User–Centered Mobile Computing

Dean Mohamedally
City University London, UK

Panayiotis Zaphiris
City University London, UK

Helen Petrie
City University London, UK

INTRODUCTION

Mobile computing and wireless communications continue to change the way in which we perceive our lifestyles and habits. Through an extensive literature review of state-of-the-art human-computer interaction issues in mobile computing (Mobile HCI), we examine recent pertinent case studies that attempt to provide practical mobile capabilities to users. We thus contribute to the reader a primer to the philosophy of developing mobile systems for user centred design.

User centred design elicits the needs and requirements of end users. Its purpose in mobile systems is to enable useful computing and communicating experiences for diverse types of users, anywhere at anytime and on demand. We shall therefore illustrate to the reader some of the key constraints of mobile devices such as limited visuals, contextual awareness and mobility itself, and more importantly how they can be overcome through innovative design and development.

INFORMATION VISUALISATION

One of the most fundamental objectives in the miniaturisation of computer technologies is to present a platform from which users can maintain usable levels of interaction with their data from wherever they are. Information visualisation has come a long way since the days of two-colour text-only format screens. Yet constraints determined by factors of physical engineering feasibility, such as screen quality and resolution, battery longevity and network capa-

bilities, give us a particularly popular arena for exploration in mobile HCI research.

Such constraints are being addressed in a number of novel interfaces, such as Electronic Ink-based screens (E-Ink, 2004) that have a high resolution similar to that of natural paper, have low power requirements, and will eventually be capable of being rolled up for storage. TabletPCs (Microsoft, 2003) have the capability to use ultra-low powered pressure-sensitive pen input devices to elicit the amount of pressure incurred and also capture motion gestures on a visual interactive user interface, creating a sense of depth perception visualisation. They also enable very distinctive handwriting recognition without the need for learning preset handwriting letter shapes.

The Rapid Serial Visual Presentation (RSVP) concept (Bruijin, Spence, & Chong, 2001; Goldstein, Oqvist, Bayat-M, Ljungstrand, & Bjork, 2001) is one of many research investigations into methods of presentation of information on a small screen (Jones, Buchanan, & Thimbleby, 2002). By the beginning of 2001, over 88 million WAP (Wireless Access Protocol) hits on mobile phone screens were made in the UK alone (WAP Forum, 2003), and therefore significant effort has been undertaken on design factors of WAP site browsing globally.

LOCATION AND GEOGRAPHIC AWARENESS

Much of the research in geographic and location aware mobile systems correlate with mixing user requirements in information visualisation with geographic sensors. For example, audio user interfaces

for Global Positioning Satellites (GPS) receivers have typically been designed to meet the needs of visually handicapped users by giving audible signals as they travel past real-world coordinates that have been pre-designated in their system.

The proliferation of GPS-based location services has seen an impressive array of uses for location awareness in mobile deployment activities. They are now becoming an embedded part of upcoming generations of mobile phones and smart personal devices in mass consumer products. Examples include experimental tourist guides (Cheverst, Mitchell, & Davies, 2001; Davies, Mitchell, Cheverst, & Blair, 1998), navigation systems for disabled and elderly people (Holland & Morse, 2001; Petrie, Furner, & Strothotte, 1998), and also in location aware collaborative systems (Rist, 1999).

Close range location awareness technologies include Bluetooth (1998) based and RFID—Radio Frequency Identification (2003) based devices with which broadcast points can beam radio data to compatible handheld receivers. The results of current research in this domain is leading to opportunities in a variety of user scenarios that are made aware of your unique presence, for example, walking into a personally aware room will turn on the lights at your chosen settings, or location enabled advertising billboards will be able to read your public profile and communicate suitable electronic media to you wirelessly.

CONTEXTUAL AWARENESS

An issue in HCI research is investigating models and scenarios for maintaining consistency between the user's understanding of their environment, the understanding of the environment reported by the system and the actual state of the environment. Context-aware systems have to react not only to the user's input but also input (i.e., context) from the user's environment (Brown, Bovey, & Chen, 1997; Schilit, Adams, & Want, 1994). This offers opportunities for helping people to accomplish their goals effectively by understanding the value of information.

A realisation in this domain involves a specifically mobile systems orientated question—do we push the contextual information into the mobile system as they move within monitored zones or pull it on demand at their request? One of the challenges in context aware-

ness is discovering computing services and resources available in the user's current environment, utilising discovery protocols such as Jini (2001) and SDP by Czerwinski, Zhao, Hodes, Joseph, and Katz (1999).

SENSORY-AIDED MOBILE COMPUTING

Mobile HCI has also changed the nature of computing for the demographics of users that have sensory disabilities, or alternatively require sensory enhancement. A low visibility prototype with supplemented tactile cues is presented in Sokoler, Nelson, and Pedersen (2002) with the TactGuide prototype. This is operated by subtle tactile inspection and designed to complement the use of our visual, auditory and kinesthetic senses in the process of way finding. It was found to successfully supplement existing way finding abilities. A mobile system that lets a blind person use a common laser pointer as a replacement of the cane in demonstrated by Fontana, Fuiello, Gobbi, Murino, Rocchesso, Sartor, and Panuccio (2002), who presented an electronic travel aid device that enables blind individuals to "see the world with their ears." A wearable prototype was constructed using low-cost hardware with the ability to detect the light spot produced by the laser pointer. It would then compute its angular position and depth, and generate a correspondent sound providing the auditory cues for the perception of the position and distance of the pointed surface. Another wearable system for blind users to aid in navigation is presented by Petrie et al. (1998), which projects a simple visual image in tactile form on the back or stomach.

Aside from aiding those disabilities it should be noted that sensory enhancement is an area for particular growth in Mobile HCI. Mobile systems that can augment the senses such as vision with heat and electrical sensors and sonic receivers are all ideas that can be investigated with undoubtedly a wide arena of scenarios.

COLLABORATIVE SYSTEMS

Mobile systems in general are becoming refined as instruments for co-operative wireless computing com-

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