An investigation of multimodal interaction with tactile displays

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PART 2: DESCRIPTION OF PROPOSED RESEARCH

OVERVIEW

The area of haptic (touch-based) human computer interaction has grown rapidly over the last few years. A range of new applications has become possible now that touch can be used as an interaction technique (Wall, et al., 2002). However, most current haptic devices have scant provision for tactile stimulation, being primarily programmable, constrained motion force-feedback devices for kinaesthetic display. The cutaneous (skin-based) component is ignored even though it is a key part of our experience of touch (van Erp, 2002). It is, for example, important for recognising texture, detecting slip, compliance and direction of edges. As Tan (1997) says "In the general area of human-computer interfaces, however, the tactual sense is still underutilised compared with vision and audition". One reason for this is that, until recently, the technology for tactile displays was limited.

Tactile displays are not new but they have not received much attention from HCI researchers as they are often engineering prototypes or designed for very specific applications (Kaczmarek, et al., 1991). They have been used in areas such as tele-operation or displays for blind people to provide sensory substitution – where one sense is used to receive information normally received by another (Kaczmarek, et al.). Most of the development of these devices has taken place in robotics or engineering labs and has focused on the challenges inherent in building low cost, high-resolution devices with realistic size, power and safety performance. Little research has gone into how they might actually be used at the user interface. Research from a human-centred standpoint is needed now to provide strong foundations for the use of this technology, to demonstrate how it can be best used in a range of applications and understand how its use fits with the senses of sight and hearing in a multimodal interface.

The innovative aspect of this research is to open up a new area of study into the cutaneous aspects of haptic human-computer interaction and to investigate a range of tactile displays to improve the whole experience of computer haptics. Results obtained will also drive the engineering of improved tactile displays. The research has two strands: the first is to look at tactile cue design, the second at applications of tactile displays. The main aims of the first strand are to:

- Investigate cutaneous perception through pin arrays, point-contact stimulators and distributed stimulators;
- Compare and combine tactile and kinaesthetic displays;
- Investigate the design of effective tactile cues on the different types of stimulators;
- Create combined tactile/auditory multimodal displays.

Once the work on basic design issues has been done, the knowledge will be applied to the areas of accessibility for blind people and interfaces for mobile/wearable computers. These two important research domains are ones in which tactile displays are likely to have a major impact. One of the main deprivations caused by blindness is the problem of access to information (Edwards, 1995), as much information is contained in pictures, graphs, tables and other visualisations. Tactile displays offer the possibility of another channel through which information can be displayed. The Royal National College for the Blind (RNC) in Hereford will be partners in this research.

Mobile phones, handheld and wearable computers are a growth area in computing. Graphical displays on these devices are small as they must be carried. This makes interface design difficult. Tactile displays have the potential to increase the display area to allow more communication. Demonstrating the effectiveness of tactile displays in these application areas will allow designers in other domains to see where tactile displays could be useful to them.

The research proposed is of key importance to the UK. The Government's Foresight Committee (1999) reports that in the near future the "… richness and diversity of both the input and the output channels will increase - multi-modal input and output will become the norm. The senses of sight, hearing and touch will be seamlessly integrated, and exploited together to maximise the bandwidth of the psychological interface". There is currently very little work in this new topic, therefore research is needed now so that the UK can be at the forefront of work in this area. The impact of this work will be great, given the already high usage of device such as mobile telephones.

Brewster's previous work provides strong foundations from which to develop this new area. He has done key work in the area of multimodal HCI using sound and force-feedback [10, 49, 90]. He has applied these technologies to provide novel solutions in the areas of medical training [21], visualisation for blind people [3] and mobile devices [2]. For the associated research project one RA (Dr Steven Wall), equipment and travel for a period of three years are requested. Progress will be measured against the following deliverables:

- Papers published on results of shape perception with pin arrays;
- Experimental results demonstrating the usability of tactile icons;
- Papers published on tactile displays for mobile and wearable computers;
- Results of experiments demonstrating the combination of tactile and kinaesthetic displays for visualisation for blind people;
- Two workshops conducted, a book published and demonstrator applications developed to disseminate knowledge gained.