Applying Tactile Displays to Automotive User Interfaces

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Abstract

Drivers' attention is occupied by an ever increasing number of in-vehicle information systems. The tactile channel offers a viable alternative for conveying information to the user while simultaneously relieving the other senses. In this paper, we propose how our previous work in the field of tactile displays can be transferred to an automotive context. We envision displaying spatial information in order to assist drivers, allowing them to focus their visual attention on the road ahead.

1 Introduction

The amount of information drivers have to process while steering a car is steadily growing. Apart from the increasing density of traffic, the growing number of in-vehicle information systems provide more and more information to process. Currently, visual feedback is the dominant modality. It can be found in e.g. dial instruments or navigation systems. However, the visual attention is required mainly on the road for monitoring the traffic and environment. Visual interfaces therefore should require minimum visual attention in order to interact with them [BJST08]. Therefore, auditory feedback has been applied for systems such as obstacle detection or navigation systems. Nevertheless, auditory interfaces compete against other sound sources, such as the car's background noise, outside noise, radio, navigation system, or the voices of other passengers. They also could be overheard, distract or even annoy the driver. Tactile feedback offers a suitable alternative that has yet received little attention in the automotive context. Tactile interfaces have especially gained attention in application areas where visual attention cannot be diverted, such as assistive systems for the blind and visually impaired, or while driving a car. In this paper we present how our previous work on tactile interfaces can be transferred to an automotive context. We also discuss potential application areas for tactile feedback in cars.

2 Tactile Displays in Cars

While driving, different information artifacts need to be, mainly visually, perceived and processed simultaneously to maneuver a vehicle. Interaction with in-vehicle information systems challenges driver's attention on the primary task of driving [BJST08]. Especially systems that demand visual attention result in considerable distraction from the road. According to Wickens' multiple resources theory [Wic84], humans are able to process different information concurrently if it is presented in different modalities. Thus, the sense of touch can be used to convey information in addition to visual and auditory feedback without diluting the driver's attention. So far, tactile feedback in the car is mainly used as a warning signal. One commercially available lane departure warning system employs a tactile display consisting of two vibration actors on the left and right side of the driver's seat to provide directional warnings[1]. Tactile warning signals can reduce reaction time to hazardous events. Spatially localized cues can be used to direct drivers' attention into specific directions [HTS05]. Evaluating several combinations of tactile and non-tactile stimuli, [KPB+06] found that in case of deviating from the lane a vibrotactile warning signal combined with a directional torque can additionally facilitate the right counter steering action. A navigational system which displays spatial information to a driver with tactile displays under each leg is evaluated in [VEVV01]. The system conveys the distance to a waypoint and displays the direction of left or right. In our previous projects, we developed a tactile display comprising six tactors equally distributed around the user's waist on a belt. The system can convey spatial information especially to blind and visually impaired people. For guiding users along a route by displaying the directions of subsequent waypoints on the tactile display, we could show that this system is suitable to present directions in an accurate and unobtrusive way [HHBP08]. We also proposed the usage of such a tactile display for conveying the location of friends in crowded environments [PHB08].

3 Challenges of the Automotive Context

Previous research has shown that tactile displays are well suited for conveying spatial information, especially directions. We envision using tactile feedback to convey spatial information in the form of the location of objects outside the car. This information could extend the drivers' field of 'view' to areas they normally are not able to see, such as dead angles or unclear streets. Application areas are support of navigation and orientation as well as conveying the location of points-of-interest and traffic participants. This could, e.g., be applied to display cars which are approaching the same crossing or which drive in the dead angle on neighbouring lanes, as these are typical situations where accidents occur. Challenges arise from the integration of tactile displays into the car's infrastructure. Cars offer plenty of contact surfaces that are touched by the user, such as seat, steering wheel, accelerator pedal, or

[1] http://www.citroen.com/CWW/en-US/TECHNOLOGIES/SECURITY/AFIL/

other controls. From an HCI perspective, the appropriate placement of tactors in the available surfaces plays a major role. Additional challenges lie in the design of the information presentation. Conveying spatial information requires multidimensional information presentation with tactile displays. For example, the location of objects in relation to the car has to be encoded by direction and distance. At least three-dimensions of information can be encoded by mapping each dimension to another parameter of tactile feedback, such as frequency, rhythm, waveform, or body location of the tactile cue as shown by [BBP06]. Their studies reveal that recognition rates are promising, but yet far from 100 percent. For displaying the location of objects around vehicles, at least two-dimensional information encoding is required. For allowing appropriate reaction to the presence of objects, additional information about the objects is required, resulting into a third required dimension. Direction has been successfully encoded by body location of tactile cues. Several solutions for presenting distances have been proposed without in-depth evaluation, so the ideal encodings have not yet been identified. Since typically the location of several vehicles plays a role in driving manoeuvres, the tactile display is required to display several entities at the same time. For preventing information overload and avoiding obtrusiveness, tactile feedback has to be conveyed considering the driver's current context. For instance, the presence of cars in the dead angles only needs to be mediated if the driver intents to change the lane soon. In the future, we will investigate these challenges based on our previously developed tactile interaction techniques. Evaluations will show how our previous findings can be transferred into automotive environments. We assume that displaying spatial information with tactile displays can enhance safety and comfort.

References

[BBP06] L. M. Brown, S. A. Brewster, and H. C. Purchase. Multidimensional Tactons for Non- Visual Information Presentation in Mobile Devices. In MobileHCI '06, 2006.

[BJST08] K. M. Bach, M. G. Jæger, M. B. Skov, and N. G. Thomassen. You Can Touch, but You Can't Look: Interacting with In-Vehicle Systems. In CHI '08, 2008.

[HHBP08] W. Heuten, N. Henze, S. Boll, and M. Pielot. Tactile Wayfinder: A Non-Visual Support System for Wayfinding. In NordiCHI'08, 2008.

[HTS05] C. Ho, H. Z. Tan, and C. Spence. Using spatial vibrotactile cues to direct visual attention in driving scenes. Transportation Research Part F: Psychology and Behaviour, 8:397–412, 2005.

[KPB+06] K. Kozak, J. Pohl,W. Birk, J. Greenberg, B. Artz, M. Blommer, L. Cathey, and R. Curry. Evaluation of Lane Departure Warnings for Drowsy Drivers. Human Factors and Ergonomics Society Annual Meeting Proceedings, 50:2400–2404(5), 2006.

[PHB08] M. Pielot, N. Henze, and S. Boll. FriendSense: Sensing your Social Net at Night. In CHI'08 Night and Darkness: Interaction after Dark Workshop, 2008.

[VEVV01] J. B. F. Van Erp and H. A. H. C. Van Veen. Vibro-Tactile Information Presentation in Automobiles. In Proc. of Eurohaptics 2001, 2001.

[Wic84] C. D. Wickens. Processing resources in attention. In Processing resource in attention. London: Academic, 1984.