User Interface Design for a Wearable Field Computer

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INTRODUCTION

Project Battuta, a joint Digital Government Initiative project being conducted by Iowa State University and the University of California, Santa Barbara, has been working on integrating heterogeneous geospatial information resources using flexible architectures for adaptive data collection in mobile environments (Nusser et al., 1999). One of our mobile computing environment is a prototype wearable computer, under development at UCSB. Version 2 of this system is now being developed, including two new components: (1) a mobile internet connection and (2) a prototype graphical user interface. It is our goal to implement the GUI, and then conduct users tests to investigate the preferred display types, modes, and interactions necessary for effective use the system in the field. This poster presents some early results and design decisions.

In the wearable computer paradigm, the computer is contained in the user's clothing, and the input and output devices interact with the normal motions and senses of the human body, including normal vision. As such, wearable computers offer two great field use advantages. First, the system can present a field user user with cartographic information in real time. When this information is placed into the vision field, it is a form of augmented reality. Secondly, the system can take advantage of distributed networks to retrieve map and image data for display based on the position of the user. This location-basis for information selection and retreival is the most basic, and maybe the most powerful form of context awareness for ubiquitous computing.

Literature on wearable and mobile computing dates back less than a decade (Gold, 1993). Several technology surveys have considered the field, and a series of conferences has been held to assist progress in the area, including *the International Symposium on Wearable Computers* (http://iswc.gatech.edu/). A comprehensive bibliography covering the early meetings, and a host of workshops and seminars is available at the University of Lancaster in the UK (Lancaster University, 1996), and the history is summarized as a timeline at the Massachusetts Institute of Technology (MIT, 1999). Much research on ubiquitous computers is available, with a literature guide at http:// www.hitl.washington.edu/projects/knowledge_base/wearable.html. Most work examines the perception and measurement of context awareness, that is what a wearable user can detect within the real and virtual environment. Azuma (1997) surveyed augmented reality applications. Billingshurst (1998) and Beadle et al. (1997) have surveyed locational applications. Clark (1996) has considered user interface design issues. Most wearable applications are found in the realms of industrial process control and in medical support.

We are researching what sorts of user interfaces work best with ubiquitous geospatial information systems. Obviously, the normal set of input and output devices have to be rethought for ubiquitous systems (Clarke, 1999a). A proposed approach is the VISIO interface standing for Voice-In, Sound and Images Out (Clarke, 1999b). Most ubiquitous systems have either small keyboards or none at all, relying heavily on voice and positioning input. Also forming input devices are head trackers, GPS devices and range finders (Clarke, 1999a). Sound as output has been exploited most heavily by the Personal Guidance System (Golledge et al., 1998), where stereo sound is used to indicate direction. No major GIS yet fully incorporates sound input or output, although research has started on this topic outside of the field (Barrass and Kramer, 1999; Krygier, 1994). Coupling with in-vision displays, particularly the augmented reality displays, with the new range of inputs offers some significant user interface design challenges. To approach these problems, the Battuta project has built and is testing a wearable computer for mapping.

THE UCSB WEARABLE MAPPING SYSTEM

A set of design goals for wearable computing systems includes that they should be lightweight, as small as possible, unobtrusive and discreet, ergonomically sound and comfortable, power-efficient, robust, and inexpensive. Several off-the-shelf wearable computers are now available, and they are a good choice for people who want to avoid the expense, effort, and time involved in building their own, but they have made trade-offs between application and cost. A more creative and customized solution for a wearable computeris to use a commercially available developer kit. The UCSB wearable computer uses the CharmIT™ kit, built on the PC/104 specification, an industry standard for embedded computing for nearly ten years. The PC/104+ configuration evolved as an extension and includes a second 32 bit PCI-based bus. The boards tend to be around 3.6” x 3.8” x 0.9” with connectors that allow stacking up or across. Many companies manufacture a wide variety of PC/104 add-ons including cards for CPU, Ethernet, PCMCIA, Flash Disk, and GPS. Our CharmIT™ consisted of a Jumptec Pentium 266 Mhz core board, an on-board 10/100 Ethernet, USB and SVGA, PCMCIA cards, power conversion/distribution board, two Sony NP-F960 batteries with approximately 5.5 hours runtime each, a customizable, lightweight aluminum case, and cables and connectors.

