The Future of Mobile Device Research in HCI

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ABSTRACT

In this paper, I present four trends that point toward the increasing importance of mobile device research in Human-Computer Interaction (HCI). These trends indicate a future in which the gap between the user and the desktop is even wider than today, mobile devices have proliferated even further in society, and computer use is more intermittent and in a greater variety of contexts than our current user models accommodate. The implications are that mobile devices must be made more accessible to an aging population, they must be designed for "situational impairments" incurred from on-the-go use, they must adopt flexible and rapid input mechanisms, and the models that describe them must be revamped to accommodate mobile use and behavior. There are also opportunities for using mobile devices in computer education and medical care in developing nations, where mobile devices are more common than desktop PCs.

Keywords

Mobile devices, handheld devices, mobile phones, input techniques, interaction techniques, situational impairments, physical impairments, user models, computer education, medical care, developing nations.

INTRODUCTION

The last decade has seen a surge in off-desktop human-computer interaction due to the prolific spread of mobile technologies. Such technologies include PDAs, handheld communicators, pocket music players, two-way pagers, digital cameras, smart watches, GPS units, medical and factory devices, and mobile phones. There are also numerous hybrid devices that combine two or more of these devices into a single unit. Along with the advent of these devices has come a flurry of HCI research on topics including mobile input techniques [10], handheld web browsing [9,20], adaptive mobile interfaces [14], interfaces that span from devices to desktops [13], sensing devices [4], and many new mobile applications [7]. Thus far, mobile HCI research has focused mainly on the devices

themselves: how to accommodate small screens, how to make devices smarter, how to design faster input mechanisms, how to establish more reliable communications, etc. In ten years, we have quickly reached the point where we can no longer afford to consider devices in isolation, but must take into account the larger social and contextual factors surrounding mobile device use. Like the early '90s that saw desktop-based HCI go beyond the GUI, we must take mobile HCI research beyond the device itself.

I see four important trends in society and technology that have direct consequences for mobile HCI: (1) the overall aging of the population; (2) the increasing amount of personal computing done away from the desktop; (3) the increasing capabilities of ever-smaller devices; and, perhaps most importantly, (4) the convergence of computing capabilities onto the mobile phone. Taken together, these trends require that the future of mobile HCI research be one which considers *context* as much as *capability*.

In the sections that follow, I discuss these trends and their implications for research, giving examples of projects that would capitalize on them. Then I discuss my own research in related areas, and finally draw some conclusions.

IMPROVING MOBILE DEVICE ACCESSIBILITY

Trend #1: The overall aging of the population.

The current population of the United States is 296.5 million people. By 2050, this number is projected to swell to 419.9 million [15], an increase of nearly 42% in only 45 years. Of the current population, 12% are aged 65 or over,[1] and this number is projected to reach 20% by just 2030 [8]. Europe is also aging. The percent of people aged 65 or over is projected to reach 23.5% by 2030, up from just 14.7% in 2000 [8]. Also consider that the average life expectancy for American males is 75 years, and for females it is 80 years. Life expectancy in Canada is even slightly higher. Clearly, the elderly are fast becoming a crucial demographic to consider, and one for whom current mobile interfaces may not be suitable.

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[1]For comparison, Canada currently has 13% of its population aged 65+. Japan is the world's highest at 20%. Europe as a whole is 16%, whereas Africa is just 3% [8].

In particular, the rapid aging of the population has implications for mobile device accessibility. As people age, they incur various impairments including loss of visual acuity, strength, fine motor control and coordination, and pain in the fingers, wrists, or other joints (e.g. due to arthritis). These impairments are particularly problematic for operating mobile devices, since devices' shrunken form factors, miniature buttons, small fonts, postage-stamp screens, and low pixel counts make even able-bodied use difficult. As the baby boomers give way to Generation X, people who grew up with mobile devices and are accustomed to using them will be increasingly challenged to do so unless devices are made more accessible. Although there have been numerous efforts at making desktop computers accessible, there have been almost no efforts to improve mobile device accessibility. (Recent exceptions are [1,22].) The infamous Digital Divide, a sad but real concept that loomed large in conversations of the Internet in the '90s, now threatens to be prominent again unless device manufacturers, interaction designers, and assistive technologists can make mobile devices accessible to people with physical disabilities.

