Search Light Interactions with Personal Projector

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ABSTRACT

Mobile projectors are an emerging trend and becoming ever more present in the consumer market. One main concern is how this resource will be used and exploited. The act of physically holding the projection device while interacting is uncommon and potentially beset with many issues. In this paper we present a mobile application, which uses the searchlight metaphor as a novel means of navigating though information space, potentially of limitless size. In addition to the searchlight navigation technique we have developed a number of input techniques which challenge the classic button press interaction with a number of intuitive gestures which complement the interaction style. We present our findings from a user study in which the usability of each technique was evaluated, we also propose several heuristics for mobile projector interaction design.

1. INTRODUCTION

Many users watch media on their portable device even though the screen size rarely exceeds 3.5 inches [1]. This is unfavorable considering the new wave of digital media, which can offer HD content and high resolution video. Recent developments in mobile projectors have allowed mobile devices to integrate projectors directly into the hardware allowing for the potential of much greater screen size and resolution which were previously impossible.

Mobile projector interaction offers a different paradigm of usability and potential problems when compared to standard mobile phone and personal display interaction. Issues include confidentiality of data, potential image distortion due to the projection surface being uneven or jitter from the user failing to keep the device steady.

Interaction design often is a fundamental element in the success of failure of a technology. In an interview Shigeru Miyamoto, a key member of the development team for the Nintendo Wii [2], mentioned how current games graphics, story line and interaction were made to fit the input method used. He also stated, "*Creativity was being stifled, and the range of games was narrowing*." Outlining the importance of design and the necessity to move away from the classic button press interaction as it can often hinder progression.

In this paper we outline our prototype, which implements the searchlight metaphor allowing intuitive navigation though the virtual data space. We also propose a series of selection and zoom gestures that could replace button interaction in a number of scenarios while using this metaphor. We create a series of test applications, which expose the interactions and test them through a user study. Our findings outline important factors to consider when designing gestures for mobile projectors.

2. RELATED WORK

Greaves et al. [3,4] created a prototype for using mobile projectors to browse an image library. The three potential interactions were phone screen only, projector only and a combination of phone and projector. Tests showed that the users predominantly preferred the projection only method and half of the participants agreed that the projection only technique was the fastest. The problem of context switches is common in both the projection only and the mixed screen technique as the user still had to use the phone keypad to navigate.

Cao et al. [5] devised a multiuser interaction space using handheld projectors and a searchlight metaphor to navigate within the application. A tracking system was used to monitor the location and pose of the handheld device, which consisted of a medium size handheld projector, with a series of hardware buttons for interaction. The main emphasis in this study was to investigate the possible applications and uses for handheld projector interaction.

Schoning et al. [6] devised augmented reality using mobile projectors and physical maps. The prototype allowed the mobile projector to provide an augmented reality by projecting relative content or highlighting POI's on the map. This was done by using visual markers on the map to realize the location of the projected area. This resulted in an accurate prediction of what real world items resided inside the projected surface with minimal processing.

Little Projected planet [7] by Löchtefeld et al. used a camera to monitor the real world contents of the projected area. This resulted in a projection based augmented reality in which virtual components could react with real world items. Similarly Raskar et al. [8] used physical sensors that interact with a mobile projector allowing some complex features such as projection stabilization and distortion free projection on multiple surfaces within one area. Again in both instances most IO interaction between the user and system was preformed via a button press.

TinyMotion by Wang et al. [9] is a camera-based motion tracking system which uses edge tracking and other video manipulation techniques to judge the movement and acceleration of the mobile phone based solely on input from the built in camera. Building on this Bucolo et al. [10] used 2d QR code style markers to develop a marble tilt style game again solely relying on the camera to measure movement. One interesting outcome from their user study was that users perceived the techniques to be faster than a standard key based navigation when the opposite results were true. Showing that the users enjoyment of an interaction can often be a bigger factor than the efficiency.

