Offsetting Displays on Mobile Projector Phones

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ABSTRACT

Emerging phone handsets include embedded projectors that will provide a widespread new form of display for mobile users. However, it is not clear how the handheld projector will be used alongside the existing phone screen. The current approach of many manufacturers is to place the projector in the top of the phone. This typically prevents users from simultaneously interacting with the phone and looking at the projection. The result is that using the phone's screen to supplement or interact with the projected information is difficult. This paper illustrates a technique to dynamically offset the throw angle of a mobile phone projector from the handset's screen to support different tasks. We describe our design and use it to explore three application scenarios that we have implemented.

1. INTRODUCTION

The emerging range of mobile projector phone devices provides a potentially unique selling point for handset manufacturers, as well as the first wave of widespread access to handheld projection technology. Mobile projected displays are being heralded as a new opportunity for co-located collaboration [4], but it remains unclear how the projected display will fit alongside the existing hardware ecology of the mobile handset. An emerging design challenge for mobile devices will be to optimise and incorporate the use of multiple displays by exploring the placement of the screen relative to the newly introduced projector. Initially it may appear that the placement of the projector is only constrained by the ergonomics of the phone handset in the hand. Nevertheless, in this paper we argue that the projector placement is also constrained by the placement and established uses of other handset capabilities, especially the existing screen on the phone.

A number of possible designs might be used to control the relationship between these two displays. Current designs typically mount the projector above the screen such that the projector throw creates a display at a right-angle to the optimal viewing angle for the screen. Yet, this fixed orthogonal angle between the screen and the projection makes it difficult for the person holding the device to see the both displays simultaneously, or even to rapidly interleave between looking at one and the other. This difficulty might not present problems if each display was used separately – for example, the projection might be used for public interactions and the phone's screen for private ones. However, this would preclude new opportunities emerging that exploit both displays simultaneously, for example Hang et al. [5] demonstrate the advantage of using both a projector and a phone screen for specific applications such as text input. With a dual display, users can also decide which data they want to keep private and which data they want to share on another screen at the same time.

An alternative two-display configuration might be realised by physically separating the projector hardware from the handset to support the dynamic juxtaposition of the displays, as with the Wowwee's Cinemin Swivel pico projector [1]. Nonetheless, physically separating devices imposes increased demands on user control, cost, power, additional hardware to send video signals, and prevents the projector from easily benefiting from handset input capabilities such as accelerometers, touch screens and cameras. Beardsley et al. [3] show handheld projectors require dynamic interaction that such separation would preclude.

Another example of a dual display approach is presented by Hinckley et al. [6]; they present an alternative to separating, interleaving or switching off displays. In this case, the device possesses a range of 'postures', corresponding to different operational modes, identified through the hinge angle, that people can use on their own or collaboratively. Such opportunities may also be available to projected displays if the user were able to configure the angle between the projection and the screen.

We argue that different applications might suit different juxtapositions between projections and screens. For example, an Augmented Reality (AR) application guiding the user through streets, such as the Nearest Tube Application [2], might benefit from being projected directly on the pavement to support group navigation where users can step onto directional arrows. Yet, control would remain on the touch screen of the phone, held in a comfortable position in the hand. Applications such as presentation viewing might benefit from being projected on a wall. For example, the AR project Map Torchlight [8] connects a mobile handset and a handheld projector in a fixed alternative configuration. It forms a 90° angle between the phone's screen and the projection throw, yet it does not respond to the problems of contextually adapting the projection angle depending on its use.

Drawing on these innovative examples, we suggest a technique for mobile projector phones in which projected displays can be spatially reconfigured with respect to one another, and with respect to existing displays such as screens. An appropriate technique will create different juxtapositions and arrangements that suit particular situations. In the following sections, we describe our design and implementation of the technique on a handheld projector phone device and application scenarios it could be applied to.

2. DESIGN

This section explores how steerable handheld projectors could be integrated into mobile projector phones to take into consideration other displays on the device. Modifying the throw angle will allow users to choose relative display angles that are best suited for them depending on the context of use.

