Flashlight Interaction: A Study on Mobile Phone Interaction Techniques with Large Displays

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ABSTRACT
In this paper, we introduce Flashlight interaction, a new approach to light-based interaction between mobile phones and large screens by using the phone camera flashlight. Using a mobile phone as an interaction device with large screens has been explored in various projects. Mobile phones are enhanced with different sensors and provide opportunities to be used as an interaction device with other devices such as a large display. Our approach supports to set up a private-public display setting and provide simple means for interaction without a wireless connectivity. Our user study results indicate that the interaction is easy to perform and understand due to the direct mapping between the phone movement and the response on the screen.

Categories and Subject Descriptors
H.5.2 [**Information Interfaces and Presentation**]: User Interfaces – *input devices and strategies, interaction styles*

General Terms
Design, Human Factors

Keywords
Mobile phone, public display, interaction, light

1. INTRODUCTION
Nowadays mobile phones are ubiquitous devices limited in size and dimensions, enriched with different sensors such as an accelerometer, a flashlight, a camera, and etc.. On the other hand, the use of computational power is more and more shifted from traditional computers to mobile phones. This causes a demand for new interaction/input techniques between our mobile companions and large (pubic) screens, which are needed to accomplish tasks the mobile phone's small display is not suited for or if a private-public display setting is needed for applications. The primary focus is to use the mobile phone's available hardware (keys, sensors, …) to perform traditional GUI-related tasks such as controlling a pointer, selecting positions and objects on the screen and eventually zooming in and out.

In this paper we introduce an interaction technique with large displays using the flashlight on mobile phones that additionally gives the chance to set up a private-public display setting for visualizing the data and communicate with the display without any wireless connectivity.

2. RELATED WORK
Many interaction techniques in current research projects rely on optical recognition algorithms. For example, *Sweep* [1] detects changes in the phone camera's optical flow to determine relative motion in the (x,y) dimensions and move a screen pointer accordingly. Or *Direct Pointer* [3] uses the phone's camera to track a virtual laser pointer point on the screen and move it correspondingly to the phone. While these approaches use the phone's camera, others use a camera attached to the screen to track the phones position in front of the screen. Miyaoku et al [4], uses the phone's display as a light source and tracks and maps it to corresponding pointer movements on the screen. An important shortcoming of this technique is that because the phone display is used as a light source the screen isn't available for using in applications. Additionally, with the approaches where the interaction tracking is done on the phone there is a reliance on a wireless connection. Since modern phones are equipped with built-in sensors like accelerometers, sensor-driven techniques are another option for the interaction [5].

3. MOBILE PHONE & LARGE DISPLAY
In the following, we introduce a new interaction technique and for evaluating our technique we describe other available techniques, which can be used for interacting with large displays.

3.1 Flashlight Interaction
In our research we developed a mobile interaction technique that uses the camera flashlight of the mobile phone. A camera, which is installed in front of a large display, tracks the light and the user can interact by moving the phone in the air and correspondingly control a mouse pointer on the display (Figure 1). This is similar to the light-based approach used in *C-Blink* [4] but the advantage is that in our technique the display is not used as the light source, therefore the display is still available to the user for interaction purposes (e.g. showing private data). In fact, all phone functionalities except the flashlight are retained for different usage scenarios, making this interaction easily extensible. Furthermore, the bright light beam of the camera flashlight allows for precise interaction even at a distance. As this interaction primarily relies on moving a light source, it can also easily be used together with laser pointers or any other light sources in a multi-device setup.

The current implementation allows controlling the mouse pointer position (absolute), making selections (by quickly toggling the light off and on, or through a wireless communication), and scrolling/zooming (relative) which is mapped to changes in distance between phone and screen, computed from the changing radius of the captured light beam. To track the mobile phone's position (the flashlight), a standard webcam was mounted below a large display. On the screen side, a Java application captures the webcam's video signal (640x480 @ 15fps) and computes the

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center and radius of the light source in each video frame. Finally, the light position is mapped from the resolution of the video input to that of the screen. If in subsequent video frames a noteworthy change in the light's radius occurred, a proportional mouse-wheel-event (zooming/scrolling) in the direction of changes (sign of the difference between last and new radius) is triggered.

