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EVALUATION OF AN IN-CALL INTERACTION TECHNIQUE FOR PROJECTOR PHONES

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Abstract

With modern mobile devices information like emails or calendar entries are easily accessible. During a phone call when not using a headset these capabilities are lost. Emerging projector phones could overcome this bottleneck with their capability to project a separated interface onto nearly any kind of surface. But still the problem exists of how to control this projection. In this paper we present and evaluate a one-handed interaction paradigm for projector phones that allows accessing the full phone capabilities during a phone call, such as apps and personal information management tools. This interaction paradigm is robust and easy to implement. In a user study we evaluate one possible implementation of the proposed paradigm.

Keywords: projector phone, in-call interaction, mobile phone, projector

1   Introduction

Modern mobile devices allow users to store and access personal information like calendar entries, emails and maps as well as navigational instructions. These services are hard to access while the user is making a phone call. The mobile device is often not utilized in these situations even though it could provide beneficial information for the conversation, like accessing the calendar to make an appointment with the conversational partner. Headsets can overcome this problem since they give the user the possibility to interact with the mobile device while making a call. But even though they are increasingly popular, they still are cumbersome to use. Users rate headsets as uncomfortable and unattractive which makes them embarrassing to wear in public (Ito et al., 2005, Li et al. 2008). Without using a headset the user has to interrupt the conversation to search for and get a glance at the needed information on the display.

Projector phones, can solve this problem, since they can provide a projected information screen during the call. But still the question remains how to operate such a projector phone during a call. Winkler et al. showed in their work how direct touch interaction could be utilized in such a situation (Winkler et al., 2011). The drawback of this approach is that the user always has to have a projection surface in their arms reach which is not always the case when one is on the go. Therefore we introduce a novel interaction paradigm in which the users can interact with the projected content using the index finger to control a cursor in the projection as can be seen in Figure 1.

Figure 1   One handed interaction with a projector phone during a phone call: The user controls

a cursor in the projection using a track pad on the back of the device.

In this paper we present and evaluate a projector phone based interaction paradigm that allows users to access the full capabilities of the phone during a call using a projected additional screen. Furthermore the proposed method provides the advantages that this setup can also be used when the user is on the move similar to (Li et al., 2008) and one hand of the user still remains free for everyday tasks like carrying a bag. We compare this interaction paradigm in a controlled experiment against two postures with different ergonomic characteristics for controlling a cursor on a projected display.

2 Related Work

With projector units becoming smaller, brighter and more energy efficient they will be more likely integrated into mobile and wearable devices. Several projector phones are already commercially available and many more prototypes exist (Rukzio et al., 2012). Initial research in the field of mobile projection was conducted by Raskar et al. with the iLamps (Raskar et al., 2005). Blasko et al. explored applications and interaction techniques for a wrist-worn projector (Blasko et al, 2005). How multiple users could benefit from mobile projection was demonstrated by Cao et al. (Cao et al., 2007). Accessing maps during a call to help the conversational partner navigate or to look up a location is one use case of the interaction paradigm we propose in this paper. Hang et al. provided clear evidence that the interaction with digital maps on mobile devices could benefit from an integrated projector (Hang et al., 2008). Their study showed that the users are significantly faster when searching on a digital map when having access to a large-scale projection.

The interaction paradigm presented in this paper is analogous to the one used by Park et al. (Park et al., 2010), but instead of performing a gesture the user steers a cursor. The idea to make the phone's capabilities accessible during a phone call is followed with the BlindSight system by Li et al. (Li et al., 2008). BlindSight allows browsing through the menus of the phone using auditory feedback and the keypad of the device during the phone call. One advantage of this approach is that the device can be operated with one hand and does not require the user's visual attention. The drawback costs are the lacking capabilities to access information like maps or websites. Another disadvantage could be the possible interference of the auditory feedback with the conversation. The interaction paradigm we present in this paper allows to access all of the phone menus and capabilities but it requires the users' visual attention.

