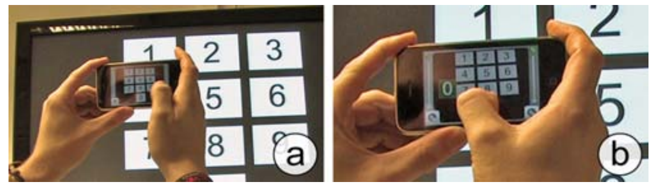

Figure 3. Local versus remote content: the PIN-pad is shown on the public display (a). Feedback is only given locally (b).

4. SUMMARY AND FUTURE WORK

We presented Touch Projector for spontaneously interacting with external screens in a semi-private fashion. Users are able to interact locally with remote content by addressing it on their personal device. Hence, others do not see where a certain user currently points at. We believe that interacting through the display can be used in various applications that may have privacy considerations. While Touch Projector has been developed to allow multi-touch input on distant screens, we assume that the local display plays a more important role. Currently, we are investigating the distribution of information across both displays. For example, the personal view can be enriched with information that is only of interest for the respective user and not intended for the public.

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