HaptiProjection: Multimodal Mobile Information Discovery

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ABSTRACT

Handheld projectors are steadily emerging as a potential display method of the future, offering many opportunities for interesting interactions with the world around us. However, to date little attention has been focused how people might move from mobile device usage to projection of interactive content. In this position paper we address this by proposing a method for location-based content discovery that helps to merge the physical and digital spaces we live in. We describe an early prototype, developed to demonstrate interaction concepts, and summarise the challenges and future developments needed for this type of system.

1. INTRODUCTION

The now widespread availability of handheld pico projectors has opened up countless possibilities for projection-augmented interaction, stimulating research into many new devices and techniques. As might be expected, a great deal of this research has concentrated on augmenting real-world objects with projected features, particularly in the mobile domain. However, there seems to be a lack of investigation into how people might make the transition between these physical and digital aspects. Previous work typically assumes a seamless flow from mobile interaction to projection, but often does not consider how the step from real-world to projected content might actually take place. For basic interactions, such as displaying photos, or playing videos, little extra effort is required, but for less-static content we believe innovations are needed. We imagine a richer, more fluid interaction style, where users need not explicitly interact with their mobile device; the phone may be the source of projection, but there is no need to focus on its screen to initiate the display, or press buttons to interact with features.

We are particularly interested in the possibilities that projection offers for mobile information discovery. Currently, information discovery is split between the physical and digital domains, with a choice between either the real world object (an event poster outside a venue, for example) or its digital counterpart (the venue's webpage). We believe that by combining other modalities with the possibility for projection, better user experiences can be offered. In this position paper we propose and discuss a method for information discovery that attempts to bridge the gap between the physical and digital worlds we live in. Consider the scenario opposite, which illustrates the concept.

Our proposed system aims to support this class of scenario, allowing users to merge their physical activities with the digital information that is associated; we are in the process of developing a prototype to explore its potential benefits. At present our prototype supports many of the interactions described, initially using vibrotactile feedback to allow users to discover the presence of interesting information in the environment around them. Once found, if

Mike and his friends are wandering around a new city, curious about what's happening that night in nearby places. Ambling through a lively area, Mike points, phone in-hand, toward a bar on his right; there's no response from the device so he switches to the bigger venue to his left. As he points, he feels a vibration from his phone. Curious, he points down to street level and the device projects details of recent events for the group to browse – pictures from past gigs and a video preview of the current show. As he points his phone around the display, different events are highlighted, allowing his friends to point and capture copies to look through later. At the gig that evening, Mike and the group are having a great time, so they take their own photos and share them with the crowd by pushing them into the hotspot he browsed earlier, leaving their own content to encourage others to participate.

**Scenario: Typical interaction flow with our proposed system.**

the user is curious, projection provides further details, with simple gestures allowing retrieval of location-based content. In the rest of this paper we discuss the benefits of our proposed system, the current state of our prototype and some of the possibilities and future extensions that offer promise to the research community.

We begin by briefly reviewing previous research into mobile projection, continuing in Section 3 with an overview of our current prototype. In Section 4 we look at the the challenges and future work that is needed, concluding the paper in Section 5 with a summary of the next steps of this research.

2. BACKGROUND

With several brands of mobile projectors now widely available, researchers have been investigating how people will use the inevitably ubiquitous mobile projector phones to display, browse and share their experiences. Many proposed applications for these devices build upon early augmented reality work, but remove the requirement for cumbersome backpacks or headsets, instead allowing users to augment anything, anywhere ([1, 7], for example). Others have studied projector interaction techniques for intuitive object manipulation [8], or direct interaction with single- [2] or multi-user projection spaces [3, 6, 9].