3. INTERACTION TECHNIQUES

The searchlight metaphor (Figure 1) as used by Cho et al. [5] allows a virtual data set to be mapped to physical locations often when the screen resolution can't accommodate the entire size of a data set. Traditionally this is done using panning techniques, which allows the viewable area to remain static and the content to move. Where as in the searchlight metaphor, if the user were to search for something within the virtual area, they would physically move the projector so that its projected surface would move and reveal different content, meaning what is displayed by the projector is relative to where the projected surface resides. The main advantage of this technique is that unlike a similar panning technique the user can associate physical locations on the wall as to where the data is potentially, thus lowering time traversing the user space when changing focus on objects.

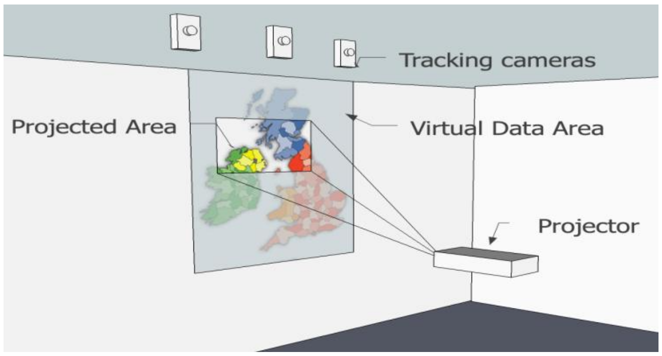

Figure 1. Example of searchlight Metaphor

3.1 Selection interaction

The selection interaction is designed to act in a scenario where a button press would normally take place. Within the searchlight metaphor there would be a cursor in the centre, the user would move the projected area over the desired item then perform the interaction to select it successfully in current implementations of the searchlight metaphor the only interaction used for selection is a button press.

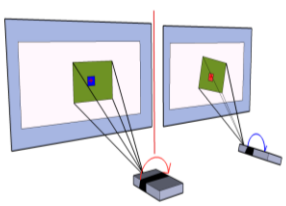

Figure 2.1. Example of the twist select

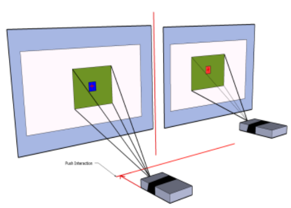

Figure 2.2 Example of the jab select

3.1.1 Twist Select

The twist interaction (Figure 2.1) requires the user to move the projector approximately 3° around the roll axis in either direction, which involves tilting the projector to an angle while keeping the projector facing forward. In a scenario where the user is interacting with the searchlight metaphor they would be able to select objects that virtually reside on the canvas by slightly twisting the device. A great bonus of this interaction is that if the user keeps the angle held, the twist interaction can act as a group selection tool where multiple objects can be selected without the need for multiple presses, clicks or interactions to take place.

3.1.2 Jab Select

The second selection interaction is a jab gesture. This involves the user moving the projector device forwards towards the wall approximately 30mm in a short sharp movement. This interaction again is designed to replace a standard button press in a number of situations, where this would feel more intuitive to use. One example is a picture selection tool, where the jab gesture would select a picture from a gallery of images allowing the user to select an item without having to look away from the screen or alter the position that they are holding the device to allow access to certain buttons.

3.2 Zoom Interaction

Many mobile devices are now equipped with mobile map software such as Google maps, allowing access to very high resolution content where through the act of zooming the user can see an overview country/world wide and zoom into a street level view. There are many techniques available such as software and hardware buttons, on screen clicking and more recently pinch gestures as used by the iPhone. A lot of the zooming techniques rely on special hardware e.g. special buttons or multi touch displays. A mobile projector hardware setup is no different and subsequently could have a unique zooming interaction. Two interactions are investigated in this paper: a push and pinch style zoom.

3.2.1 Push Zoom

The first style of interaction is the push zoom which requires the user moving the device closer to the projection surface and further away to change the zoom level on the map. It was decided in order to match the second interaction technique that when the device was moved away from the wall the image would increase in size and it would decrease the closer it got to the wall. Thresholds were added to this scale so that the zoom wasn’t linear with the movement, as small movements by the user would cause the projected contents to resize immediatly causing a less usable interaction.

