mobile VCE
: research innovation application :

Thermal Feedback for Mobile Interaction

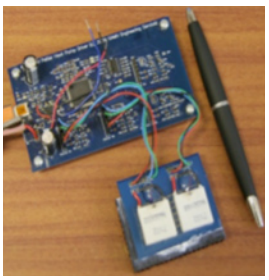
Industry brief

Strategic Business Relevance:

Thermal stimulation is a rich, emotive and salient feedback channel that is well suited to HCI, but one that is yet to be fully investigated. Thermal feedback may be suited to environments that are too loud for audio or too bumpy for vibrotactile feedback. In comparison with other feedback modalities it is also entirely private. Thermal feedback also has an affective element which is not present in other feedback modalities.

Some like it hot? Thermal feedback for mobile devices

Modern mobile devices are almost uniformly moving towards interfaces based on physical interactions such as multitouch and 3D spatial input through gestures. Although the use of haptics has received a lot of attention, this has mostly been through the vibrotactile actuators built into phones. There has been very little work within the field of Human-Computer interaction focussing on other aspects of touch, particularly thermal feedback, which we focus on in this work. Fundamental research needs to be conducted in order to assess the merits of thermal feedback as a practical display method. It is necessary to understand the stimulus characteristics that are most effective for creating effective thermal cues.



Core Research: User Interactions for Breakthrough Services

This research addresses the ways in which users interact with portable and mobile devices (and other devices in their physical and logical environments) in order to enable new types of personalized and highly contextualized services.

The thermal feedback research informs the demonstration prototypes of new user interaction technologies.

Virtual Centre of Excellence in mobile and personal communications

MOBILE VCE

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How well can an individual detect changes in thermal output? Is this affected by mobility?

Industry brief

Some like it hot? Thermal feedback for mobile devices

We have conducted studies into how well users can detect hot and cold stimuli when they are presented to different arm locations. Evaluations were carried out in both static and mobile settings. Thermal perception is influenced by many factors, both internal and external. For our evaluations we chose three of the most important of these factors: *rate-of-change* (ROC; how quickly it warms/ cools), *intensity* (the extent to which it warms or cools) and the *direction* of change (whether it warms or cools). We compared 2 *ROC* (1°C/sec and 3°C/sec), 3 *intensities* (1°C, 3°C and 6°C) and both *directions (warming and cooling)*.

Evaluation

We presented every combination of the stimuli to 4 body locations associated with mobile device interaction (fingertips, base of the thumb, top of the forearm and top of the upper arm) while participants were sitting or walking. The purpose of the evaluations was to identify which stimulus characteristics are the most easily perceivable and comfort-able, with a view to using these in the design of structured thermal icons/notifications.

Findings

The results of our evaluations show that increasing intensity or ROC, or using cooling changes, increases a stimulus' likelihood of detection, although detection was never guaranteed (i.e. no stimulus was detected 100% of the time). 1°C intensities are least likely to be detected (<=57%). Comfort decreased as intensity and ROC increased, although the only "uncomfortable" stimulus was 6°C warming at 3°C/sec, with a comfort rating of 2.2 out of 7 (>=3 is "comfortable").

Summary

Cooling stimuli are more comfortable, less intense and yet more detectable than warming stimuli, regardless of intensity/ROC. The base of the thumb was most sensitive, followed by the arm locations. Perhaps surprisingly, Fingertips were the least sensitive area, so are not as suitable for thermal feedback perception.

Effect of mobility

Walking decreased the likelihood of stimulus detection but all other trends, relationships and findings remained the same.

Key Points

- The palm of the hand is the optimal location for feedback, but other arm lo-cations, e.g. wrist and upper arm are also suitable. Fingertips are less useful.
- All rates of temperature change were usable, but have different impacts with regards to power consumption.
- Although both warm and cold stimuli can be detected, cold stimuli are faster to detect, require less change from neutral temperatures to detect and are more comfortable for users as they feel less intense.
- Users perceptions of different intensities could mean that different levels of warm and cold could be used to display different types of information.

Industry focused research, innovation & application