User Requirements for Large Virtual Display and Finger Pointing Input for Mobile Devices

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ABSTRACT

Mobile computing is moving towards continuous Internet connectivity including always-on connection with selected people as well as on-line services provided by the wireless Internet.

In this paper, we discuss the requirements for mobile computing concentrating on usability, utility and user acceptance issues. We established a focus group to find out about the needs for and the common problems with current hand-held devices. The users repeatedly pointed to problems associated with small displays and clumsy input methods with tiny buttons.

As a solution to these problems we presented a pragmatic gestural user interface approach for hand-held devices - MobiVR. The basic idea is to combine any tracking method, a near-eye microdisplay, and wireless communication into a hand-held device in a manner that enables intuitive finger or stylus pointing. The MobiVR enables a large display with a full-resolution view in a hand-held device. The user's finger can replace a mouse.

The majority of the focus group thought the MobiVR could solve many usability issues, although it would not be a universal solution for all kinds of tasks, users, contexts, devices, and environments.

Categories and Subject Descriptors

B.4.2 Input/Output Devices, H.5.2 User Interfaces, H.1.2 User / Machine Systems, I.4.9 [Image Processing and Computer vision] Applications

General Terms
Design, Human Factors

Keywords
Mobile Computing, Near-eye Display, Finger Pointing, Usability

1. INTRODUCTION

The dominant paradigm of computing seems to be changing towards mobile computing and wireless Internet. The imago of mobile devices, especially the mobile phones, is that they are personal devices for everyday usage. The status of "everyday thing" can nevertheless be achieved only by good usability. The GUI (Graphical User Interfaces) and the WIMP (Window, Icon, Menu, Pointer) UI have proven to be easy to use when PCs are concerned. However, these UI types familiar to users can't be efficiently used in mobile computing, because they are not well enabled with the current I/O devices. The needs for bigger displays and more natural input methods for hand-held devices are paramount. Near-eye microdisplays would provide truly lightweight and high-resolution virtual screens for hand-held devices, and they are becoming realistic in the near future. McLaughlin Consulting Group predicts that over 10 million microdisplays will be embedded to some mobile phones, PDAs, and Internet appliances [4] in 2005, with the number growing very fast.

A microdisplay can solve the screen size issue, but the input becomes then a problem. Cursor movement could be handled by e.g., a touchpad or a tiny joystick, but they may be slow and clumsy to operate. Hand gestures could be a more natural and intuitive way of pointing.

The MobiVR concept [5] consists of a near-eye microdisplay, a tracking system that facilitates finger pointing or similar gestures, and a wireless network connection. It can interact with any local or remote applications, information stores, or devices, which export their interfaces to it. It enables to use even a traditional WIMP user interface in a hand-held device.

In this paper, we discuss the usability and user acceptance issues of the concept. We established a focus group to find out about common problems with current hand-held devices. The users repeatedly pointed to problems associated with small displays and clumsy input methods.

We then introduced the MobiVR concept, and found out about the reactions and ideas about it. The majority of the group thought that it would solve many problems, although it would not be a universal solution for all kinds of situations, tasks, users, contexts, and environments.

Section 2 sketches the user requirements for mobile interaction found out in a focus group discussion. Section 3 presents the basic idea of the MobiVR user interface, and section 4 describes the focus group comments and ideas about it. Conclusions are given in section 5.

2. USER REQUIREMENTS FOR MOBILE INTERACTION

To find out about the acceptability and utility of current mobile devices (such as mobile phones and PDAs) and the problems in their usage, we formed a focus group of six experienced mobile phone users. The group consisted of technically oriented urbanites, which had experiences of the advanced features of mobile phones, more specifically WAP and cameras. The group's profile was formed in order to reach opinion of people that are most likely among the first active users of new mobile technologies.

The conversation was first guided towards the current mobile device usage experiences: What are the needs for mobile computing? What kind of problems they have accounted with the interaction and user interfaces? In this section we present the opinions of the focus group participants.

