ScrollPad: Tangible Scrolling With Mobile Devices

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Abstract

In this paper we approach the problem of managing large visual sets of data on small mobile devices. While current approaches either focuses on 1) scrolling on the mobile device, or 2) reducing the content in various ways (e.g. zooming, automatic redesign depending on the screen size of a mobile device, etc) our approach is to scroll with the mobile device itself (i.e. object in the world scrolling) over a large virtual area. We present the background for this project and working prototype called ScrollPad developed to illustrate this concept. We then present an initial user study conducted and relate this project to similar efforts made before concluding the paper.

1. Introduction

A problem with mobile devices is that they have limited screen real estate. Further on, many sets of visual data are larger then a normal PDA, or mo-bile phone screen (e.g. regular web pages or street maps) thus making it hard for the user to get an overview of the content. This problem has so far been approached from two angles. Either 1) traditional desktop computer scrolling functionality has been implemented on the mobile device, or 2) content has been reduce in various ways (e.g. zooming, automatic redesign of screen layout depending on the screen size of a mobile device, [6] etc). However, these two approaches each have their drawbacks. The first approach (i.e. traditional graphical scrolling functionality) brings an additional graphical element onto an al-ready tiny screen thus reducing the area for the content to be displayed on even further. The second approach (i.e. reducing or

reconfiguring the content for "optimal" fit according to a specific device) has several drawbacks in that several versions of the content has to be developed (or at least several algorithms for automatic redesign has to be developed), and the user will not be presented to the same *look ´n feel* as in front of an ordinary computer which might introduce additional navigational problems for the user since he/she might not recognize e.g. a familiar web page although it's design and navigation might be well known on a desktop PC.

In our research we have explored an alternative approach to these two alternatives outlined above. Our approach builds on an idea to scroll with the mobile device itself over a large virtual area.

The rest of the paper is structured as follows: In section 2 the background and fundamental idea behind our project is outlined followed by section 3 where we describe the design of ScrollPad, a working prototype that enables its user to, in a very tangible way, scroll large virtual areas by just grabbing the PDA in one hand and then move the mobile device itself around over a flat surface. In section 4 we present an initial user study of the ScrollPad followed by a summary of the results from that study in section 5. We then discuss the design of ScrollPad (section 6) before relating it to similar efforts made (section 7) and concluding the paper in section 8.

2. Background

In this section we outline the basic idea behind the design of ScrollPad. Basically, the difference between

scrolling the content on the device vs. scrolling with the device itself can be formulated accordingly:

A PDA can on the one hand be understood as a self-contained world of objects (e.g. programs, files, etc). On the other hand, the mobile device itself is an object in the world. In our project we can thus distinguish between on the one hand: 1) *traditional stylus scrolling* on a mobile device as an act of manipulating *a world of objects* inside a PDA without considering that the device itself is actually a movable (read "mobile") *object in the world* outside the digital world (often referred to as the "real" world in contrast to the virtual world), i.e. *world of object scrolling* and on the other hand 2) *scrolling with the device itself* as an act of *object in the world scrolling*.

We believe that our approach (i.e. the *object in the world scrolling* approach) have great potential, not at least due to the current trend towards *embodied interaction* [1], and TUIs (Tangible User Interfaces) where the user interact with the computers in a more physical and direct way.

3. Prototype design

In order to illustrate how these two high-level conceptualizations (i.e. world of object scrolling vs. object in the world scrolling) can inform design of mobile technology and to make empirical evaluation possible, two prototypes were designed and implemented. In the following, each of these designs is presented in relation to their respective high-level conceptualization.

3.1 Scrolling a world of objects

The first prototype (i.e. the StylusScroller) was designed to reflect a typical way of designing scrolling interfaces, where the PDA takes on the role of a world of objects that can be manipulated by the user. The only functionality it supports is the possibility to scroll a bitmap image by means of direct manipulation of the image. In order to display a new section of the image, the user grabs hold of the image and drags it in any direction. Given this style of interaction, the document subject to scrolling can be considered to be in motion relative to a fixed PDA.