Despite the excitement within academia, participants in early exploratory projector studies are often unsure how they might use projector phones above and beyond the simplest media sharing or large mobile display scenarios [4]. Of course, it is important to bear in mind the early stage of these devices – much research into user reaction to mobile projection is still in progress ([12], for example). However, we believe it is important to ease the transition from mo-
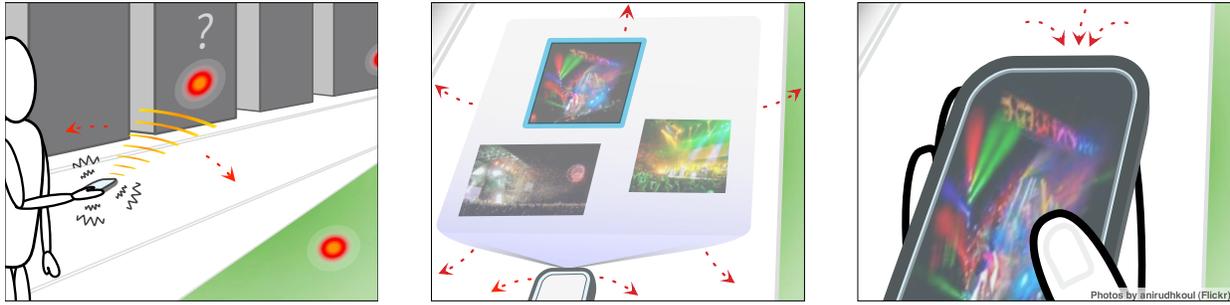
Figure 1: Interaction with our prototype system. Left: Users browse their environment while on the move, discovering location-specific information via vibrotactile feedback. Centre: Once discovered, projection is activated, allowing easy browsing of interesting content. Right: At any point, users can bring their phone back up to capture a copy of the selected content on their mobile device.

bile device to projection by blending these new devices into the world that users are already familiar with. Our prototype system uses a standard mobile phone with orientation sensors and vibrotactile feedback to allow users to interact with real world objects, before seamlessly switching to projection to display and manipulate interactive content.

3. PROPOSED SYSTEM

Our proposed system would allow users to probe their environment for information while on the move, only switching to a projected view when necessary. Information discovery is achieved via simple feedback, allowing users to scan their environment for desired information with little effort. For example, users might point at potential points of interest, feeling vibration or hearing a particular sound if content exists. Importantly, at this stage no visual interaction would be necessary with the device, allowing users to walk on if no content of interest is found. When feedback is felt, though, users can project the required information by pointing at a nearby surface. Friends might join in to share their own experiences, with each participant using their mobile devices as pointers to browse through the displayed content.

3.1 Current Prototype

We built a prototype system to investigate possible uses for this casual information discovery interface. Fig. 1 illustrates the current interaction flow of the device. Information discovery is achieved by simple scanning movements while holding the prototype. Vibrotactile feedback is felt if content is available, at which point users can initiate projection by pointing downward. This gesture requests and displays the information, clustering into content types (such as images, videos and webpages).

During projection, displayed objects stay in fixed positions as the device is moved, allowing the user to point at individual items to select them, or around the current projection surface to see more of a particular content type (as shown in Fig. 2). If interesting information is found, pointing at it and then bringing the phone back to a level position will retrieve the content to the user's device, allowing them to display it or save for later.

3.2 Implementation

Our prototype is implemented using a Nokia N95 mobile phone in conjunction with an Optoma PK-101 pico projector. Orientation and movement sensing is provided by an attached SHAKE SK6 bluetooth sensor pack [11]. The SK6 is a small integrated sensing device that provides range of sensing and feedback options. We use its internal pager-style motor to provide vibrotactile feedback, and

Figure 2: The prototype in use, showing a user selecting content (highlighted in blue) by pointing the device itself. Content remains stationary to allow easy selection of individual items.

its accelerometer for higher-resolution data than that from the internal N95 accelerometer. In addition to the accelerometer, the device also includes three-axis angular rate and, importantly, magnetometers, which allow detection of the direction the user is pointing.

The tactile interaction techniques used in our prototype build upon the results of previous research which found that casual target discovery and selection was possible with this simple vibrotactile feedback [10]. The projection element of the system uses device orientation information to compensate for image skew, and moves projected content to correct for users' movement of the device. As a result, users are given the impression that the content they are interacting with is attached to the surface it is projecting on. This allows easy pointing to individual content items without the need for a visual pointer, or indeed any method for touch-based interaction; instead, the user points using the device itself. The sensor-based detection of movement requires none of the image processing that similar camera-based methods (such as [1] or [7]) depend upon, providing some of same functionality with the benefit that there are no coloured finger tags or lanyards to be worn.