A major challenge, however, is that the approaches traditionally taken to improve desktop accessibility are not likely to work on mobile devices. A main difference, of course, is that interaction with a desktop PC is mediated by the mouse and the keyboard, neither of which exist on a mobile device. Thus, the approach of *emulating* input devices with accessible hardware or software, like mouse or keyboard emulators do, will probably not work on mobile devices. Since mobile device interaction is with the fingers or a pen, it is more direct than interaction with a desktop PC, and therefore more difficult to emulate. Thus, new approaches to providing accessibility are required.

A promising aspect of research in this area is that it stands to improve the design of mobile devices for *everyone*, not just for those with physical impairments [19]. This is particularly important for mobile devices because, as I will argue in the next section, all users incur impairments of some kind when using mobile devices on-the-go.

RESPONDING TO SITUATIONAL IMPAIRMENTS
Trend #2: The increasing amount of personal computing done away from the desktop.

As mobile devices permeate our lives, greater opportunities exist for interacting with computers away from the desktop. But the contexts of mobile device use are far more varied, and potentially compromised, than the contexts in which we interact with desktop computers. For example, a person using a mobile device on the beach in San Diego may struggle to read the device's screen due to glare caused by bright sunlight, while a user on an icy sidewalk in Pittsburgh may have gloves on and be unable to accurately press keys or extract a stylus. By comparison, the differences between these people's desktop experiences would almost certainly not be so dramatic.

These observations suggest that we need to better understand *situationally-induced impairments and disabilities (SIIDs)* [17,18], or "situational impairments" for short. For example, although situational impairments have been mentioned in the literature, to my knowledge no studies have been conducted to find out how input techniques are affected by the act of walking. (A related exception was a study of text *reading* while walking [12].) Our models of users and empirical user tests are mainly geared toward unimpaired desktop use in a laboratory setting. Thus, our understanding of situational impairments is in its infancy, and more research in this area is needed.

Once situational impairments are better understood, it would be useful and interesting to discover whether physical impairments and situational impairments affect users in similar ways. For example, does a user with poor vision face similar challenges as a user dealing with glare? Is a user whose fingers are inflamed due to arthritis similar to a user whose fingers are very cold? Is a user with tremor similar to a user who is trying to write while walking? Depending on the answers to these questions, certain designs may be able to benefit large numbers of users, and designs successful for one user group may transfer with minimal refinement to another.

Ultimately, it should be feasible to construct devices and interfaces that automatically adjust themselves to better accommodate situational impairments. This kind of sensing and adaptation is in the spirit of the work begun by Hinckley et al. [4] but is taken further to specifically address situational impairments. A device could sense environmental factors like glare, light levels, temperature, walking speed, gloves, ambient noise—perhaps even user attention and distraction—and adjust its displays and input mechanisms accordingly. For example, imagine a device that is aware of cold temperatures, low light levels, and a user who is walking and wearing gloves. The device could automatically adjust its contrast, turn on its backlight, and enlarge its font and soft buttons so as to make the use of a stylus unnecessary. If it detects street noise it could raise the volume of its speakers or go into vibration mode. In short, understanding situational impairments presents us with opportunities for better user models, improved accessibility, and adaptive user interfaces.

UBI-INPUT: LEARN ONCE, WRITE ANYWHERE
Trend #3: The increasing capabilities of ever-smaller devices.

With the advent of so many new devices, it can be frustrating to learn new input techniques when encountering each new device. For instance, on the Palm PDA we had Graffiti. Then it became Graffiti 2. PocketPC devices use Jot. Then there are two-way pagers, like the *Glenayre Access Link II* (http://www.glenayre.com), which uses four directional arrows and a SELECT key. On the iPod, we have a scroll ring but no text entry, a feature wished for by many "power users" who have tens of thousands of mp3s and

want to search them or at least jump quickly down long lists using "type ahead." Mobile phones offer a variety of methods, most commonly *Multitap* and *T9*. Users familiar with the former often find it awkward at first to use the latter. The input techniques on digital cameras are lacking even more, and tagging photos for later organization, search, and retrieval is a nightmare at best and impossible at worst.

The input landscape only threatens to grow more varied as new devices emerge. Furthermore, formerly non-computerized devices are now being imbued with computing power. Many of them will need at least minimal input capabilities. For example, wrist watches, which were commonly mechanical devices, may now be full-fledged PDAs, like the Fossil Wrist PDA (http://www.fossil.com). In the future, even simple items like credit cards may be able to accept a password, display a balance or credit limit, or even read our thumbprints. Such devices may therefore require some basic form of input.