Winkler et al. presented an interface that would allow interacting with the phone interface during a call (Winkler et al., 2011). In their approach the user interacts with the projection by touching it. The disadvantages of this interaction technique include that it not only requires a surface calibrated for finger tracking and in reach of the users' hand, but that it also requires the user to have a free second hand. Our proposed interaction technique allows the use of every surface that is suited for projection and the user only needs the hand, which is already holding the device. Moreover, our approach relies on reliable touch input and is easy to implement in contemporary projector phones. Even though the proposed interaction paradigm is a form of back-of-device interaction, it is not meant to solve the fat-finger problem as presented by Wigdor et al. (Wigdor et al., 2007), since the fingers do not occlude parts of the display.

3 Interaction Paradigm

To illustrate the paradigm more fully one can imagine the following scenario: During the lunch break Adam, a manager, is walking back to the office from a deli with a sandwich in his hand. He gets a call from a business partner to arrange a meeting next week. He uses his projector phone to project his calendar on the street and controls a cursor in this projection with his index finger to interact with the calendar. For privacy reasons his calendar is masked in such a way that it is only visible whether a time slot is blocked or not. Details are only shown if the user explicitly demands them. With that he is able to arrange a meeting without stopping or needing both hands. This scenario is illustrated in Figure 1.

One major advantage of the proposed interaction paradigm is its simplicity. The interaction with the device is based on a robust one-handed input technique. To select an item with the cursor several

possibilities are reasonable. Our first tests showed that double tapping as well as using a hardware button on the side (e.g. the volume rockers) are both feasible. Through the user study described below we want to find out how this one-handed interaction technique for projector phones compares to two different postures for controlling a cursor on a projected display. However, only one of the postures allows for in-call interaction as described in the above scenario. We expect the pointing performance of in-call interaction to be lower than the pointing performance of two-handed interaction in particular, but we aim to quantify the additional overhead incurred by the in-call technique to decide whether it is acceptable for short interactions during phone calls. The benefit of such in-call interactions might be high enough to justify a certain loss in overall interaction performance.

4 User Study

The user study aims to estimate interaction performance of the proposed in-call interaction relative to existing techniques without the ability to access the phone capabilities during a call. For the study we decided to control the cursor using an integrated touch-pad on the back of the device similar to already existing hardware as used e.g. in the Motorola Charm. The cursor is controlled using relative positioning as on a touch-pad. This decision was made since in pilot tests we found that users cannot estimate well where the finger initially touches the touch pad, such that absolute positioning was not deemed suitable. The mapping of the touch input to the velocity of the cursor followed a linear acceleration. We measured the time users required to select targets in the projected display.

4.1 Design

The study was set up as a within-participants design with the input method and the distance between targets as the two factors. We compare three different postures to control the cursor in the projected display, called Ear, Pad and Remote (compare Figure 2).

1. **Ear**: The Ear position simulated the in-call setting where the subjects hold the mobile phone to their ear in such a way that the touch screen is facing away from the head so that it is reachable by the index finger (Figure 2, left).

2. **Pad**: A touch-pad of a Laptop is modelled in the Pad task. The mobile phone is held with one hand alongside and the input on the touch screen is carried out with the other hand (Figure 2, middle). This position also imitates how the LG eXpo projector phone is operated.

3. **Remote**: With the Remote task the mobile phone is held similar to a remote control with one hand. The input on the touch screen is done with the thumb (Figure 2, right). This position simulates how a cursor on the projection of a projector phone like the Samsung Galaxy Beam is controlled.
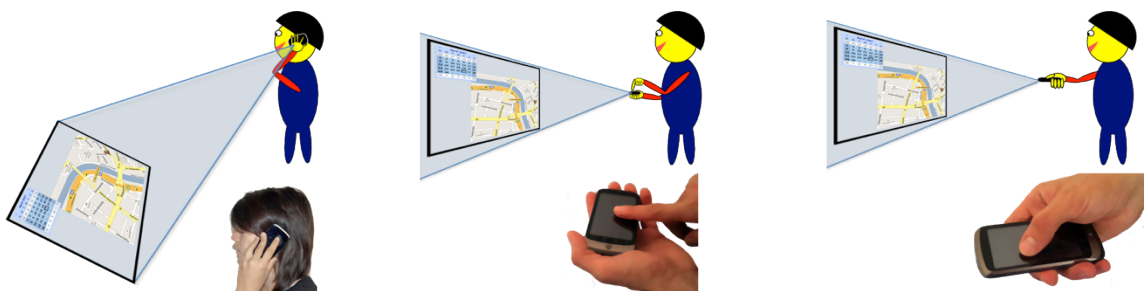

