

# The eSleeve: An Arm Mounted Wearable Computing System\*

Cliff Randell

Department of Computer Science, University of Bristol, UK. BS6 7SR  
cliff/henkm@cs.bris.ac.uk,

Henk Muller

<http://wearables.cs.bris.ac.uk/>

## Abstract

*We present a wearable computing configuration which incorporates several computing devices mounted on the user's forearm. A user interface employing speech recognition and a small display has been incorporated along with location and heading sensors. Applications described include searching a database of locations, and implementing a minimal augmented reality system. The effectiveness of these different approaches at conveying location based information is discussed.*

## 1 Introduction and Background

With the proliferation of personal computing devices such as mobile phones, the potential for increasingly complex software applications that can be used on a day to day basis away from the desktop is of both academic and commercial interest. Wearable computing provides an ideal platform for developing and testing sophisticated applications that may be suitable for widespread use without the costs associated with prototyping miniaturised electronic devices with embedded computers.

We are interested in applications that can be developed for embedding in minimal platforms such as mobile phones or PDAs. The onHandPC has been chosen as a suitable platform for this research with a 16bit processor, 2MB flash memory and 102x64 pixel screen. It has an RS232 serial interface that enables contextual data to be gathered from devices such as a GPS receiver, electronic compass and speech recognition module.

Using these sensors 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 - the eSleeve.

## 2 Implementation

Sensors were selected by considering the need for each of the possible six degrees of freedom. We assume that the user is standing on the ground; is upright (not leaning to

either side); and is looking ahead. 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.

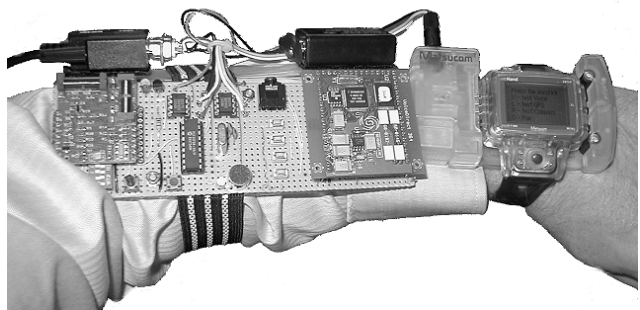


Figure 1. The eSleeve.

Our design uses speech for control (with a limited vocabulary) and a 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 test 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 for viewing the display. The location of the GPS receiver is less critical, only requiring line of sight to the sky. Upper arm, shoulder or belt mounting all proved to be satisfactory solutions.

The architecture 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.

\*This work is performed in collaboration with, and with support from, Hewlett-Packard Research Laboratories, Europe. Funding is also received from EPSRC GR/N 15986

### 3 Applications

The main applications developed for our tests were the PubCrawl/TouristGuide originally prototyped on the Bristol CyberJacket [1]; a simple augmented reality program; and utility functions available on demand e.g. 'time' and 'appointments'.

#### 3.1 Pub Crawl

We needed an application which could aid the user in finding locations which were numerous, of everyday 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 2. 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 on-HandPC produces a beep whenever the user faces towards the selected pub.



Figure 2. 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 [2]. 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 [3]. 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 3. Additional useful information is then added to the display giving an augmented reality effect.

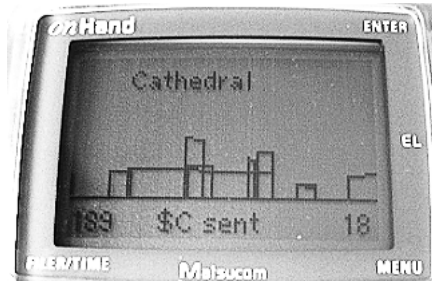


Figure 3. Augmented Reality Display.

### 4 Results and Conclusions

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 the building 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 sophisticated techniques such as billboarding are frustrated by the limited processing capability of the onHandPC.

We concluded that the simple message of 'this is the right direction' given by the audio beep provides a more effective user interface than the augmented reality display. Nevertheless the display was useful for providing descriptions of the nearest pubs. While the use of the onHandPC has provided insights into the uses of minimal augmented reality displays, we are now exploring the possibilities provided by larger handheld displays.

### References

- [1] R. Hull, P. Neaves, and J. Bedford-Roberts. Towards situated computing. In *Proceedings of The First International Symposium on Wearable Computers*, pages 146–153, October 1997.
- [2] S. Feiner, B. MacIntyre, T. Hollerer, and A. Webster. A touring machine: Prototyping 3d mobile augmented reality systems for exploring the urban environment. In *Proceedings of The First International Symposium on Wearable Computers*, pages 74–81, October 1997.
- [3] E. Geelhoed, M. Falahee, and K. Latham. Safety and comfort of eyeglass displays. In *Proceedings of The Second International Symposium on Handheld and Ubiquitous Computing*, pages 236–247, September 2000.