Input and output devices were added to the core system. For text input, we use the Twiddler2, a one-handed keyer. With only 18 keys, the Twiddler2 keyboard is designed to perform all functions of a full, 101-key keyboard by “chording”. Just like playing a musical instrument, this requires the user to press multiple keys to produce specific letters and numbers. It takes some time to become proficient, but with practice the user can reach 35 words-per-minute. Despite the learning curve, the Twiddler2 has the unique advantage of leaving one hand free while typing, and it does not require a device driver. A thumb-driven mouse is included. We are now investigating alternatives to the Twiddler, and some are illustated on the poster.

The primary output device is a miniature visual display. As display products became smaller and the increased information content was compressed, the demands on the display size and resolution increased dramatically. On a handheld display with a typical width of 5-10 mm, the pixels for SVGA (Super Video Graphics Array) resolution cannot be resolved by the human eye. This means that additional pixels, the power involved in processing and presenting the information, and the additional cost for the device are wasted. The UCSB wearable system therefore chose a MicroOptical display. The company offers two color monocular (320x240) displays, a clip-on display and an integrated eyeglass display that magnifies the image displayed and, therefore, provides for a range of resolutions. The eyepiece of the clip-on display is suspended from a clear support and provides minimum occlusion by allowing a vision around all four sides of the virtual image. The display clips onto the user's eyewear frame and allows the user to wear prescription or other preferred eyewear, whereas the integrated system, being a complete eyewear system, may require a custom fit. The integrated system is the least obtrusive, but because the clip-on version is more flexible, we decided to exploit a clip-on version in our prototype system and leave the integrated approach for future consideration, but are now working on the integrated alternative.

Power management is a one of the most crucial considerations when designing a wearable system. The power consumption of a system depends on many factors, including system capacity, the operating system employed, board and modules used, and the physical environment that the unit is exposed to. There is a trade-off between the size, weight and power capacity of a battery. Rechargeable lithium ion batteries are have been the standard for wearable systems. Environmental energy sources may replace batteries in wearable subsystems and some innovative altenative sources are envisioned. Storage devices for wearable systems are magnetic hard drives, PCMCIA hard drives, flash memory, and external storage such as a USB hard drive. The clothing industry has accepted the goal to integrate computers into washable vests, coats, jewelry, and accessories. Fabrics used for clothing can mix conductive fibers and regular fabric and can be fashioned to suite wearable systems. When positional devices are considered, ubiquitous mobile networking offers many new possibilities for GPS technology. Because of the future requirement for cell phone companies to be able to physically locate callers to 911, and because of GPS receiver miniaturization, GPS receivers are expected in mainstream cell phones in the very near future. This development suits wearable design and this tendency is reflected in several GPS receivers and embedded GPS modules. Integrated GPS units make it unnecessary to carry an external antenna. Since selective availability has been disabled, the accuracy of civilian-class GPS is adequate for most sea and land navigation, and a differential receiver might be needed only for special applications. To provide better orientation in space, the UCSB system uses a fluxgate compass with three-dimensional amplified sensing capability, and measures the users view roll, pitch and yaw continuously.

In summary, the UCSB wearable computer supports both text and GPS input, and augmented reality visual output. Other communications for both data input and forms output are driven using mobile cellular connections to the world wide web via cellular telephonic connections. Thus the user can know exactly where they are in geographic space, and can interact with and report spatial and attribute information in real time.

THE USER INTERFACE

Most GIS applications have been designed for desktop use and do not meet the needs for wearable use. The desktop GUI is based on the WIMP (Window Icon Menu Pointer) metaphor and assumes that interaction with the computer is the primary task. In contrast, the user of wearable computer applications is most likely distracted by the environment, and the operation of the computer is not necessarily the primary task because the user is doing something else besides interacting with the computer. Some designs for the mobile ubiquitous GIS user interface are feature frames, three dimensional glyphs, text feature annotation, monochrome feature filters, feature location identification and selection, Internet linkage, haloing, and pointer and navigation aids and mechanisms. We illustrate some of these concepts.

Navigation can also be significantly enhanced through augmented reality. Users can be pointed to locations, or naviagtional indicators such as magic carpets and floating arrows can be used as aids. Even a disoriented user can be simply pointed towards the correct target. Similarly, locations can be linked directly to web-based information via web hotlinks.

CONCLUSION

High mobility and wearable computing constitute a new paradigm for field computing. User interface design is critical, yet current research has little to guide this new field of research. When map creation and use are synonomous, many tried and trusted principles of cartographic design fail. Project Batutta hopes to provide the first advances in the new field of wearable computer mapping, and to demonstrate the utility with the project prototype wearable system.

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