2.1 Utility and Desirable Application Areas

The focus group's needs and desires for mobile computing can be determined by three application areas: *communication, control of everyday life***,** and *knowledge management.*

One of the most important needs for mobile computing is the person-to-person communication, especially between friends and loved ones. The needs for *communication* can be categorized by their time criticality, more specifically whether there is a need for real-time solutions or not. Especially the focus group participants emphasized the possibilities for subtle messaging, e.g. the boss can send an important message to the employer outside the office hours without interrupting family dinner or the wife can send her love to her husband even when in a meeting.

The *communication* can also be determined by the information, which is shared. The focus group participants presented the needs to share experiences, feelings and moods, in addition to the traditional needs to convey information. This social and emotional information, which is rich in nuances, requires more creative and expressive tools than basic verbal announcements. For example, the focus group appreciated the possibilities to take and send pictures.

According to the focus group the everyday life is full of different controlling tools. For balancing everyday life there is a need to manage connections, time and money. On an ordinary day the user must carry with him/her a mobile phone, a watch, a calendar, money, keys, etc. The focus group indicated the need for combining the tools for *controlling everyday life* in a mobile device. The users were disappointed with the current digital calendar solutions. The main problem in the integration of different everyday objects (e.g., a mobile phone-calendar) is the synchronization. The integration is useless, until the information can fluently and easily be updated and transmitted to various devices, such as similar mobile devices (e.g., a friend's calendar) or other devices (e.g., a PC). In addition, it should be noticed that all of these objects, which are carried with, present also the users identity. For example, the paper calendar consists not only of the dates and times of appointments, but also of scribbles that describe the emotional charge of the event.

Knowledge management is needed both for work and leisure. The focus group accesses information mainly by the Web. The search for information is active and done with a good sense of direction. These advanced users differ quite a lot from the novice users, because they normally know what they are looking for and also where the information may be found. These aspects could be seen to create a good base for enthusiastic attitude towards wireless Internet, nevertheless the group members talked about wireless Internet with concern. Different unusable WAP solutions have caused frustrations and the current low-resolution screens are not seen sufficient for web browsing.

2.2 Problems of Current Interaction Methods

The main principle of mobile computing is to enable the usage of computational devices while on the move. City people, such as the focus group's participants, see different transportations as a main usage context for mobile devices. The usage of mobile devices should be possible in a rush hour bus, in the trembling train, while riding a bike, driving a car, etc. The usage of mobile device should not acquire all of user's attention. It should not shut the user from the world outside.

The participants stated that mobile device should also be passive in some terms, even though the direction is towards continuous connectivity and ubiquity. For example a mobile phone can be seen as a loyal friend, which accompanies the user in every situation and place, and which offers assistance but does not force itself upon the user. Push type of services are considered to be disturbing. The user should be able to determine activity level of the mobile device.

The users are accustomed to visual feedback and therefore the *small screens* of mobile devices generate a major problem, or at least are great challenge in information visualization [3]. The small screen can offer only little information at a time, which makes difficult to perform even the basic functions of information management, such as forming the general view and comparing different information. In addition, the lack of visibility strains the user's memory. The chains of functionality or actions are so long, that user's may loose the thought of the original goal. Small screen does not allow user interface design, which supports the users performance as the icons and spatial grouping does in GUI or WIMP solutions on PC.

The small screen is also partly the cause of *navigation problems,* because the presented amount of information about user's location and possible options is restricted. Problems are also caused by the limited possibilities to move in the UI navigation hierarchies, to point and to select objects. Small joysticks and possible arrow-keys do not offer easy input.

The focus group considered touch screens as rather intuitive and easy input method, which supports especially the navigation. Another advantage of the touch screen is that it enables the usage of a bigger display without enlargement of the mobile device itself. The users had quite good experiences with virtual keyboards. The *text-input* with them were considered to be quite fast and easy. The only disadvantage that the users mentioned was again the size: small screens can offer only little space for the virtual keys, which makes it a bit hard to hit the right keys (e.g. with a pen) while the user him/herself is on the move, for example in a trembling bus.

The users acknowledged the speech to be one of the most natural *text-input* methods. The advantage of speech is that it enables multitasking and mobility, because it does not require hands. Nevertheless the users didn't see speech as an acceptable choice for general interaction, because mobile devices are mostly used in public places, even though the task can be extremely private. It is also error-prone especially in noisy environments.