On the phone side, the control over the camera flashlight is possible through proprietary APIs of some phone manufacturers as well as through the *Advanced Multimedia Supplements* (also JSR-234 or AMMS) on phones supporting the Java ME platform and AMMS.

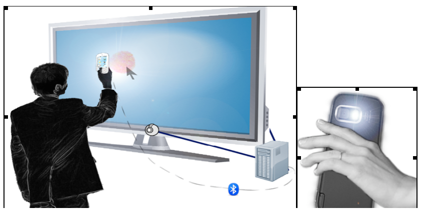

Figure 1: A camera below the display tracks the flashlight movements.

3.2 Other Interaction Techniques

Moreover, there are other techniques available that use other sensors on mobile phones for the interaction. Since Nintendo's Wii and Apple's iPhone made the use of accelerometer sensor in HCI commercially popular, accelerometer sensors are believed to play a big role in the future mobile market. While the accelerometer sensor can also be used to measure relative movement, it can be used for controlling a pointer on a large screen. To control the pointer with the mobile phone's accelerometer, the user turns the phone around its own axes. The sensor data can be constantly transmitted via Bluetooth to the screen server and mapped to screen coordinates, (e.g. [6]). Additionally interactions can be performed throw gestures.

Another option can be using the buttons on the mobile phone called Directional Pad (D-PAD) to control a pointer on the screen. All the mentioned techniques offer this chance to set up a private-public display setting.

4. USER STUDY & RESULTS

To evaluate our technique we conducted a user study with 11 participants with an average age of 25 and used three techniques flashlight, accelerometer-based, and D-PAD interactions to perform Fitts' Law task. Each participant performed a series of Hover- and Click-Tasks with each technique and filled out a survey afterwards. In total, all techniques provided comparable results in the user study. At the Hover-Task, D-PAD interaction was slower than the other techniques, because it only allows one-dimensional movement at a time. For the same reason, D-PAD yielded slowest results during the Click-Task. However, the difference to both other techniques (flashlight, and accelerometer-based) was not significant and other techniques had higher error rates (clicking outside the target). This made participants to rate the D-PAD as easiest technique for the Click-Task despite being rated as the most uncomfortable one. Accelerometer based interaction yielded the best average results and was also reported feeling the fastest, yet it did not feel most comfortable and took more time to learn and accustom to. Users found the flashlight interaction very direct and easily understandable because of mapping between movement of the phone and the response on the screen. Also it achieved best results for the Hover-Task. However, with the flashlight interaction a reaching the corners was comparatively difficult due to conceptual shortcomings of the technique (central camera location). Finally, users argued about the high amount of physical movement and needed space for flashlight interaction.

4.1 Conclusion

In this paper we introduced a new interaction technique with a large display using the flashlight on a mobile phone. To evaluate our technique, we ran a user study and compared it with accelerometer-based and D-PAD techniques. Our study revealed that the flashlight and accelerometer-based input technique were faster than D-PAD. Users value the lower error rate of the D-PAD and were not only concerned with the task completion time in their rating of the different techniques. They found the flashlight interaction faster to learn and easier to understand than the other interaction techniques due to direct mapping of the light and pointer on the screen.

In contrast to other techniques, the flashlight interaction provides the opportunity to set up a private-public display, as the display is not involved in the interaction. Also without wireless connections, simple interactions such as clicking are possible by toggling the flashlight on and off. As the flashlight interaction requires physical movement, as mentioned in [2], this technique can contribute on grabbing more attention and making people more curious on trying the technique themselves in interaction with large public display. In our future work, we want to focus on how this technique can be used in different application domains.

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