Physiological fatigue detection system for drowsy driving prevention

Abdelrahman Abdou[1], Taspia Wahid[2] and Jennifer Eshoua[3]

[1, 2, 3] Department of Electrical, Computer, and Biomedical Engineering, Faculty of Engineering and Architectural Science, Ryerson University, Canada
(E-mail: abdelrahman.abdou@ryerson.ca[1], taspia.wahid@ryerson.ca[2], jennifer.eshoua@ryerson.ca[3])

Problem Description

Drowsy driving is a major cause of road traffic accidents. The risks, dangers, and possibly deadly consequences of driving in a state of sleepiness or fatigue are alarming, considering the commonality of tired drivers. Drowsy driving can at times be more dangerous than driving under the influence [1] as drunk drivers may be able to drive slowly and react to visual stimuli, whereas drowsy drivers can nod off while maintaining road speed and be unable to brake or swerve if an incident appears before them. In terms of numbers, 58.6% of Ontarian drivers have admitted to occasionally driving in a fatigued state, while as many as 167,000 Ontarian drivers may have been involved in one crash due to drowsy driving in 2016 [2].

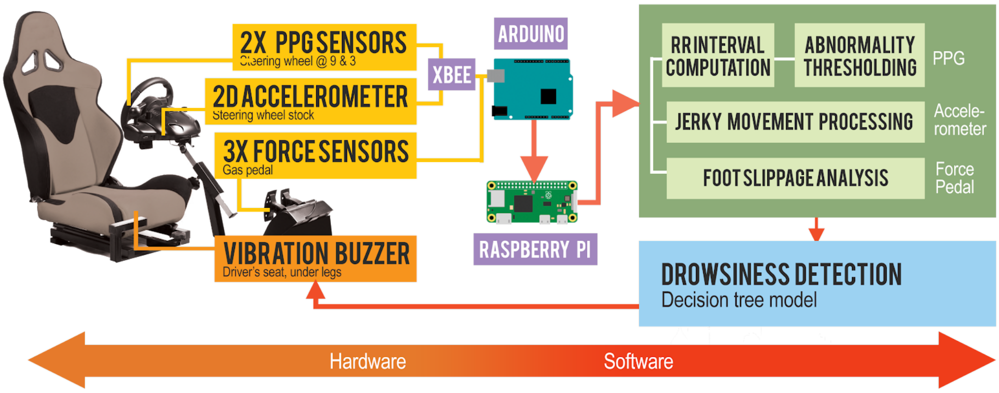
Despite knowing the dangerousness of being drowsy while driving, it is difficult to define and set limits on fatigue because of large inter- and intra-driver variability. Drowsy driving can happen when a driver has not slept enough, but it can also be linked to unstimulating driving conditions, side effects of medications, and numerous other causes. For these reasons, we identify that there is a need in the market to identify and address drowsiness from the user-level. A targeted approach to fatigue detection can be individualized to each and every driver by using biological signals to monitor the drivers alertness. This paper discusses the design behind developing a comprehensive physiological monitoring approach for real-time detection of fatigue in drivers.

Design Solution

The design is split into three distinct sections, the hardware signal acquisition, signal processing, then a machine learning stage, all which operate sequentially and cyclically on a real-time basis with minimal delay. The system works by obtaining driver data such as their heart rate through PPG sensors that are strapped onto the steering wheel. Also on the steering wheel is an accelerometer that detects jerky motion, which is indicative of wakefulness after a bout of drowsiness. These two signals are wirelessly transmitted to the main system located under the driver's seat where foot-pressure data is obtained from the gas pedal. Literature review finds that drowsy drivers tend to have their foot slip down to the bottom of the gas pedal so our system monitors the maximal location of the foot. The data from all three sensors are sent to an onboard computer that performs analysis on the information and machine learning to predict whether the driver is drowsy. If it is found that their fatigue levels surpass a given threshold, the drivers are quickly alerted of their state with a buzzer located on the driver’s seat under the driver’s leg which is intended to vibrate for a short period of time to rouse the driver to a state of alertness. This process runs cyclically until the car is turned off or the user turns the system off.

Application

Overall, the Automate system was found to be effective in its purpose. The high-level overview of the fatigue detection process along with the physical placement of the sensors in-vehicle are shown in the figure below.



With rigorous testing of the system both in-vehicle and in modular simulations, the sensors and processing was found to have 1-2 second lag time, which effectively ensures the device interprets data in real time. Further, the data was found to be highly accurate with a signal to noise ratio of 80 dB. These factors resulted in a useful vibration under the driver's leg to promote alertness when the system identifies a bout of drowsiness while still not being an annoyance from too many vibrations. The system was found to be non-obstructive and easily installed in any make/model of vehicle since it is small, portable, and repositionable. The system is currently intended to be powered through a cigarette lighter receptacle in the vehicle and the sensors are durable, ensuring that maintenance of the AutoMate system is easy if not negligible.

Implementation

Currently, the pathways of improvement for this project include setting up the AutoMate system to have customizable user thresholds to account for any physiological variables. Further, the AutoMate system could benefit from a connected app that gives the user an individualized summary of their drowsiness during a trip and in the long-run. The scope of this project has the capability to enter in a very large and quickly expanding market. As car users spend more and more time on the road, collisions are becoming very common especially those due to fatigue. Target markets for the system include insurance and logistical companies.AutoMate would have the capability to report to companies the frequency of an individual's driving habits. As driver fatigue and impairment rise to be one of the most problematic symptoms on the road, fatigue detection modules such as the one proposed are the future to a safer driving society.

References:

[1] "Drowsy Driving vs. Drunk Driving: How Similar Are They?", *Sleepfoundation.org*, 2018. [Online]. Available: https://sleepfoundation.org/sleep-topics/drowsy-driving-vs-drunk-driving-how-similar-are-they. [Accessed: 14- Feb- 2018].

[2] R. Robertson, E. Holmes and W. Vanlaar, *The facts about fatigued driving in Ontario*. Toronto, Ontario: Traffic Injury Research Foundation, 2009.