3.2 Introducing ScrollPad: Scrolling the world with an object

The second prototype was designed to manifest the view of PDAs as objects in the world. Compared to the first prototype, the PDA is not only a container of interactive objects but also very much an interactive object in itself. In order to scroll a document, the user slides the PDA on a flat surface to gradually reveal new areas of the document. The interactive qualities of the prototype emerge in the blend of the characteristics of the PDA and the flat surface. Figure 1 (top) illustrates this idea:

Fig. 1. By physically moving the PDA itself around like an ordinary computer mouse the virtual display "underneat" the device is displayed on the mobile

device (top). Schematic figure of a PDA mounted onto an optical mouse to enable scrolling over a flat surface by moving the device around (middle), and final implementation of the working ScrollPad (bottom).

The design of ScrollPad was realized through of a combination of the sensing circuitry of an off-the-shelf optical mouse and a custom made circuit. The main function of the custom made circuit is to read movement data as reported by the sensing circuitry and communicate the data to the PDA. The implementation makes use of the PDA's capacity for infrared data communication, which allows for an untethered, serial link between the PDA and the sensing device.

As shown in figure 1 (bottom), the circuitry is fitted inside a casing designed to allow for smooth sliding over flat surfaces.

As the user slides the PDA, the application software in the PDA reads the motion data from the infrared port of the PDA and updates the display accordingly. This solution has proved to be a simple, yet effective way of prototyping the notion of the PDA as an object in the world.

4. User study

In order to substantiate the conceptual distinction between PDAs as objects in the world versus worlds of objects with some empirical grounding, we have conducted a preliminary user study. This study was part of a larger research project (i.e. [5] on visualization of time and events. In this paper, we report only on those aspects that are relevant in relation to the conceptual distinction.

4.1 Design of user study and test procedure

A total of 16 participants took part in the evaluation, with an equal gender balance. Each participant used both the ScrollPad and the StylusScroller alternative (i.e. traditional scrolling on the mobile device).

Two different datasets and associated tasks were devised to avoid situations where a participant's self-reported experience is influenced by the information content of the prototypes rather than the design. Thus, each participant was confronted with two datasets, one for each prototype. To address potential effects that a combination of a prototype design and a dataset might have, measures were taken alter the combinations of

dataset and design. Also, to compensate for any effects that the order in which the different design are used, the order was altered as well.

Given the two prototypes and two datasets, the following orderings are possible:
1. First ScrollPad with dataset 1, then StylusScroller with dataset 2
2. First ScrollPad with dataset 2, then StylusScroller with dataset 1
3. First StylusScroller with dataset 1, then SlideScroller with dataset 2
4. First StylusScroller with dataset 2, then ScrollPad with dataset 1.
This set of combinations was repeated two times for each gender.

A dataset in this context refers to a temporal landscape with events with a start and an end. A portion of a landscape is shown in figure 2 and a larger part of it is visible in figure 3. The datasets implies a fictional scenario of university events (lectures, seminars, etc) that takes place in time at specified locations, with names persons responsible for each event. This kind of scenario was chosen because it is a familiar kind of context for the participants.

Associated with each dataset was a set of tasks that the participants were given one at a time after an initial briefing about the evaluation and about a minute of getting familiar with the prototype. Examples of such tasks are:
• What event or events overlap the course introduction in political led by A Wigren?
• Assume that you should schedule a session in the timetable that must not start before 11.00 and no later than 20.00. What alternatives do you have at your disposal?
• I would like you to locate the event that concerns Preparations that K Lavander and others from informatics are involved in?

The evaluation was not concerned with performance measures such as time to completion, error rates and other quantitative aspects of performance. The tasks were used as a means to get the participants to express themselves and, hence, they were asked to think aloud while attending to the tasks.

The participant's interactions and expressions thereof were recorded with a digital video camera.