But few people want to learn a new input technique for every new device they acquire. We therefore need input techniques that are capable of being used on multiple devices and with a variety of input mechanisms or sensors: so-called "ubi-input." These techniques must remain consistent in the conceptual models they present to the user so that people can "learn once, write anywhere." Examples of text entry methods that can be used on a variety of devices include MDITIM [6] and EdgeWrite [21]. If we are to take advantage of the trend of growing device capabilities, we will have to design more powerful input techniques for humans to utilize on virtually any device or off-desktop platform.

EDUCATION & MEDICINE ON MOBILE PHONES
Trend #4: The convergence of computing capabilities onto the mobile phone.

Mobile phones are by far the dominant mobile platform. More than 15 billion SMS messages were sent every month in Europe in 2004 [3]. And Africa is now the world's fastest growing mobile phone market at 65% per year [2]. In fact, there are more people in Africa using mobile phones than using conventional landline phones.

The explosive growth of mobile phone use in both industrialized and developing nations has yet to be fully exploited by HCI researchers. Mobile phones still suffer from tedious input techniques, poor form factors [5], low resolution, unreadable fonts, and confusing user interfaces. Besides improving these problems, however, is the opportunity for HCI researchers to rethink computing on an entirely new platform apart from the desktop.

A venue for which this "rethinking" may be particularly appropriate is Africa. With the proliferation of mobile phones, African students may have opportunities for computerized education for the first time in their lives. How can mobile phones be used for education in classrooms

whose students have never seen a desktop PC? What kinds of phone-based applications could be developed to help kids learn math, science, writing, or reading? How might the teacher interact with a classroom full of students with mobile phones? The opportunities for voice I/O and for short-range networks might enable new educational opportunities in classrooms across Africa.

Another potential benefit of mobile phones in Africa is for the delivery of medical and health information, particularly to rural areas. Volunteer physicians could use phones to store and retrieve medical histories without needing to have bulky, power-hungry laptops on hand. Also, Africans in rural areas whose phones have connectivity may be able to gain information about symptoms and their treatments, enabling better informed diagnosis and treatment.

There are undoubtedly myriad ways in which mobile phones could be used as the primary computing platforms in 21st century Africa. Microsoft has highlighted this opportunity with a $1.2 million funding offer for related projects [11]. But research will have to be conducted that involves experts across the HCI spectrum, from anthropology to interaction designers to usability engineers. The social, economic, educational, and medical issues will have to be understood before software can be written or user interfaces designed. This is a large task but the potential benefits to Africans and the computing disciplines could be enormous.

MY OWN WORK ON MOBILE INPUT & INTERACTION
I have worked on two projects that are relevant to the issues raised in this paper. First, I noticed how abysmal handheld web browsing could be on a PocketPC device, and decided to redesign the handheld web browser with new interaction techniques. These techniques were embodied in a prototype called *WebThumb* [20], which featured techniques such as picking apart page elements for retention and reuse, using the directional pad to "break apart" dense columns of links, and using rapid serial visual presentation (RSVP) [16] to intelligently "play" text in place for reading. This paper was early in a line of papers on improving handheld web browsing through interaction techniques (e.g. [9]).

My most recent work has focused on making handheld input more accessible through the development of the *EdgeWrite* input technique [22]. EdgeWrite uses a plastic template with a square hole to provide stability for a stylus as it moves along the edges and into the corners of the square in patterns reminiscent of hand-printed letters. EdgeWrite was over 18% more accurate than Graffiti for able-bodied novices, and 200-400% more accurate for people with moderate tremor caused by Cerebral Palsy, Muscular Dystrophy, and Parkinson's. In addition, EdgeWrite has proved versatile enough to be adapted to a variety of input devices while presenting the same alphabet and conceptual model to its users [21]. Versions of EdgeWrite exist for PDAs, joysticks, touchpads, trackballs, buttons, watches, and mobile phones.

CONCLUSION

Important trends are underway concerning the proliferation and use of mobile devices. Although we will have the desktop computer with us for many years to come, mobile devices represent an even larger portion of the future of HCI. New research opportunities exist for improving mobile device accessibility; understanding, sensing, and responding to situational impairments; inventing new input techniques that can be used across multiple devices; and deploying new applications for education and medicine in developing nations. These exciting efforts await researchers skilled in mobile HCI and in meeting the needs of real users.

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