3. THE MOBIVR CONCEPT

After the discussion about mobile devices and their use in different environments to perform multiple tasks, a new mobile concept for display enlargement, MobiVR, was introduced to the focus group. MobiVR consists of a near-eye microdisplay and a tracking system to track a finger. The device does not use any external sensors or signals, and is thus self-contained with a display and computer vision-based tracking.

The user sees a “virtual touch screen” in front of him/her and can point to the items on it intuitively with a finger (see Figure 1). Objects can be selected (“clicking the mouse”) e.g., by a gesture, or the device or a pointing stylus may incorporate a conventional button for selection.

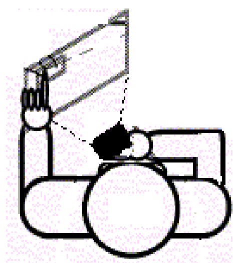

Figure 1. The user can point a finger to the objects on the virtual touch screen.

The device can be described, thought of, and applied in many ways. It could be seen as a hand-held web browser, an integrated UI component of a hand-held appliance, a universal remote control, etc. Its design can resemble e.g., a camera or a stick.

Computer vision-based finger tracking can be made robust and real-time. Also, since there is immediate visual feedback on the finger tracking and an opportunity for correction, the system should be useable without achieving 100 % accuracy on tracking.

Although MobiVR is a little similar to some wearable computing and virtual reality (VR) user interfaces, the main contribution is that MobiVR adjusts the user interface for mobile computing by giving it a new form and a relevant context. The device is hand-held, not head-mounted, and thus does not occlude the real world all the time, as many wearable and VR user interfaces do. This is convenient for most consumers and real usage situations.

An early prototype of MobiVR has been implemented with modified low-cost components [5]. The prototype works relatively well and responds fast to finger movements. A video will be put to http://www.cs.tut.fi/~ira/MobiVR.html to demonstrate the idea.

3.1 Use Scenarios

The introduction of MobiVR was done with two scenarios including MobiVR integrated into a mobile phone. The first scenario was presented with still images, which introduced a MobiVR usage situation where the user investigated the timetables for buses while waiting at the bus stop. The second scenario had two colleagues meeting in the café and checking information on a forthcoming event (Figure 2).

Figure 2. Scenario of checking details of a forthcoming event from the Internet using MobiVR integrated into a mobile phone.

A mobile phone as an implementation platform and an Internet browser as an example application were chosen to get the focus to the MobiVR concept and out of the device and application, since members of the focus group were familiar with them. With the scenarios, the focus group participants were strained the main characteristics of MobiVR concept; near-eye display, large virtual display, and natural pointing input method.

4. FOCUS GROUP COMMENTS

The focus group showed great interest and enthusiasm towards the MobiVR. The participants clearly indicated that the idea seemed to solve the crucial problems of small displays and inconvenient input method.

However, during the conversation there came up some doubts concerning the acceptability and usability of the MobiVR, more specifically:

- The possibility of *isolation* from the world around while using a near-eye microdisplay
- The influence of near-eye microdisplay usage on *vision*.
- The social acceptability of the input method – *pointing something invisible.*
- The lack of *discreet* usage possibilities (using MobiVR without indicating it to the surrounding environment).

Raising a mobile device near the eye was initially considered to be a bit strange as users are used to hold devices only on their ear or hand. Covering a part of the face was thought to be a bit unsocial.

In addition the group feared that the usage of mobile device near the eye would cause *isolation* from the surrounding environment. This may, on the other hand, be just an initial resistance similar to seen with Sony Walkmans in late 1970’s when they entered the market. Walkmans, which are now accepted as everyday devices, were also seen as obscurely immersing people into their own aural environment. On the other hand, the focus group thought that the partial isolation, a mobile device near the eye, could be a good way to indicate the user’s status for the people near by. The indication would be similar to the currently used ones, for example holding a mobile device on the ear sends a message that the user is on the phone and should not be disturbed.

The isolation aspect can nevertheless be also approached via the possibilities of semitransparent views: a virtual desktop placed upon the user's view of the real surrounding environment. The transparency is a challenge for the UI design among which for example the digital television application design has struggled.

MobiVR seems to be socially more accepted than using a head-mounted display. Nevertheless, the focus group – reluctant to carry any extra weight (phone, calendar, wallet) - considered the possibility of separate dataglasses instead of self-contained mobile device. Most of the users ended up with a reluctant feeling towards the idea of dataglasses and wearable computing, which is supported also by former studies.

