Pre-print: Wolf, F., Feldman, P. & Kuber, R. 2014: Towards Supporting Situational Awareness using Tactile Feedback. In proceedings of the IEEE Symposium on 3DUI, Minneapolis, USA, 131-132.

Towards Supporting Situational Awareness using Tactile Feedback

Flynn Wolf, Philip Feldman and Ravi Kuber

UMBC

Abstract

In this paper, we describe an approach with the aim of supporting individuals engaged with a task where the eyes are occupied to monitor obstacles within their wider environment. A head-mounted interface has been developed where tactile feedback can be presented to alert the user to important situational events, such as the presence of spatial obstacles. Our research aims to examine ways in which cues can be developed to support levels of situational awareness for decision-making. Early results from our work suggest that the participatory approach adopted offers considerable potential when developing feedback for presentation to sites on the body which are rarely used for tactile interaction (e.g. locations on the head).

Keywords: Tactile, wearable.

Index Terms: H.5.2. User Interfaces: Haptic I/O.

1 Introduction

Situational awareness (SA) relates to being aware of what is happening in the vicinity, in order to understand how information, events, and one's own actions will impact goals and objectives [10]. Decisions or judgments can be made, once an understanding of the situation has been gained. While the role of SA has been examined within cognitively and perceptually challenging work domains (e.g. aviation and industrial control), research has yet to focus intensively on ways to support the user in developing and maintaining SA when performing day-to-day attention-demanding tasks, where the visual channel may not be available to monitor the wider environment.

Examples include focusing on a mobile device to perform a task (e.g. composing an SMS) while performing a second task (e.g. walking). The user is required to shift attention from the graphical interface to the path ahead, to monitor the presence of spatial obstacles (e.g. pedestrians, traffic, objects blocking path). However, difficulties in multi-tasking are known to both impact the primary task (e.g. errors in the message being composed) and the secondary task (e.g. injury and fatalities can be caused when unintentionally encountering obstacles).

Tactile feedback can play a valuable role under these circumstances, communicating the presence of spatial obstacles surrounding the user, leaving the eyes free to focus on the mobile interface. Using the feedback provided by a situational awareness solution, the user can then decide whether to respond to the threat by moving away from the obstacle, or by diverting attention from the graphical interface, to visually-assess the environment to make an informed decision on how to proceed.

In this paper, we describe the first steps in the development of a tactile interface, designed to support users when engaged with an attention-demanding task. Tactile cues are presented to locations on the user’s head to communicate the presence of obstacles. As research examining the potential of tactile head-based interaction are limited in number [8], our work aims to further the knowledge in this area.

email: { flynn.wolf, feld1, rkuber } @ umbc.edu

2 Related Work

Given its practical potential to augment other sensory channels and assist in maintaining spatial orientation, tactile feedback has been studied with regard to spatial navigation. Chiasson et al. [1] described effective coding schemes for belt-based tactile aids for both ground and air waypoint navigation. The tactile-enabled schemes yielded both limited performance improvements in situational awareness measures and better post-trial user acceptance values. The importance of simple and user-customizable tactile coding schemes, and avoiding interference with primary user physical and cognitive work, were found by Jacob et al. [4]. In their study of route navigation, cognitively distracted users were found to have better post-trial recall of their geographic environment when assisted by tactile cues in their task.

Raj et al. [9] presented vibrotactile feedback to participants in a simulated helicopter hovering task. Results demonstrated that vibrotactile cues can be used to improve performance in spatial tasks, especially in the presence of distracting secondary workload tasks. However, when reporting situational awareness scores, no significant difference was found between the tactile and non-tactile conditions. Ho et al. [3] examined the feasibility of using spatially-distributed vibrotactile warning signals to direct a person’s attention to the front or rear in a simulated car driving task. Participants were found to respond significantly more rapidly following both spatially-predictive and spatially-non-predictive vibrotactile cues from the same rather than the opposite direction as the critical driving events.

The studies summarized offer guidance to interface developers aiming to use touch to alert the user and communicate direction of the alert. However, research has yet to focus on developing cues to support head-mounted interactions to convey surroundings.

3 Research Objectives

The aim of the proposed research is to investigate ways to use tactile feedback, to communicate the following to increase situational awareness among mobile device users engaged within a task where the eyes are occupied:

(1) The number of spatial obstacles within a fixed range of the user;
(2) The position of obstacles in relation to the user;
(3) Identify whether the distance between the obstacles and the user is narrowing/widening.

We aim to manipulate parameters of touch (e.g. frequency, amplitude, duration, waveform and location of stimulus) to form

Pre-print: Wolf, F., Feldman, P. & Kuber, R. 2014: Towards Supporting Situational Awareness using Tactile Feedback. In proceedings of the IEEE Symposium on 3DUI, Minneapolis, USA, 131-132.

unique experiences (termed "tactons"). The tactons will be integrated with a head-mounted interface prototype, developed as part of this research. These will then be evaluated under controlled conditions, to address the efficacy of the tactile cues developed to communicate awareness of surrounding obstacles, and determine whether informed judgments can be made (e.g. moving in a particular direction to avoid obstacles).