Figure 2 below shows a user scrolling on the device with an ordinary stylus (i.e. the StylusScroller). This figure also shows what is actually visible to the user on both the StylusScroller prototype and the ScrollPad. Figure 3 on the other hand shows the ScrollPad in use where the user physically moves the whole mobile device around to uncover the information that is virtually "underneath" the device. However, the virtual surface outside the screen of the PDA is not visible to the user during actual use. Here we have made a photomontage where we have added that virtual surface underneath the device just to illustrate how the device shows different parts of a larger material when it is physically dragged over the flat surface.

Fig. 2. Stylus scrolling on the PDA.

Fig. 3. The ScrollPad in use and here presented as a photomontage that helps illustrating the idea of a virtual surface "underneath" the device.

Finally, figure 4 shows a user during the user study as he is holding the device in his left hand and physically drags it up and down across the A3 paper on the desk.

Figure 4. Picture taken of the ScrollPad in use during this initial user study.

5. Results

In this section we present some observations made during this initial user study. The observations concerns both 1) interactional aspects of the ScrollPad in use as well as it covers 2) some observations made that is more related to the technical aspects of the current implementation of the ScrollPad prototype. Below we present these findings in more detail.

5.1 Interactional aspects of ScrollPad in use

As seen in figure 4, a sheet of A3 paper was fastened to the desktop. The reason for doing that was twofold. First, it proved to be a better surface for the ScrollPad's optical sensor. Second, and more interestingly, it was meant to serve as a point of reference for the interaction with the prototypes.

When asked what appeared to be a somewhat surprising question concerning the extension in centimeters of the temporal landscape, several participants answered by referring gesturally to the A3 paper as if it were a yardstick. This happened only when the question was asked in relation to the ScrollPad prototype. This seems to resonate well with the aim of realizing the notion of a PDA as an object in the world.

What we take to be an inclination to refer to the environment outside of the PDA is not solely based on gestures that the participants made. Also, there were some articulated expressions such as the one in the following quotation:

We find this particular kind of expression interesting because it suggests that the participant's experience of interacting with the PDA, in the case the ScrollPad, is not confined to the device us such. Rather, the interaction experience seems explicitly influenced by the physical context where it was used.

5.2 Technical aspects of ScrollPad in use

The sensing technology used for the ScrollPad is inherently relative. Position is inferred from motion, rather than tracked absolute according to a specific geographic position. This design aspect was evident in the user study. Some participants used the ScrollPad much the same way as a mouse is used, i.e. by repeatedly sliding, lifting, retracting, sliding, etc. An absolute position tracking, would not allow for that kind of interaction. Plausibly, a more forcing, absolute tracking of the PDA geographic position would emphasize the notion of the PDA as an object in the world. The device position and current interface view would be more tightly coupled. However, the choice between relative and absolute position tracking is not without trade-offs, as will be argued in the discussion below.

The design of the ScrollPad requires the device to be used in conjunction with a flat surface, preferably a tabletop. On the hand, this requirement can be seen as a limitation, as done by [4]. On the other hand, it can also be seen as a quality of the design that ensures a certain distance between the device and its users that allows for collaborative use of a single device. Further on, while observing the participants using the two prototypes, it seems as if the use of the ScrollPad is associated with problems related to lack of visibility due to glare and a less than optimal viewing angle. This was not the case with the StylusScroller. This can be explained by the fact that PDAs are typically designed to be used *vertically* by *one* user that is holding the device upright in his or her hand. This is very different from the use scenario we are envisioning where *several* persons together and simultaneously uses a *one* PDA *horizontally* on a flat surface. The advantage here when it comes to our implementation of this by relying on a relative position tracking technique is that it will not only allow for passing the device around, but also

allow for the whole virtual workspace "underneath" the device to be moved around from person to person as the device is passed on to another user.