While no formal user study has been carried out to date, we have informally piloted the prototype, and received positive feedback. Responses from users and observers have focused upon the serendipitous aspect of the system, with comments such as "it's like StumbleUpon[1] for the world around you", referring to the unknown aspect of the content that might be displayed.

4. FUTURE WORK AND CHALLENGES

As our current prototype demonstrates, the type of system we propose is possible with current devices and interaction techniques.

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[1]Browser add-on for content recommendation: stumbleupon.com
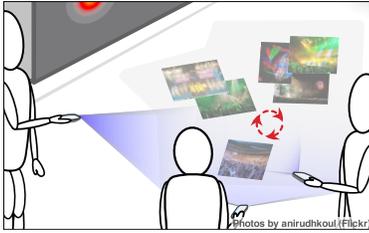
Figure 3: Extending our current prototype: projection encourages in situ content sharing and collaboration between users – both groups of friends and interested bystanders.

In addition, while our prototype uses several separate (and rather bulky) components, it is reasonable to believe that future pico projector phones will include as standard the types of sensors we require; indeed these are already available in, for example, the Nokia N97 or Apple iPhone 3GS. Looking beyond hardware refinements, however, there are several immediate areas for future work, each presenting their own research challenges.

Collaborative Projection: Although several possible content interaction methods were described in our initial scenario, we currently provide browsing and retrieval for only one user, and have not yet allowed for collaborative behaviour. Previous research has suggested exciting methods for sharing media using either a single projector [5], or the automatic fusing of separate devices to create a shared display space [9]. In addition to these real-time collaborative scenarios, there are also possibilities for users to share with friends or strangers by leaving content in public locations, allowing location-based blogging in the real world.

Content Manipulation: Our current prototype uses the projection device itself as a pointer to allow users to interact with the content they are browsing. This peephole-type interaction might be sufficient for surfaces that are too far away to touch or manipulate directly, but for closer objects the touch-based methods that are now common on mobile devices could offer benefits (pinch zoom; touch scrolling, for example). While projector versions of these interaction styles have been demonstrated with finger tags and image processing, other possibilities exist, such as using two separate devices to manipulate and explore content in tandem, or taking advantage of the screen on the phone as a second display, as in [5].

Projection Surfaces: While mobile projectors are still in their early stages, it is usually only possible to display higher resolution content on fairly dark surfaces. As projection quality increases, however, more complex displays will undoubtedly be possible. We currently use a fixed projection location (floor or ceiling), but compelling prototypes have been created that use almost any object as a projection surface [7]. The advantage of our method is that no image processing is required; instead, realtime sensor data is used to alter the projected display. With the decreasing costs and increasing power of mobile devices, though, this will be less of an issue for systems to come, allowing increasingly elaborate interactive displays to be implemented using standard mobile devices.

User Evaluation: Clearly a formal trial is necessary before coming to conclusions about the usability and effectiveness of our current prototype; we intend to conduct user studies with a more advanced system when development has progressed further to allow some of the more engaging interaction styles discussed above.

In addition to device-specific evaluation of our prototype there are also more general questions about how people might use mobile projectors in real scenarios. Previous work has investigated some of the issues surrounding these devices, and the types of user behaviours that might result [4], but there is still much to be done. Several users have expressed privacy concerns about specific data types (e.g. text, in [12]), but the wider issue of privacy still remains.

Researchers have yet to fully investigate the possible effects of ubiquitous mobile projection on the people who are not projecting. While previous research found that bystanders were often rather indifferent to these devices [4], this attitude may well change when anyone can project anything anywhere. Just as looking at a mobile screen can take a single user's attention away from their real-world surroundings, personal projection can affect both the person holding the device and the people around them, and this is an important consideration to take into account when designing the future of these mobile devices.

5. CONCLUSIONS

In this paper we have discussed using a combination of tactile feedback and personal projection to provide content awareness and filtering in a physical environment. An initial prototype has demonstrated basic functionality; we plan to extend this to allow richer interactions with the physical world via the combination of modalities, and we welcome feedback from the research community.

6. ACKNOWLEDGEMENTS

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