Figure 2   *The three different ergonomic positions tested in the user study: Ear (left), Pad (middle) and Remote (right) with detail shot.*

4.2   Participants and Apparatus

The study was conducted with 18 participants, 10 female, 8 male, ages 18-41 (average 26.5). The subjects were mostly undergraduates with varying degrees of technical background. 17 subjects were right-handed and one was left-handed. The study took approximately 50 minutes including the questionnaire and the subjects were paid an incentive of 10 Euro for their participation.

4.3   Task

The user study adopted the cyclical multi-direction pointing task paradigm of ISO 9241-9 (ISO, 2000) in which the cursor was steered via the touch-screen of a Google Nexus One. The raw touch input from the device was sent via WiFi to a desktop computer that was coupled to a display. We simulated the projection using a 23" display. The choice was based on measurements of the size of the projected image of an Aiptek T30 pico-projector. Held in a 45° angle, 1.6m away from the projection surface its projection field closely fits the size of the chosen display. In the cyclical selection paradigm the subject is required to move the cursor to sequentially numbered targets which are equally spaced around the circumference of a circle. The task starts when the user moves the cursor to the topmost target and ends when the sequence is completed (the topmost target is selected again). The next item to select is always close to opposite clockwise around the circle. For our setting we chose 9 targets, which were altered in distance. The subjects had to stand during the whole study, for the positions Pad and Remote a display was mounted in eye height and for the position Ear another Display was standing on the floor in a 45° angle. The targets had a size of 8x8mm and the distances were 75, 125 and 175mm (on the screen).

4.4   Procedure

Since the Ear position created a situation where the mapping of x- and y-direction from touchscreen input to cursor-movement is not obvious for the user and can vary between the user first the moving directions of the cursor were determined by the subjects. It was possible to define the mapping for each ergonomic position separately. After choosing a mapping the participants performed a practice-phase in which each posture could be tested two times with the cyclical selection paradigm to verify the moving directions. Following this the actual study began. For each of the three ergonomic posture the cyclical selection task was tested with three different circle size and for each of these settings seven trials were conducted. Overall each participant had to undertake 63 trials. The order of the ergonomic positions and the circle sizes were counter-balanced between the participants. In the end the subjects had to fill out the corresponding questionnaire to the cyclical multi-direction pointing task of ISO 9241-9 (ISO, 2000).

4.5   Results

The overall mean target selection time across all techniques was 13.1s, the results broken down by interaction technique are 17.6s for *Ear*, 9.5s for *Pad*, and 12.1s for *Remote*. As expected, a clear advantage can be seen for two-handed interaction. Figure 3 shows the results further broken down by target distance. A within-subject repeated measures ANOVA shows that the effects of interaction technique ($F_{2,34} = 98.95$, $p < 0.001$) as well as target distance ($F_{2,34} = 273.20$, $p < 0.001$) on selection time are both statistically significant. Post- hoc multiple comparison tests (Tukey) show that the results are pairwise significantly different for both interaction technique and target distance. We identified stronger learning effects for the *Ear* technique compared to the other two postures. Overall