6. Discussion

Stylus interaction – as embodied by the first prototype (i.e. the StylusScroller) – promotes a certain kind of use that is largely private and individual. In order to manipulate the interface successfully, the user needs to handle the PDA in such a way that makes it difficult for other people than the one holding the device to take part in the interaction. In that regard, PDAs are similar to interaction with physical notepads in that shared use typically requires one user to hand the device over to some else for that person to take part in the interaction. Just as stylus interaction promotes a certain kind of use, the sliding kind of interaction promotes a different kind of interaction that allows for a more social use, where several people can take part in the interaction.

The aim of the evaluation was not about arriving at a conclusion concerning which of the two prototypes is the best one. Rather, the results seem to indicate that PDAs can be designed to embody quite fundamentally different high-level conceptualisations. We have investigated PDAs as objects in the world and compared with what we take to be the more common conceptualisation, PDAs as worlds of objects. In doing so, we believe that we have uncovered a largely unexplored parts of the design space of PDAs and mobile technology. Having that said, we could however observe that several subjects had various kinds of problems with the StylusScroller whereas the ScrollPad seemed to be a very intuitive tool to the users. This might be because all of the subjects in this study where used to scrolling with an ordinary computer mouse.

Finally, the view of PDAs as worlds of objects is associated to a kind of mobility that emphasizes the mobility of the user. We suggest that viewing PDAs as such emphasizes the mobility of the artifact in interaction. This corresponds to the distinction between local and micro-mobility made by [4].

7. Related work

Of particular relevance to the work presented in this paper is the work of Fitzmaurice *et al* on spatially aware plamtop computers (see for instance, [2] and [3]). More recently, Yee [7] has presented work on so-called

Peephole Displays. However, while Yee [7] focuses on how to create an exact mapping between a certain absolute position in the real world and a similar position in the virtual world we focus our attention on relative positioning solutions. We believe that relative positioning between the physical and virtual world has its advantages for three different reasons:

1) First, people are used to traditional mouse interaction, which also relies on relative positions (e.g. the mouse pointer might not be at the very right on the screen just because the mouse is place close to the right edge of the desk).

2) Second, relative positioning allows for mobile use of the device since the virtual content can follows the user wherever he/she goes (compared to an absolute positioning solution where the virtual world is in a fix location as a layer on the physical world).

3) Finally, the relative positioning solution does not require heavy additional equipment (e.g. a ultrasonic tracking system mounted in the sealing) to make it run. Instead it can be run everywhere (both indoors and outdoors) as long as it can rest on a flat surface such as a desk or a floor.

8. Conclusions and future work

In this paper we have presented the concept of *object in the world scrolling* to approach the problem of viewing large sets of data on small mobile devices. Our approach contributes to the two current approaches to this problem (i.e. on display scrolling and automatic content reconfiguration) by enabling a mobile device itself to function as a combined scrolling and viewing device. Our work also contributes to similar efforts made by focusing on relative positioning to enable also the virtual surface to become mobile, thus enable its user to use the device wherever he/she wants to go, thus supporting mobility rather then exact mapping between the geographic position in the real world against a similar position in the virtual world. In a sense, ScrollPAD realizes relative context awareness on a micro-mobility [2] level of analysis.

We believe that our approach to the scrolling problem on small displays might be fruitfully applied for application areas like web navigation and street map viewing where the user needs to get an overview of a large graphical area. We also think that this interaction technique can open up new dimensions for computer games on mobile devices.

The designs presented in this paper open up possibilities for different kinds of future research.

Amongst other things, we find it important to generate knowledge concerning the design and use of mobile technology conceived of as worlds of objects versus objects in the world. In our studies we will also focus on the use of the prototypes in collaborative settings. It is our hypothesis that the different prototypes will give rise to quite different interaction patterns. We anticipate the ScrollPad to support a relatively more concurrent, collaborative interaction, whereas the stylus scroller will foster a turn-taking oriented collaboration where each participant might look at the device in short individual turns compared to collectively moving the ScrollPad device around and make suggestions to each other about where to go next in the collective interaction with the device.

9. Acknowledgements

10. References

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