The focus group discussed also some issues related to the user's *vision*. The group wondered about the adaptation needed from the eye to change the focus from one view to another (one provided by the MobiVR and the other of the real world), and whether the long-term usage would damage vision, even though MobiVR is intended only for very short tasks.

The input method of MobiVR, *pointing something invisible* in the airspace in front of the user, seemed at first little obscure to the focus group. However, they almost immediately noted that people are already – due to hands-free option of mobile phones - used to people talking with themselves on the streets.

Another natural input method was suggested due to the users' wish that they would not need both hands to operate MobiVR. The group had an idea of tracking eye movements and applying a relatively long gaze as mouse click. The group also considered text-input via gaze and Dasher [1] type zooming interface, even tough they agreed that controlling eye movement can be somewhat stressful as for example the user might fear that gazing some object may cause a mouse click even though the user have just wanted to stop to think for a while.

Another problem with input of the MobiVR was, according to the group, the lack of tactile feedback and the necessity of visual feedback. These aspects make the discreet or "hidden" usage quite impossible.

The group agreed that some sort of virtual display is the only reasonable way to increase the size of the display mobile devices.

5. CONCLUSIONS AND DISCUSSION

The small display and difficult input are major problems in current and especially in future hand-held devices. The MobiVR concept derives largely from VR, but gives it a new form and context, which is more suitable for mobile computing.

The physical infrastructure for the MobiVR concept will soon become a part of many appliances anyway, imposing no extra hardware, weight, or cost.

The idea seems to be very interesting and relevant for mobile devices. It may be a viable solution to the real issue on how to have a decent sized display and an easy way of inputting data and checking information on a pocket-sized device. The invention is fully compatible with WIMP, featuring also a smooth transition path to many post-WIMP user interfaces like augmented reality and virtual reality.

Usability studies for the system are very important and interesting to find out about task performance, user acceptance, and possible technical and usability shortfalls. According to this focus group study, the MobiVR concept seems to fit to mobile or relatively short tasks. It can be seen to benefit all the desirable application areas of the focus group. The large display makes it possible for example to increase the alternative messaging formats (*communication)* and access data e.g., in the Web easily (*information management*). The natural and easy input enables free input in at least two dimensions, which can be used for example for the scribbling in the calendar (*control of everyday life)*.

Clearly MobiVR is not suitable for all uses or users. For example collaborative use is not possible, because display view cannot be shared. In addition, the actual typing via virtual keyboard without tactile feedback can be slow and impractical. Also some notice has to be given to studies of headmounted microdisplays, which indicate that operating some tasks, such as stereoscopic game playing, may cause nausea [2]. Despite these disadvantages, MobiVR enables new UI design possibilities by which good usability of mobile computing solutions and applications can be achieved.

The user requirements for mobile computing are extremely complex, and therefore the design for usable UI is challenging. The first focus group comments confirm that the MobiVR concept is intriguing and worth further studies. Thus this focus group session will be followed by other sessions with other user groups (e.g. teenaged users). In addition full usability tests will be carried out with the MobiVR prototype.

6. ACKNOWLEDGMENTS

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7. REFERENCES

[1] The Dasher project. Cambridge, Cavendish laboratory, The inference group. http://www.inference.phy.cam.ac.uk/dasher/

[2] Häkkinen, J., Vuori, T. & Puhakka, M., Postural Stability and Sickness Symptoms after HMD Use. IEEE International Conference on Systems, Man and Cybernetics, Oct 6-9, 2002.

[3] Marcus, A., Babyface Design for Mobile Devices and the Web. Proceedings (Vol. 2) of the Human-Computer Interface International (HCII) Conference, New Orleans, LA, USA, Aug 5-10, 2001. 514-518.

[4] McLaughlin Consulting Group. Market Overview: Projection and Microdisplays. (April 2001). http://mcgweb.com/presentations/USDC.htm

[5] Rakkolainen, I., MobiVR - A Novel User Interface Concept for Mobile Computing. Proceedings of the 4th International Workshop on Mobile Computing (IMC'2003), Rostock, Germany, June 17-18, 2003. 107-112.