It is clear from previously discussed examples that some offsets are better suited than others for particular applications; for example the "difficulties in handling the context switch" described by Hang et al. [5] indicate that particular visual fields may need to be aligned. Another type of difficulty in switching contexts may be that mobile phones and Personal Digital Assistants (PDAs) contain private data such as contact details, personal information, text messages, emails or pictures. Cao et al. [4] address this privacy issue with a permission control system, in which documents are either public, semi-public or private and are displayed accordingly. We propose a technical solution in which displaying such categories of information determines, or is determined by, the spatial relationship between the screen and the projected display.

This approach might allow users to choose where to display the information; for example to decide to use a larger projection space in front of them, or a smaller one on a desk for more controlled semi-private sharing (Figure 1). Also, depending on the user's location, one specific angle might be more adapted to respond to the physical constraints of the projection surfaces available. For example, on a train, an appropriate projection space might be the folding tray attached to the rear of the seat in front.

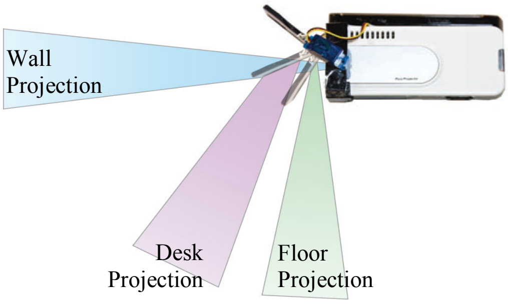

Figure 1 - Examples of projection angles

From these examples, we expect that the optimal projection angle depends at least on the properties of the application displayed on the screen and the required privacy settings, which include data privacy, as well as the relationship between private and public spaces. Despite these cues, however, we currently have little information on driver mechanisms or preferences for offsetting projected displays. To explore this emerging design space, we have begun by looking in particular at the angle between the mobile phone's screen and the projection space. The following section describes a prototype that we have created to support angular variation of offset projected displays. In the subsequent section we explore different scenarios of use which may prefer different offset angles of projection.

3. IMPLEMENTATION

It should be possible to physically couple the projection hardware to the display using a hinge (as in Hinckley et al.'s Codex [6]) or a passive-compliance motor to continuously vary angles between displays through electronically powered manipulation. However, such designs will be susceptible to mechanical wear and complex to integrate into a small handheld form factor. An alternative is to steer the projector throw using a rotating mirror in front of a fixed projector's lens. This is the solution we have initially explored.

We have not used an existing mobile projector phone device to illustrate our idea as no current platforms on the market have open enough development environments for our purposes. Instead, we have implemented a prototype (Figures 1 & 2) using a Samsung Omnia HD i8910, running Symbian 5th Edition OS, combined with a handheld projector (Pico Pocket V3 Projector). The phone handset and the projector communicate through a bespoke TV-out/mono cable. The prototype is fully modular; the architecture can be used with any mobile phone equipped with TV-out capability. It can also be used with any handheld projector with Composite Video input.

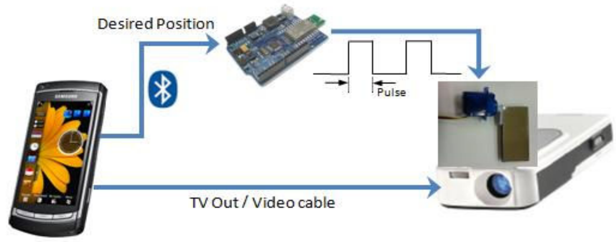

Figure 2 - System Architecture

For this prototype, the projection throw is reflected by a rotating black-edged mirror at the top of the projector lens. We do not support direct physical manipulation of the motor/mirror as an interaction technique, because the miniature motors are typically not backdriveable, and touching the mirror may introduce fingerprints or other occluding features of the projection. Moreover, the use of the hand to steer the mirror is likely to temporarily occlude the projection, and it is difficult to provide an appropriate physical control at such small scales. Instead, the mirror is attached to a micro servo-motor (Hitec HS-55) controlled by an Arduino Bluetooth microcontroller. We have allowed remote setting of the mirror angle through the phone – the phone application sends information to the Arduino board which modifies the mirror position accordingly.

