Using Tactile Communication to Enhance Awareness in a Distributed Multitouch Game

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BACKGROUND

When people work face-to-face, they use multiple cues like gesture, orientation and visual attention to co-ordinate interaction, maintain awareness and negotiate meaning (e.g. Gutwin and Greenberg, 1998). Tabletop interfaces are often said to support these multiple cues: people are able to see each other across the table; interface manipulations require large movements and so are more visible than when using a mouse; and hands are free to gesture (e.g. Scott et al., 2003). However, there are often multiple breakdowns of awareness, failures of co-ordination and clashes even when working face-to-face and on shared collaborative task (Hornecker et al., 2008).

Figure 1: the blind folded subject (right) tracks the approaching orange ball by sensing its movement as vibration on his abdomen. This demonstration took place at 'Curious', a public engagement event at the University of Sussex, March 2009.

Researchers are also beginning to explore how *remote* tabletop systems can be designed to support collaborative work. In this situation, collaborators work with representations of the same interactive space on different surfaces and it is an even more challenging task to design systems that support effective collaboration. When compared to co-located working, the communication channels of distributed tabletop systems are much more limited. Mechanisms such as shadows showing the movement of a remote collaborator's arm in the shared workspace have been used to facilitate awareness of other's actions and to support deictic reference. While quite successful, there are a number of difficulties inherent in this approach. In particular, Tuddenham and Robinson (2009) describe how interface actions that can be instigated from any part of the interface (such as moving scrolling the background image) cause particular awareness problems, as do actions that rely on action perpendicular to the surface of the table such as double-clicking to bring up a menu; it can also be difficult to communicate using gestures, e.g., pointing to out of reach areas (Pinelle et al, 2008). In the proposed research outlined in this position paper, our goal is to explore the potential of tactile representations to facilitate workspace awareness. In order to do this, we plan to develop "Locust", an engaging collaborative tabletop game that can be played by both co-located and remote players.

SEEING THROUGH THE SKIN

As part of the e-sense project (http://www.esenseproject.org) we are building novel augmentation devices to explore sensory, bodily and cognitive extension (Bird et al, 2008). We have developed a wearable vibrotactile array and initial experiments have demonstrated that vibrations generated by this device can guide behaviour. For example, the system has been used as part of a minimal tactile vision sensory substitution system that maps an image captured by a webcam (either fixed or head-mounted) into vibrotactile stimulation. Initial experiments using a very small array of vibration motors (3x2) demonstrated that blindfolded participants can successfully track a slowly moving ball and indicate whether it is approaching their left or right hand side in a two alternative forced-choice The array now has up to 64 points of stimulation and enables people to track and bat approaching balls (Figure 1). There are details of these experiments in Bird et al (2009).

Our aim in this project is to investigate the potential of vibration to enhance workspace awareness by providing a communicative channel to both remote and co-located individuals playing a collaborative game called "Locust". We are developing software that maps the position and activity of fingers on the work surface to an array of vibration motors positioned on each collaborator's abdomen. Our hypothesis is that actions such as double tapping can be clearly signalled using vibration and sensed even when they are outside of a person's visual field. We also anticipate that participants will use vibrotactile stimuli to communicate simple gestures, such as moving a finger along the table surface to point towards a particular region. A further hypothesis is that using vibrotactile feedback frees the demands placed on vision, enabling people to focus on the task while still being aware of their collaborators' actions in the workspace and consequently leading to increased collaborative task performance.

The design of the vibrotactile feedback is purposefully simple and underspecified. This is in contrast to previous work on tactons (Brewster and Brown 2004). Following Gaver et al (2003), we predict that this ambiguity might encourage a more active participation, which will lead to a deeper understanding and appropriation of the information being represented. We can describe our approach using an evolutionary metaphor: we place people in a dynamic environment (the game), where there are selection pressures that favour the development of communication protocols (the participants' motivation to do well, the necessity for collaboration to succeed and the increasing difficulty of the game) and a clear fitness measure (their level of success at the game). Given these initial conditions, we hope to witness the evolution of communication protocols in the tactile modality by the participants themselves.

THE LOCUST GAME

This is a fast-paced, dynamic game where success requires co-workers to co-ordinate their behaviour. Each player has a region on the tabletop where they can cultivate crops which provide the energy necessary for them to continue in the game. Crops have to be tended with regular finger taps, otherwise they die and the player has to drop out unless another player transfers some food to them by dragging it with their fingers. All might be well in this garden of Eden if it were not for the regular appearance of swarms of boid-like locusts that rapidly move around the table eating crops. The behaviour of these boid-like virtual insects is based on Reynold's (1987) algorithms. There are moveable wall objects scattered around the table that the locusts cannot move through. Players can arrange them to fence off their crops or to herd the locusts and even trap them. Tapping on a locust removes it from the game, but they try and avoid regions where other locusts have recently been squashed, making it difficult to eliminate them one at a time: it is far more effective to trap them inside walls and prevent them from feeding. However, the walls are not abundantly spread around the tabletop: they are a limited resource and there are not sufficient to protect every player's crops. Furthermore, walls do not last forever but deteriorate over time, although new ones do appear from time to time at random locations on the table. We can control the difficulty of the task for the players varying: the size of the locust swarms; the frequency with which the swarms appear; the speed at which locusts move; the complexity of the insects behaviour; the number of walls available to the players; and how long these obstacles last before disappearing from the game area.

The software will record how long the groups survive under different levels of difficulty. It will also log any occasions when a wall or locust is touched by more than one collaborator at the same time: a situation that may indicate a lack of workspace awareness. We will also use video analysis (cf. Hornecker et al., 2008) to measure whether vibrotactile feedback enhances workspace awareness and improves group performance when playing 'Locusts'. We are particularly interested in how players might develop communication protocols using vibrotactile feedback that is directly mapped to the group's finger touches on the tabletop.

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