3.2.2 Pinch Zoom

The second style is a pinch zoom, similar to the first but this requires the user to push the device closer to the screen, press the pinch button, which would mimic the user grabbing the image then when they pull the device towards them it would increase the size of the image until they were to release the pinch button which would leave the image at the desired zoom level. To zoom out, a similar interaction would be performed but the user would push the device towards the screen as if to move the map further away. This interaction was designed to create an intuitive design which is similar to the push zoom but will not have the same error rate with accidental activations when in normal use, as the interaction can only take place when the pinch is activated. This gesture can be thought of as similar to a real world scenario where the user would grab an item to get a closer look at it.

4. PROTOTYPE

In order to accurately capture the orientation of the projector and the potential interactions preformed, a camera-based infrared tracking system by Natural Point [11] was used. The system offers 6 degrees of freedom (6 DOF) for any defined object with three or more attached markers (infrared, reflective) placed in view of the cameras. The hardware setup consisted of 3 infrared USB cameras that connected to a standard dual core windows laptop and a Nokia N95 with a hand held auxiliary projector attached.

On the laptop a system was implemented which dealt with the setup and management of the tracking system. This consisted of periodic location updates that contained the Roll Pitch Yaw, and XYZ coordinates for every defined object currently in the view of the cameras.

Figure 4.1 Example of selection game

Figure 4.2. User selecting a 'target'

Figure 4.3. Sample screen shot of projected content for selection game

Figure 5.1 User interacting with map application

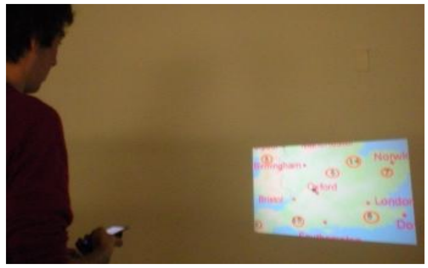

Figure 5.2 Map application showing the searchlight metaphor

Figure 5.3. Sample screen shot of projected content for map application

This was implemented in C using the OptiTrack toolkit [11]. The second main element to this system was the Bluetooth manager, which packaged up the necessary information and sent it to the mobile device using Bluetooth. This part was implemented in Java SE due to the vast range of java compatible Bluetooth stack implementations.

The mobile device consisted of a Nokia N95 and an Optima pk101 Pico Pocket projector, a LED based projection device capable of projecting up to a 60" screen connected via the video out provided by the Nokia. The application was made in PY60, a mobile version of python for Nokia S60 devices [12] that offered a range of tools for graphics and networking, communicating with the laptop subsystem via Bluetooth. Due to the limited processing power of the N95 and the vast amount of processing needed to calculate where the projected surface is residing some processing had to be preformed on the laptop system before it was streamed to the device. This was primarily to increase response time in the overall application.

5. EVALUATION

Two applications were implemented which were designed to expose the interaction technique to the user as best possible and offer a quantifiable way of assessing usability of the techniques. The applications were designed to offer a fun environment for the user to 'play' with the technology and interactions.

5.1.1 Memory Search Game

This application consisted of a simple GUI (Figure 4.3), which contained several targets or 'cards'. When a user selects a card it flips over to reveal a shape, the user must then select another card hoping to reveal a matched pair. If the two shapes match the cards remain flipped, otherwise they are reset and the user must continue finding the matching shapes. The game is won when the user has successfully turned over all the cards.

Using the searchlight metaphor and a cursor which is placed in the centre of the projected area the user can maneuver the projector so that the cursor will be placed on top of a desired target. Once they have successfully acquired the target the user will perform one of the interactions to reveal the shape underneath the target.

For the evaluation the user was asked to play the game to completion with the twist, jab and button interaction. The button interaction was just a standard button press and used as a base comparison with the implemented interaction techniques. Three card configurations were devised so the user could play the game with each interaction style so that their performance wouldn't improve through learning.

5.1.2 Map Browsing

With this application the user was able to interact with a map, the searchlight metaphor as shown in Figure 5.1-2 was used to allow the user to physically navigate. The map contains a series of numbered targets, which users had to locate one by one and place a marker on top (Figure 5.3). The user performs one of the zoom interactions to zoom in and out of the map to acquire the targets faster, but in order to place the marker accurately the user must zoom in to increase the size of the target. Again a button press interaction was also implemented for comparison, this consisted of two buttons one allowed the user to zoom in and the other allowed them to zoom out.

