The eSleeve: A Novel Wearable Computer Configuration for the Discovery of Situated Information*

Cliff Randell Henk L. Muller
Department of Computer Science, University of Bristol, U.K.
cliff/henkm@cs.bris.ac.uk

Abstract

This paper describes work in progress on wearable computing configurations which provide audio and visual output based on the position and orientation of the user. We introduce the 'eSleeve' - a wearable wrist computer with position and heading sensors combined with a user interface employing speech recognition and a small display.

Applications described include searching a database of locations, and implementing a minimal augmented reality system. The effectiveness of different approaches at conveying location based information is discussed and we also describe our continuing research into position based audio and visual interfaces.

***Keywords** - wearable computer, architecture, augmented reality, location sensing, GPS, compass, speech recognition.*

1 Introduction and Background

The Bristol Wearable Computing project is part of an interdisciplinary research initiative - Equator - which aims to promote the integration of the physical with the digital by uncovering, and supporting, a variety of possible relationships between physical and digital worlds [1]. The Equator challenge brings together researchers from eight U.K. Universities who are working on a variety of projects that draw together approaches from computer science, social science, cognitive science and art and design. Wearable computing provides an ideal platform for developing and testing related applications that may be suitable for widespread use without the costs associated with prototyping miniaturised electronic devices with embedded computers.

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We are particularly interested in the presentation of information which is linked to physical locations [2]. Our early work associated web pages with GPS positions and experiments were carried out with applications such as tourist guides [3]. More recently we have become interested in displays which are dynamically linked to the user's position and orientation.

Mobile and wearable computers which are able to access situated digital information have the potential to display physical and digital artefacts. We believe that such devices will create new forms of play and entertainment; promote learning, participation and creativity; and support activities both inside and outside of the workplace, including maintaining family and social relationships. Previous work in this field has used tablet and palmtop computers [4, 5], and map based applications for laptops and palmtops are becoming available commercially [6].

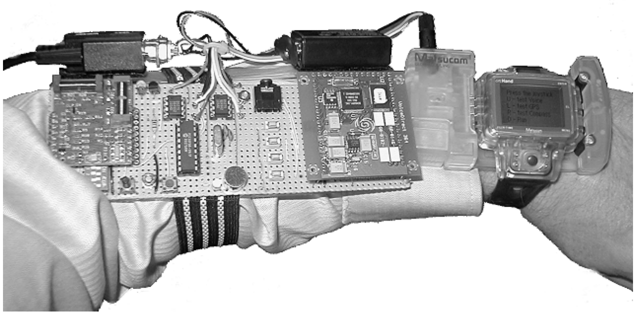

Figure 1. The eSleeve.

We describe research using a smaller, and wearable platform, the Matsucom onHandPC. This research has contributed significantly to the design of our current wearable infrastrucure. The onHandPC is a wristwatch computer with a 16bit 3.6MHz CPU running a DOS operating system, 2MB flash memory, 102x64 pixel screen, and a RS232 serial interface that enables contextual data to be gathered from devices such as a GPS receiver, an electronic compass and a speech recognition module - we call this the 'eSleeve' - see Figure 1.

Using these devices we have tested applications which require small databases and graphics, as well as investigating the potential of a user interface that combines speech input and visual output in an arm-mounted form factor.

2 The eSleeve

Our intention is to experiment with displays which are more intuitive than simple 2D maps. Full Augmented Reality (AR) was considered to be beyond the scope of this project, however similar principles to those required for AR needed to be applied. Sensors were thus initially selected by considering the need for each of the usual six degrees of freedom. We assume that the user is either sitting or standing on the ground; is upright (not leaning to either side); and is looking ahead. The eSleeve design encourages the user to adopt an appropriate attitude. Consequently we need only deal with three degrees of freedom - position (x,y) and direction of view or heading. This data can easily be collected using a GPS receiver and an electronic compass.

The user interface employs speech for menu-based control commands, and the watch-sized display capable of providing both text and graphics for the computer output. We also use the onHand PC to produce 'beeps' as a further method of user feedback. Using this configuration we are able to explore the hypothesis that speech with a display may become a preferred interface configuration for mobile devices.

The compass and display are automatically aligned by mounting the compass on the forearm along with the display and speech recognition module. The board-mounted microphone is optimally placed when the arm is raised to view the display. The location of the GPS receiver is less critical, only requiring line of sight to the sky. Upper arm or shoulder mounting were found to be satisfactory solutions.

Previously we have experimented with architectures which have continuously polled sensor devices on a number of communication ports. This approach proved to be power hungry and we subsequently designed, and simulated, an event managed architecture which promised to achieve considerable power savings [7]. The eSleeve afforded the opportunity to carry out a limited test of this architecture - see Figure 2.

The design uses a PIC microcontroller to handle the low level contextual data. The PIC is continuously - and economically - polling for data and events at the request of the main processor. The main processor is used only when an event is generated to handle database queries and for display functions.

Using a complete system which can be worn comfortably on the forearm, we are thus able to compare the effectiveness of several different approaches to providing location related data to the user.

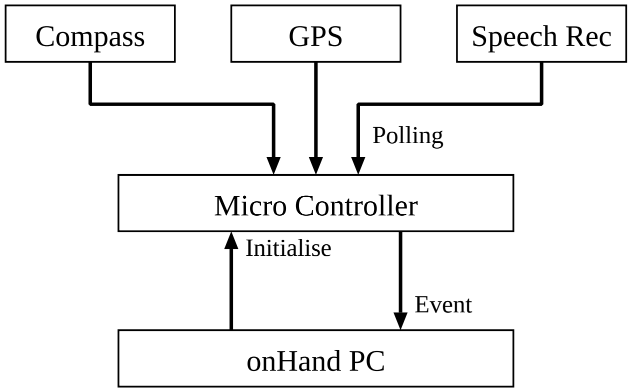

Figure 2. eSleeve Architecture.

