Thermal In-Car Interaction for Navigation

Patrizia Di Campli San Vito
University of Glasgow, School of Computing Science
Glasgow, United Kingdom
p.di-campli-san-vito.1@research.gla.ac.uk

Stephen Brewster
University of Glasgow, School of Computing Science
Glasgow, United Kingdom
stephen.brewster@glasgow.ac.uk

Frank Pollick
University of Glasgow, School of Computing Science
Glasgow, United Kingdom
frank.pollick@glasgow.ac.uk

Stuart White
Jaguar Land Rover Ltd.
Coventry, United Kingdom
swhite8@partner.jaguarlandrover.com

ABSTRACT

In this demonstration we show a thermal interaction design on the steering wheel for navigational cues in a car. Participants will be able to use a thermally enhanced steering wheel to follow instructions given in a turn-to-turn based navigation task in a virtual city. The thermal cues will be provided on both sides of the steering wheel and will indicate the turning direction by warming the corresponding side, while the opposite side is being cooled.

CCS CONCEPTS

• **Human-centered computing → Haptic devices**;

KEYWORDS

feedback; thermal; in-car interaction;

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1 INTRODUCTION

In-car entertainment and information systems are gaining more and more importance as the offered applications expand. These systems and the driving task are competing for the attention of the driver, especially if the information from the infotainment system is presented visually, as this is the most important sense for driving. Eye glances away from the road have been shown to contribute significantly to incidents and crashes [2]. According to the Multiple Resources Theory [9] information should be distributed across modalities not occupied by the primary task. Using haptic feedback, especially in combination with different feedback types, has been shown to decrease reaction time whilst not increasing mental demand [5] in a car. Most commonly used non-visual feedback types are auditory and vibrotactile. Vibrations can reduce reaction time, when combined with another modality and are easily implemented, but they can be mistaken for natural in-car vibrations [1]. Auditory feedback is often perceived as disruptive during conversations. Therefore, we present an alternative haptic interaction type: thermal feedback.

2 RELATED WORK

Thermal feedback in vehicles has not yet been investigated, even though heated steering wheels and seats are common option. Furthermore, research into thermal interaction has shown promising results for mobile devices [10]. Studies showed that the direction of temperature change (warm/cold) can be correctly recognized with 94% accuracy and the rate of temperature change (moderate/slow) with 73.1%. Furthermore, navigation task studies utilizing temperature change have been conducted for pedestrians [8] and a two dimensional maze game [6], in which thermal interaction helped participants to successfully navigate towards their destination.

Haptic feedback in cars has been investigated for different uses, locations and feedback types. Mostly navigational cues or warnings were given through haptics. Van Erp and Van Veen [7] used vibration on the seat to give navigational cues, while Kern *et al.* [1] added the vibration to the steering wheel. Medeiros-Ward *et al.* [3] used two tactors on the steering wheel, moving the driver's skin into the turning direction. Haptically enriched multimodal warnings, with vibration on a waist belt, have been investigated by Politis *et al.* [4]. The overall results show that the addition of haptic feedback to other modalities add to the efficiency of the interaction.

3 METHODOLOGY AND APPARATUS

A thermal steering wheel has therefore been designed to investigate the effectiveness of thermal interaction in a car for navigation purposes (see Figure 1). Four Peltier elements were mounted on the steering wheel, two on each side with one facing to the front and one to the back.

The turn direction is mapped to the direction of change (warm and cool), while the time span encodes the distance. In accordance with preferences given by participants in a previous study, the turning direction is indicated by warming the two devices on the corresponding side, to which the user should turn, while the devices of the "wrong" direction are cooled down. Imitating well known auditory navigation systems, the participants are given two separate warnings: one warning 200 metres before the turn, and the second stimulus right before the turning point. Both cues are presented

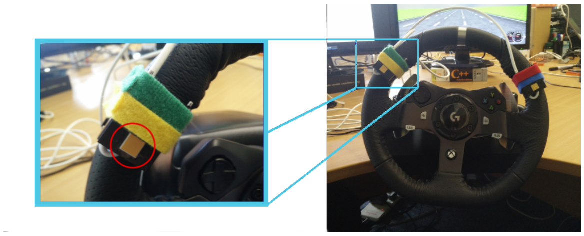

Figure 1: The set-up of the thermal steering wheel. The Peltier element can be seen on the left (red circle), mounted on a heat sink. The hardware was designed and built SAMH Engineering.

with a rate of change of 3°/s to a maximum of 6°C. Starting from a neutral temperature of 30°C the turning direction is indicated with 36°C, while the opposite side is cooled down to 24°C. In the first warning the temperature is held for 3 seconds after reaching the goal temperature and then the Peltiers will be immediately turned off. When the turning point is reached, the steering wheel will stay warmed and cooled, respectively, until the turn is completed. The Peltiers are then being brought back to the neutral temperature and turned off afterwards. After each turn the driver's car will be reset on a different location in the simulated city, where the participant can follow the road straight ahead, until the next turning point is communicated.