the decrease in target selection time was 25% for *Ear*, 12% for *Pad* and 11% for *Remote* from the first to the seventh trial (averaged over all distances). Especially for the short distance (75mm) the average target selection time decreased by 28% in the *Ear* posture. For comparison in the *Remote* posture the decrease is only 9% and in the *Pad* posture it is 14% for the short distance.
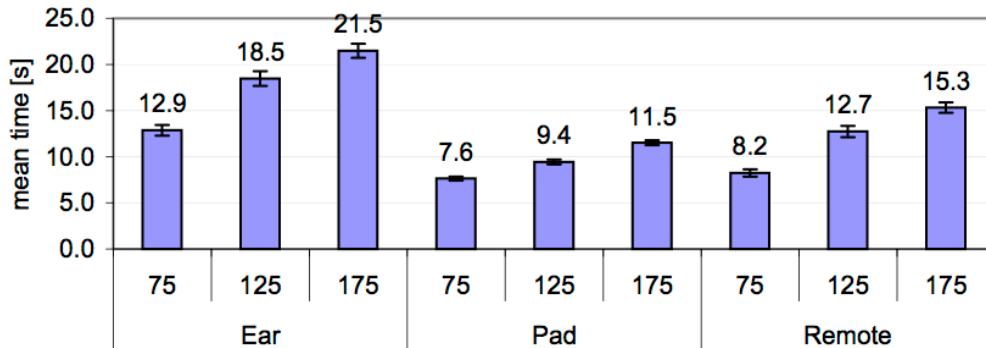

Figure 3   *Mean target selection times by interaction technique and target distance (in mm).*

(Vertical bars show 95% confidence intervals.)

The questionnaire on input devices revealed that overall the users rated the posture *Ear* significantly lower than *Remote* ($p < 0.001$) and *Pad* ($p < 0.001$). Especially the significant poor rating of the "General comfort" ($p < 0.01$) and the "Wrist fatigue" of the *Ear* posture compared to the other two postures showed that the implementation using a touch pad is too exhausting for the users. In the free answer field 6 participants stated that the *Ear* posture was easier to use with the small target size (75mm). Based on the smaller range of operation that the index finger has in the *Ear* posture compared to the *Pad* these results are reasonable. But still it is the only paradigm that allows one handed in-call interaction in an adequate speed.
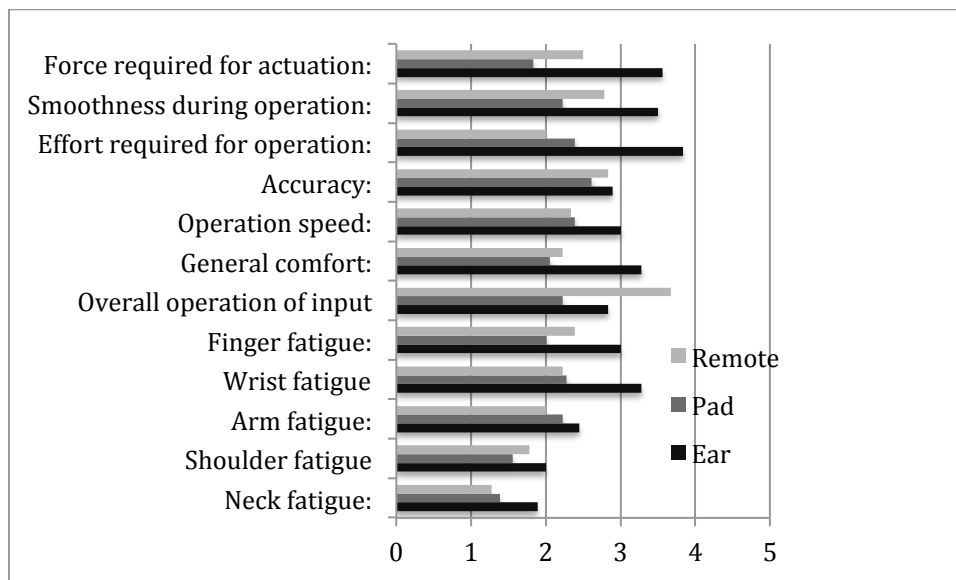

Figure 4   *Results of the ISO 9241-9 (ISO, 2000) questionnaire (lower values represent a better rating).*

5   Conclusion and Future Work

In this paper we presented a robust and easy to implement in-call interaction paradigm for projector phones that allows accessing the phone's normal UI. We conducted a user study to evaluate the performance of this paradigm. The results of the user study show that even though the presented interaction paradigm is rated low, users are fast at learning the paradigm but still there is room for optimization. The usage of an isometric joystick instead of a touch pad should increase the efficiency since our study showed higher performance for smaller movements of the index finger on the back of the device. From these results not only fellow researchers can benefit but also phone manufacturers can take them into account for future design considerations.

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