4. SCENARIOS

Our design allows simultaneous use of the projector phone screen and projection space. Different offsets imply that different behaviours could be supported by the device. In this section we explore three example scenarios which identify example behaviours that balance information across the phone's displays according to the offset projection.

4.1 Scenario 1: Aligning Displays

In the first scenario, we explore the visual alignment of the screen with the projection for an individual by projecting onto a wall. The projection is used to amplify the scale of the screen; the user can then exploit the different display properties by shifting their visual field back and forth. The device can be used by a single user, who may wish to either view information on the phone's screen or on the projected image. Embedded projectors provide larger visualisations but the resolution and brightness are still poor in comparison to a mobile phone screen. One use of our prototype, therefore, is to align information across displays with contrasting properties so that they can be used together by rapidly interleaving perspective between them.

4.2 Scenario 2: Shared Manipulation

In the second scenario a group explore information on the projected image (Figure 3), while control of the projection remains through the screen rather than through the projection itself. Depending on the context and the environment, a person might want to display information using the projection but without everybody in the surrounding environment seeing their data. Changing the projector's throw angle in order to project on a desk or on a table, while interacting with the screen, allows a certain level of privacy even in a public context. Similarly, multiple users with the same device can combine their projection angles to display information without exposing their controls. In fact, the use of hidden control of group displays will suit some activities such as presentations that have hidden 'manipulations' but public 'effects' as suggested by Reeves et al. [7].

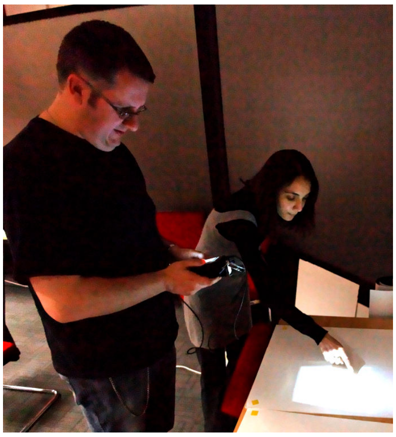

Figure 3 – Scenario 2: Shared Manipulation

4.3 Scenario 3: Disconnected Displays

In the third scenario, a floor projection provides both personal and public navigation information while the user interacts with their screen for other purposes. The floor projection provides onlookers with relevant public information, while they could still want to use their phone for other things. In this case, the user is navigating (and advertising their route) by following projected arrows to get to a certain destination, while it would be possible for them to also use the handset to display the area map (Figure 4).

5. FUTURE WORK & CONCLUSION

In this paper, we introduced a technique for offsetting the projection angle from the screen of the mobile projector phone. We explored how to technically achieve such behaviour on the handset, and then identified a number of potential uses – from closely perceptually aligning the same information on displays with different properties, to disconnecting private and public information across different displays. In the future we hope to evaluate the extent to which our scenarios reflect actual uses, and to identify further new forms of display offsetting.

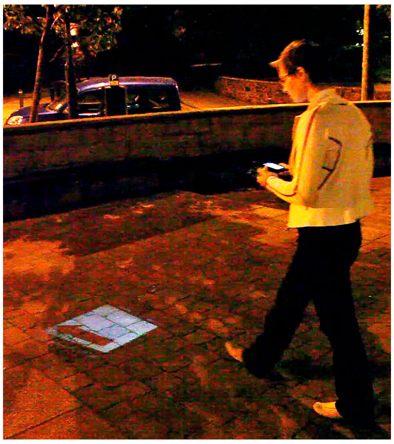

Figure 4 – Scenario 3: Disconnected Displays

6. ACKNOWLEDGMENTS

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