## PART 2: DESCRIPTION OF PROPOSED RESEARCH

### OVERVIEW

Most PDAs and smart phones have sophisticated graphical interfaces and commonly use small keyboards or styli for input. The range of applications and services for such devices is growing all the time. However, there are problems which make interaction difficult when a user is on the move. Much visual attention is needed to operate many of the applications, which may not be available in mobile contexts. Oulasvirta *et al.* [29] showed that attention can become very fragmented for users on the move as it must shift between navigating the environment and the device, making interaction hard. Our own research has shown that performance may drop by more than 20% when users are mobile [4].

Another important issue is that most devices require hands to operate many of the applications. These may not be available if the user is carrying bags, holding on to children or operating machinery, for example. **The novel aspect of this proposal is to reduce the reliance on graphical displays and hands by investigating gesture input from other locations on the body combined with three-dimensional sound for output.**

Little work has gone into making input and control hands-free for mobile users. Speech recognition is still problematic in such settings due to its high processing requirements and the dynamic audio environments in which devices are used. Much of the research on gesture input still uses hands for making the gestures. There is some work on head-based input, often for users with disabilities [26], but little of this has been used in mobile settings. Our own previous work has begun to examine head pointing and showed that it might be a useful way to point and select on the move [3].

Many other body locations could be useful for subtle and discreet input whilst mobile (e.g., users walking or sitting on a bumpy train). For example, wrist rotation has potential for controlling a radial menu as the wrist can be rotated to move a pointer across the menu. It is unobtrusive and could be tracked using the same sensor used for hand pointing gestures (in a watch for example). Small changes in gait are also a possibility for interaction. In previous work [12] we extracted gait information from an accelerometer on a PDA to look at usability errors. We can adapt this technique so that users could slightly change the timing of a step to make input. There has been no systematic study of the different input possibilities across the body. We will develop a novel testing methodology using a Fitts' law analysis along with more subjective measures to find out which body locations are most useful for input on the move.

Output is also a problem due to the load on visual attention when users are mobile. We and others have begun to look at the use of spatialised audio cues for output when mobile as an alternative or complement to graphics [1, 6] [19, 32]. Many of these use very simple 3D audio displays, but, with careful design, spatial audio could provide a much richer display space. Our AudioClouds project built some foundations for 3D audio interactions, investigating basic pointing behaviour, target size and separation [1,3]. We need to now take this work forward and develop more sophisticated interactions. Key aspects here are to develop the use of egocentric (fixed to the user) and exocentric (fixed to the world) displays, and how they can be combined to create a rich 3D display space for interaction. The final key part of this project is to create compelling applications which combine the best of the audio and gestures. We can then test these with users in more realistic settings over longer time periods to fine-tune how these interactions work in the real world.

Therefore, the core aims of the project are to:

- Develop a testing methodology to characterise body locations in terms of their input capabilities;
- Find a set of body locations that can be used for successful unobtrusive and discreet hands-free gestural input and assess them in static and mobile settings;
- Develop sophisticated egocentric and exocentric 3D audio interaction techniques and assess them in baseline static and then mobile settings;
- Combine the best gestures and 3D audio interaction techniques into complete applications to allow evaluation of these novel techniques in realistic settings to assess their real usefulness;
- Develop design guidelines and a toolkit of interaction techniques to help interface designers use the results generated in their own work.

The research team have an excellent track record in this area and are the best placed in the UK to carry out the work. Brewster, Murray-Smith and Crossan have published widely in the areas of audio, gesture and tactile displays for mobile devices [1,3,4,6,7,12]. The team has strong contacts with companies such as Nokia and Samsung for potential commercialisation of results, and Nokia Research Centre (NRC) has agreed to be a partner in the research (contributing equipment and funding). For the project one RA and one RS, equipment and travel for a period of 3 years are requested. The main stages of our work will be to:

- *Year 1:* Develop a testing method to assess the input abilities of different body locations; Investigate different movement sensors; Design egocentric 3D audio interaction techniques and test in both static and mobile settings; Publish papers on results.
- *Year 2:* Investigate different body locations using method from Year 1 in static and mobile settings; Develop gesture recognition algorithms for recognising input at the different locations; Develop exocentric 3D audio interaction techniques; Publish papers on results.
- *Year 3:* Combine the best body locations and audio interaction techniques and evaluate these in a range of applications; Produce final design guidelines and toolkit of interaction techniques; Host workshop to disseminate knowledge gained.