AutoEmotive: Bringing Empathy to the Driving Experience to Manage Stress

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Abstract
With recent developments in sensing technologies, it's becoming feasible to comfortably measure several aspects of emotions during challenging daily life situations. This work describes how the stress of drivers can be measured through different types of interactions, and how the information can enable several interactions in the car with the goal of helping to manage stress. These new interactions could help not only to bring empathy to the driving experience but also to improve driver safety and increase social awareness.

Introduction
Driving can be an emotionally stressful experience. Some of the main stressors are the lack of control, the potential negative impact of accidents, and the high cognitive load that is required [1] [3]. While certain amounts of stress help the driver to remain alert and attentive, too much or too little can negatively impact driving performance. Furthermore, stress in large doses has been linked to a large array of adverse health conditions such as depression, hypertension and various forms of cardiovascular disease. In this work, we discuss how stress can be comfortably measured and describe how this type of information can be used to help manage the stress of drivers.

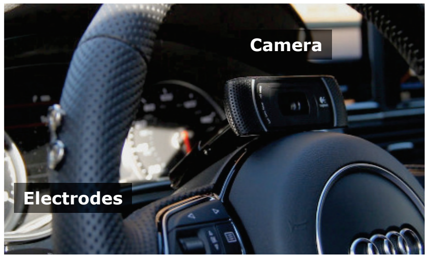

Figure 1. Close-up of the steering wheel showing the camera (center) and the electrodes (left) to comfortably monitor physiological signals.

Stress Measurement

Stress can be sensed from many different modalities. One of the most common approaches is to measure physiological signals such as heart rate variability or electrodermal activity that change during the stress response. For instance, Healey and Picard [4] used these signals in addition to others to automatically recognize the stress levels of drivers. While their study required cumbersome hand-built computers, recent developments of wearable technologies have enabled less disruptive monitoring in challenging daily life situations. For instance, we have successfully used wireless biosensors to measure stress of call center employees [5]. Furthermore, we have also demonstrated that it's possible to capture heart rate, respiration rate, and heart rate variability remotely with an inexpensive camera [9]. We have been able to incorporate both of these sensors into the steering wheel of a car (see Figure 1) which enables non-disruptive monitoring. Interactions of the driver with the car can also provide indications of stress. For instance, previous studies (e.g., [2]) have explored the utility of using voice features to measure stress of drivers. This type of information could be extracted from interactions of the person with the phone and/or the GPS. Furthermore, some of our recent work has also shown that stress can increase hand pressure and amount of contact with computer peripherals during stressful situations [6]. Similar approaches could be used in the car to measure the amount of contact and forceful grasping of the door handle, the steering wheel and even touch interactions with the navigation system. Finally, we expect that contextual data such as the amount of acceleration, average speed, and amount of gas in the tank will also provide meaningful information. Figure 2 shows an overview of the relevant information that can be used inside the car to sense drivers' stress.

Figure 2. Potential stress indicators inside the car.

Interactions to Help Manage Stress

When abnormal levels of stress are detected, the car can use the information to automatically adapt its interactions with the driver and increase individual and social awareness, helping the driver to better manage stress. Some of the possible interactions are:

Adaptive Music

Music has been widely used for emotion manipulation. If the car detects that the driver is overly stressed, it may recommend lowering the volume or listening to more relaxing audio. However, auto-selecting songs may elicit additional stress due to the lack of control so a compromise between the two methods may be the best solution. In general, solutions aimed at reducing

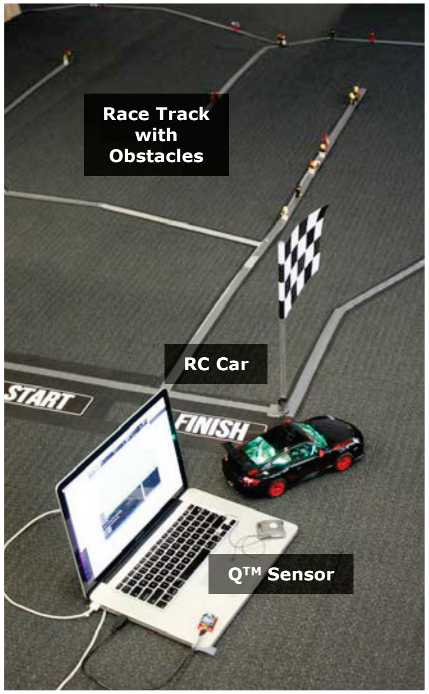

Figure 3. Prototype of a Remote Controller car that reflects the physiological readings of the driver

