CarDio: Using Shape-Changing Materials and Visual Feedback To Enhance Driver Self-Awareness

Abstract. Despite recent developments in information technologies for the automotive field, the affective aspects of the driving experience are still under-explored. Advancements in sensing technologies make it possible to measure physiological data in the car environment, opening up the possibility of harnessing such data for just-in-time feedback to drivers. In this paper we present designs and techniques for measuring breathing patterns and inducing behavior change in the driver through shape changing materials and visual feedback, thereby providing increased safety and improved user experience.

Contribution statement. We present a sensor-powered system for changing the behavior of a car driver through tactile and visual feedback that influence the respiratory patterns of the driver, and thus change the driver’s arousal state.

Keywords: affective computing, subliminal interfaces, behavior change, automotive, shape-changing interfaces

1 Introduction

Monitoring driver stress and frustration level is of increasing importance to public institutions and industry, even being listed as one of the key areas for improving intelligent transportation systems [1], [2] and [3]. Ideally, the act of driving a car is performed while the driver is in a moderately aroused state. If we were to be able to detect and respond to moments of extreme arousal level, namely drowsiness on the one extreme or stress on the other, this could be beneficial to drivers [4].

The CarDio project employs physiological sensing techniques and focuses on the use of tactile and visual cues to induce change in the drivers’ arousal state. Many studies have demonstrated that the breathing pattern, in combination with other physiological signals, such as heart rate or skin conductance, can indicate different states of arousal [5], which can be in high to low stress, and high to low drowsiness [6,7]. This project describes how the use of visual and tactile feedback to recreate change respiratory patterns can lead to increased self-awareness [5][8] with the objective of either calming or increasing the arousal state during driving tasks, and hence, improving the driving experience and strengthening safety.

2 Sensing

The alertness of a driver can be measured through the combination of respiration rate (RR), heart rate (HR), and electrodermal activity (EDA). In this project we place sensors in such a way as to avoid interfering with the driving task. We embedded a camera and electrodes in the steering wheel to track HR and EDA. RR is measured...
using a contact-less sensor, as well an accelerometer in the seatbelt. The use of the HR and EDA will provide information on the level of stress of the driver [9], and RR will allow us to study the driver’s breathing pattern, drowsiness and alertness [10].

3 Feedback of Alertness

When driving a car, a driver primarily relies on their visual perception, while other senses remain relatively underused and as such are available for providing useful feedback [11]. We present methods of giving subtle cues to change breathing pattern.

**Tactile: Pneumatic steering wheel.** The addition of a pneumatic device on both sides of a conventional steering wheel can aid the user by conveying information in a tactile way [12,13]. Through the inflation and deflation of the pneumatic device, it is possible to mimic the driver’s breathing pattern and provide information through the unused tactile sense while driving.

**Visual: Ambient light.** Studies demonstrate that a subtle change in visual perception can induce information perception. We have installed programmable LED lights around the interior of the car to mirror driver’s breathing rate, and changing its pace according to the driver’s alertness state. These breathing patterns can be perceived by the peripheral vision [14,15], and therefore allowing to provide information without significantly altering the environment and demanding the driver’s attention.

4 Evaluation

We conducted a preliminary user test to analyze the effects of tactile and visual driver feedback, as well as the effectiveness of the current system in keeping the user in a desired “window” of level of alertness. A group of 7 people provided qualitative feedback on the system through a two-part test: in the first part we used the pulsing of the ambient LED lights to give the driver feedback about their breathing rate, and also setting custom fast and low rates, and in a second part of the test we used the shape-changing steering wheel to do the same. Users reported that the pneumatic actuator was more noticeable compared to the changes in lights, and that it did not interfere while handling the steering wheel. Furthermore, the breathing sensor reported that participants’ RR were changing when we increased or decreased the frequency of change from the pneumatic actuator, although they would not reach the specified rate.

5 Conclusions And Future Work

This work describes two methods that provide information to a driver with the objective of augmenting their self-regulatory processes. Through the preliminary tests, it was revealed that using subliminal cues could enhance self-awareness by recreating breathing patterns. Future efforts will focus on refining the current prototypes in order to have a better understanding of the effectiveness of this approach in the user’s level of alertness.
References