The demonstration utilizes a Logitech G920 Driving Force steering wheel, with the 1x1cm Peltier elements mounted on it, and can be run on a Dell XPS 15 9550 using Windows 10, with a monitor connected to it. The driving simulation is implemented in OpendDS 3.5.

4 APPLICATION AND FUTURE WORK

The utilization of thermal interaction in cars can be used to enrich feedback with additional content and its use can benefit from inherent interpretations, for example given through children games such as "Hot and Cold". The application of thermal feedback for in-car warnings seems to be an especially interesting field to explore, as results from Wilson *et al.* [11] show that warm temperatures were associated with insecure and therefore dangerous web sites. This correlation of warm or very warm temperatures for danger could add an immediate sense of the severity of in-car warnings. In future work we will investigate the addition of thermal feedback to multimodal in-car warnings.

Thermal interaction on the steering wheel of a car is a novel approach and its unobtrusive feedback can be a very beneficial addition to multimodal feedback designs.

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REFERENCES

[1] Dagmar Kern, Paul Marshall, Eva Hornecker, Yvonne Rogers, and Albrecht Schmidt. 2009. Enhancing navigation information with tactile output embedded into the steering wheel. *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* 5538 LNCS (2009), 42–58. https://doi.org/10.1007/978-3-642-01516-8{_}5

[2] S.G. Klauer, S.G. Klauer, T. a. Dingus, T. a. Dingus, V. L. Neale, V. L. Neale, J.D. Sudweeks, J.D. Sudweeks, D.J. Ramsey, and D.J. Ramsey. 2006. The Impact of Driver Inattention On Near Crash/Crash Risk: An Analysis Using the 100-Car Naturalistic Driving Study Data. *Analysis* April (2006), 226. https://doi.org/DOTHS810594

[3] Nathan Medeiros-Ward, Joel M. Cooper, Andrew J. Doxon, David L. Strayer, and William R. Provancher. 2010. Bypassing the Bottleneck: The Advantage of Fingertip Shear Feedback for Navigational Cues. (2010), 1650–1654. https://doi.org/10.1177/154193120104500402

[4] Ioannis Politis, Stephen Brewster, and Frank Pollick. 2013. Evaluating Multimodal Driver Displays of Varying Urgency. 13 (2013), 27–30. http://eprints.gla.ac.uk/106341/http://eprints.gla.ac.uk

[5] Ioannis Politis, Stephen Brewster, and Frank Pollick. 2014. Speech Tactons Improve Speech Warnings for Drivers. (2014), 17–19. http://eprints.gla.ac.uk/106338/http://eprints.gla.ac.uk

[6] Jordan Tewell, Jon Bird, and George R. Buchanan. 2017. Heat-Nav. *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems - CHI '17* (2017), 1131–1135. https://doi.org/10.1145/3025453.3025965

[7] Jan B F Van Erp and Hendrik A H C Van Veen. 2004. Vibrotactile in-vehicle navigation system. *Transportation Research Part F: Traffic Psychology and Behaviour* 7, 4-5 (2004), 247–256. https://doi.org/10.1016/j.trf.2004.09.003

[8] Reto Wettach, Christian Behrens, Adam Danielsson, and Thomas Ness. 2007. A thermal information display for mobile applications. *Proceedings of the 9th international conference on Human computer interaction with mobile devices and services - MobileHCI '07* (2007), 182–185. https://doi.org/10.1145/1377999.1378004

[9] Christopher D Wickens. 2008. Multiple Resources and Mental Workload. 50, 3 (2008), 449–455. https://doi.org/10.1518/001872008X288394.

[10] Graham Wilson, Stephen Brewster, Martin Halvey, and Stephen Hughes. 2014. Thermal feedback identification in a mobile environment . *In : 8th International Workshop on Haptic and Audio Interaction Design , 18-19 Apr 2013 , Daejeon , South Korea . Copyright © 2013 Springer-Verlag Berlin Heidelberg A copy can be downloaded for per* October (2014), 18–19. https://doi.org/10.1007/978-3-642-41068-0_2

[11] Graham Wilson, Harry Maxwell, and Mike Just. 2017. Everything's Cool : Extending Security. In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems*. ACM, Denver, Colorado, USA, 2232–2239. https://doi.org/10.1145/3027063.3053127