6. Study Results

A small user study took place consisting of 9 users 5 male, 4 female between the ages of 17 and 26. They were asked to complete the memory game and the search game using the developed interaction techniques.

Users were asked to play the search and map game and complete the task once using each of the interactions. Roll Pitch and Yaw (R,P,Y), XYZ coordinates of the device and completion time were recorded for each user so their motion and performance when performing the interaction could be monitored.

6.1 Selection Gesture

The results in Figure 6 show the mean completion time for the selection interactions. Overall the button interaction has the lowest completion time, with the twist resulting in the longest overall time. This can be explained when comparing the twist RPY values to the other gestures, the roll value fluctuates a great deal less with the twist. This is because the users have to restrict their movements when using this gesture to avoid triggering the interaction.

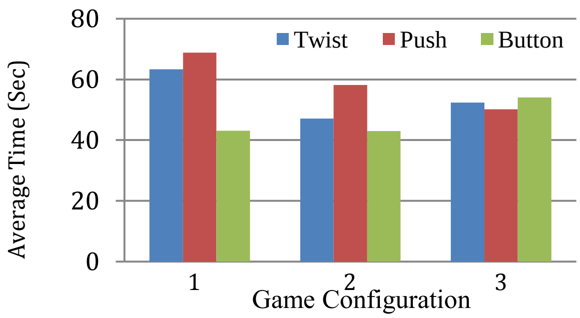

Figure 6. Selection Interaction Results

6.2 Zoom Interaction

The results in Figure 7 show the average completion time for the selection zoom interactions, the poor performance with the pinch gesture is reflected by the user feedback for this interaction. The major comments were that the interaction was 'too tricky', although the intention was to avoid unintentional zooms caused by user movement, the extra step of having to activate the pinch caused much confusion and often users would get 'stuck' in the pinch menu as they forgot to deactivate the pinch setting.

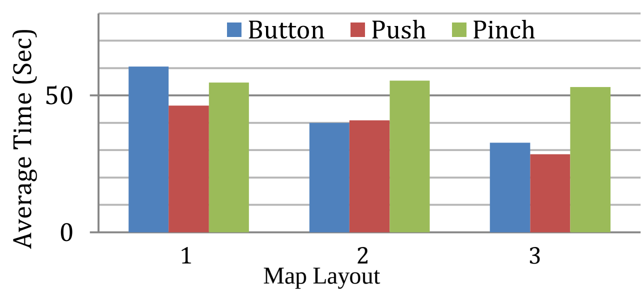

Figure 7. Zoom Interaction Results

7. CONCLUSIONS

One of the biggest issues raised was the restriction in maneuverability caused by some of the interaction techniques, namely the twist selection technique, which relies on monitoring the roll motion. The roll pitch and yaw values were monitored for each environment and results showed that the users motion in the roll plane was less active in the twist interaction. This happened as in order to stop a false trigger of the interaction the user had to mentally monitor the devices movement in the roll plane, causing adverse effects.

One issue found was the clarity of the projected contents when the device wasn't projected perpendicular to the wall, the skew effects created lowered accuracy and were most notable the further the projector was skewed. This could be corrected using projective transformations on the images to skew the projected image which when displayed on a non-perpendicular surface would correct its self. This wasn't implemented in this study was that the processing overhead in python had a huge impact on the performance of the mobile application.

Feedback from several users said that they found accuracy a key element, on reflection it was highlighted that the element of completion time caused this focus on accuracy. Further research into a less formal context i.e. photo browsing would be beneficial for future interaction development.

Although this study used motion capture to derive the positioning of the device it is possible with a calibration stage to achieve the same effects with a digital compass and a digital accelerometer. The main issue would be the accuracy archived by a user calibrating the device on the fly, which could greatly impact on the usability.

There is a necessary to create fundamental programming resources for mobile projector usage, a 'projector canvas' that would perform all necessary skew correction in a much lower lever more efficient language is paramount to the development of future mobile projector applications which rely on movement of the device to infer interaction.

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