We also aim to determine the amount of information that can be presented using tactile feedback, without causing undue stress or overload to the user.

4 Design of Interface

The head-mounted tactile interface prototype is similar in design to the system developed by Kalb et al. [6]. The interface consists of a set of tactile actuators, controlled by an audio adaptor (Vantec USB External 7.1 Channel Adaptor) and a laptop. In the current version of the prototype, up to eight actuators are affixed to a helmet (Figure 1).

Figure 1: Tactile Headset

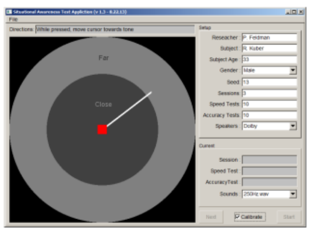

Figure 2: Application Interface

An application has been developed to play a sequence of tactile cues, in the order specified by the designer (Figure 2). The setup information can be stored within an XML file. The application itself has been written in MSVC, using FLTK and OpenGL for the GUI and XAudio2 for Dolby 7.1 sound playback.

The application can also be used as a recording tool, to enable users to select points on the diagram corresponding to positions on the head where they originally perceived vibrations (Figure 2 – left). Users are also able to identify metaphorical associations with the feedback presented, indicating whether they convey that the obstacle is within close proximity or located somewhat in the distance.

5 Refinement of the Prototype

More recent updates have been made to the prototype, based on findings from pilot studies. C2 tactors (www.eaiinfo.com), commonly used in HCI research [5], have been integrated with the solution. These were selected as they are easily programmable, robust in nature and light in weight. The actuators have been integrated with a lightweight skullcap. The skullcap has the advantage of providing a tighter fit, enabling information to be delivered more successfully compared with the helmet.

6 Current Work

We are using a participatory approach to designing tactile feedback for maintaining situational awareness. This was initiated with online questionnaires and small group interviews, intended to solicit discussion of real-world multi-tasking strategies and utilization of tactile feedback, as well as examples of spatial and situational impairment. This user input formed the basis for several user persona and use case scenarios presented as design prompts, which were presented to three participatory design focus groups, in which participants were asked to formulate tactile signals with which to convey important situational cues.. Strategies and conclusions were captured and passed on to each subsequent group for evaluation and iteration.

Early results of these groups indicate the utility of the participatory approach in developing effective tactile cues. The groups were successful in identifying common tactile design principles, such as simplicity and learnability, while iterating concepts such as the layout of the device hardware to account for the use case requirements. Although participants had limited experience with tactile head-based interactions, they were able to consider the strength of cues, to ensure that they would capture the user's attention, but not create discomfort due to their design.

The selection of a development path based upon participatory design appears to reinforce consideration for adapting tactile technologies to real-world applications, aspects of which may be unfamiliar to the developer. The iterative nature of the process also appears to have yielded a greater sense of contribution and confidence in its conclusions on the part of participants [7]. The observations of the focus group participants, and their broad perspective, included the varied needs of mobile users, particularly those using assistive technologies, which would otherwise be difficult for developers to identify [2].

Acknowledgments

We thank Brian Frey (UMBC) and Jenny Martin for their assistance with the project. This research is supported by the National Science Foundation – Award No. 1352924.

References

[1] J. Chiasson, B.J. McGrath and A.H. Rupert. Enhanced situation awareness in sea, air and land environments. Technical Report, Naval Aerospace Medical Research Lab, Pensacola FL, USA, 2003.

[2] R.D. Ellis and S.H. Kurniawan. Increasing the usability of online information for older users: a case study in participatory design. *International Journal of Human-Computer Interaction*, 12(2):263-276, 2000.

[3] C. Ho, C. Spence, H.Z. Tan., Using spatial vibrotactile cues to direct visual attention in driving scenes. Transportation Research Part F: Traffic Psychology and Behaviour, 8:397-412, 2005.

[4] R. Jacob, A. Winstanley, N. Togher, R. Roche, and P. Mooney,. Pedestrian navigation using the sense of touch. *Computers, Environment and Urban Systems* 36, 513-526, 2012.

[5] L. Jones and N.B. Sarter. Tactile displays: guidance for their design and application. *Human Factors,* 50(1):90–111, 2008.

[6] J.T. Kalb, B. Amrein and K. Myles. Instrumentation and tactor considerations for a head-mounted display, Technical Report - ARL-MR-705, Army Research Lab Aberdeen Proving Ground, MD, USA, 2008.

[7] M.J. Muller. Participatory Design: The third space in HCI. *The Human Computer Interaction Handbook* . Taylor and Francis, second edition, , 2008.

[8] K. Myles, and J.T. Kalb. *Guidelines for head tactile communication*. Technical Report - ARL-TR-5116, Army Research Lab Aberdeen Proving Ground, MD, USA, 2010.

[9] A.K. Raj, S.J. Kass, J.F. Perry, J.F. Vibrotactile displays for improving spatial awareness. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting,* pages 181-184, Santa Monica, CA, USA, 2000.

[10] Wickens, C. Situation awareness: review of Mica Endsley's 1995 articles on situation awareness theory and measurement. *Human Factors, 50*(3): 397-403.