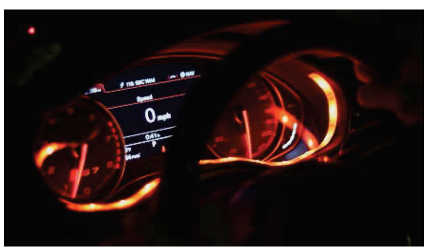

Figure 4. Real-time visualization of physiological data on the dashboard of a vehicle.

stress should give participants a greater sense of control, no less.

Empathetic GPS
Nass et al [8] performed a relevant study where the voice of the GPS matched the induced emotional state of a driver and found that congruent emotional states improved driving performance. Although in their study they used subdued and happy states, the same underlying theories and methodology could be applied in the context of stress.

Calming Temperature
During intense stress episodes, it's common to experience a sensation of increased heat. The car could potentially detect early indicators of stress and automatically adapt the temperature and its intensity to help alleviate this sensation.

Corrective Headlights
One of the changes associated with stress is the loss of peripheral vision, also known as tunnel vision. This is especially dangerous during the night where vision is already limited. The car could compensate for this by auto-adjusting the field of view of headlights.

Reflective Dashboard
Many technology-based stress reduction interfaces provide physiological information to the user so s/he can reflect on it and take control of the situation (e.g., [7]). An appropriate interface to achieve this in the car could be changing the color of the dashboard based on physiological changes. For instance, green and red colors could indicate a more relaxed or stressed driver, respectively. We have further explored this idea and created a small prototype that wirelessly connected the Affectiva Q™ sensor (www.qsensortech.com) with an array of LED lights inside a Remote Controlled car. We then asked several volunteers to wear the sensor and drive the car through a circuit with several obstacles as fast as possible (see Figure 3). Although this is only a small step towards the final goal, we were able to see how the lights turned red every time drivers crashed against obstacles and/or had to make pronounced turns. Furthermore, the feedback system made some participants more aware of their affective states and several slowed down when the reddish color appeared. Figure 4 shows an adaptation of the prototype in the car dashboard.

Communicative Paint
The same type of information could also be provided to other road users to improve driving safety. For instance, if a cyclist or a pedestrian detects that a driver in a car is overly stressed, s/he could intentionally keep larger separation and prevent adding additional stress. The communication of the information could be done through LEDs such as the previous prototype or even by changing the color of the whole car. To further explore the latter idea, we built a prototype of a small car and painted it with thermochromic paint, which has the ability to change color based on different temperatures. We used the same setup as the previous prototype but instead of connecting the biosensor to the LEDs, we connected it to a thermoelectric/peltier mini module. This setup enabled us to control the temperature of the surface based on the physiological readings of the person. Although we were able to change the color fairly quickly, the amount of current (1A) required to manipulate a squared inch may not be easily scalable to a full-size car.

Figure 5. Stress-free-routes to prevent future stress.

Long-term Vision

Collecting stress data of multiple drivers and associating it with other kinds of information can enable other compelling interactions. For instance, some days a driver might prefer "the least stressful" route home, even if it is not the fastest route. The collective stress level can be combined with mapping/routing tools to geographically identify routes that minimize stress whilst taking you to your destination (see Figure 5). This capability could be especially useful for people with high sensitivity to stress or just a need to be calmer before going home. Furthermore, analyzing the stress levels of hundreds of drivers around the city at different times of day and different days of the week could help find stressful locations and help design more livable cities and commutes that improve the well-being of citizens.

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Conclusions

This work describes how different driver's interactions can provide insightful information about stress and how this information can be used to better manage stress. While we have just started prototyping some of these applications, we have already performed extensive research in stress sensing in real-life settings. Future efforts will focus on refining the current prototypes in order to better understand the implications of such applications. Important considerations such as avoiding additional stress, ensuring privacy, and maximizing driver safety will be the main design principles of our research. We are looking forward to a future when emotion sensing in the car would not only be used at the individual level to enhance the driving experience but also at the collective level to live healthier lives and empower social awareness.

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