3 Applications

The main applications developed for our tests were the PubCrawl/TouristGuide originally prototyped on the Bristol CyberJacket [3]; a simple augmented reality program; and utility functions available on demand, for example 'time' and 'appointments'.

3.1 Pub Crawl

We needed an application which could aid the user in finding locations which were numerous, of everday interest, and could be easily distinguishable using readily available location sensing technology i.e. GPS. We have previously experimented with sites that may be of interest to tourists and while these are worthwhile for occasional use, they are generally not sites that are of everyday interest. The English public house - or pub - is well known as a place that can be visited regularly, and is also frequently used as a point of reference when directions are being given.

The application responds to a user request to 'find pub' by searching the database to find the three nearest pubs. These are displayed along with the distance to the pub, and it's heading - see Figure 3. The user is able to select a pub to see additional information including address and particular features of the pub e.g. beer garden. Additionally the onHandPC can produce a beep whenever the user faces towards the selected pub.

Figure 3. PubCrawl Application.

3.2 Augmented Reality

The advent of wearable computers with sufficient processing power to enable augmented reality applications has already enabled research to be carried out using head mounted displays [8]. The use of such systems brings challenges such as head tracking, minimising latency and handling loss of tracking.

We are interested in the opportunities for the use of augmented reality without using head mounted displays, particularly as there are significant issues associated with the everyday use of such displays [9]. By using an arm mounted display latency becomes less critical and head tracking becomes unnecessary. The separate display encourages the user to intuitively compensate for tilt, skew and height.

A model incorporating the main vertices of significant buildings situated in Bristol City Centre is used. The GPS and heading data make it possible to render the outline faces of the buildings on the onHandPC display as wireframe representations - see Figure 4. Additional useful information is then added to the display giving an augmented reality effect.

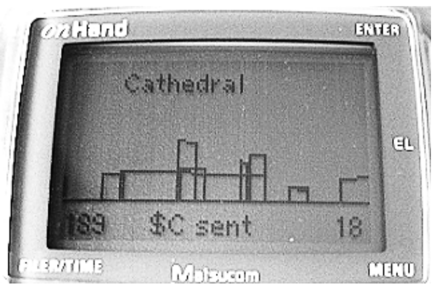

Figure 4. Augmented Reality Display.

4 Results and Continuing Research

The applications chosen demonstrated two significantly different methods of providing location and direction information to users. PubCrawl used a single beep to indicate that the user was heading towards the desired location, whereas the simple augmented reality program guided the user by employing a simple graphics display.

The graphics display is effective when the quality of the model provides sufficient visual cues to identify buildings in addition to any labelling. The model of Bristol Cathedral is thus instantly recognisable, however less intricate buildings, such as an office block, do not have readily identifying characteristics which can be displayed using our wire frame model on the small display. More advanced techniques, such as billboarding, are limited by the processing capability of the onHandPC, and the specification of it's display.

While the GPS accuracy (around 5m CEP, 10m 95% with a clear view of the sky) is perfectly adequate for PubCrawl, problems were experienced with the augmented reality application. In the urban environment used for testing, the user was frequently erroneously positioned by the GPS inside the buildings to be rendered. This problem was overcome by simply not rendering buildings within 15m - if the user was there already, there was no need to direct him further.

Users concluded that the simple message of ‘this is the right direction’ given by the audio beep provided a more effective interface than the augmented reality display. Nevertheless the display was useful for providing textual descriptions of the nearest places of interest.

The other user interface, speech recognition, proved to be somewhat unreliable. We had expected that enviromental noise would interfere with recognition, however in this implementation we found that the user’s intonation played a more significant part. This had the odd effect of the recognition working well when the user was relaxed, but when the user concentrated hard on correct intonation, or if the user became stressed, the recognition performed badly.

The eSleeve form factor was found to be readily accepted by users, and the total integration of the eSleeve into a wristwatch device was considered desirable. The main drawback was the speech interface which at first was found entertaining, but soon became frustrating to use.

Current Research

The work with the eSleeve has developed in two distinct directions. Firstly, the limitations of the onHandPC have been addressed by moving to a H-P Jornada 568 palmtop platform. This provides a 240x320 colour display combined with a StrongARM processor fully capable of 3D graphics. We have interfaced this with an ultrasonic indoor positioning system [10] and electronic compass. Working indoors we are able to experiment more efficiently with different graphics - such as maps, radar-like displays, and field of view. This work is being carried out as part of two of the Equator projects - one working with information in the city e.g. museums, and the other aiding in understanding how children interact with virtual objects in real spaces. The results are now being evaluated with extensive user testing.

Our other line of research builds on the importance of using audio interfaces. We are constructing soundscapes which are located in virtual space and accessed using a wearable computer with differential GPS position sensing and an electronic compass. By using spatialised sound rendering we are able to provide located audio experiences to users in real space. Our partners in this collaboration are Hewlett-Packard Laboratories, Europe, who are interested in the provision of services which are both personalised and localised using wireless technology.

The eSleeve development has thus contributed positively to our current research, and we intend to return to arm-mounted wearable computing when the next generation of wrist computers emerges.

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