Driver Seizure Detection: Using Wearables and eHealth to Improve Road Safety

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Abstract
The aim of this project is to develop a means of epilepsy detection using wearable monitoring devices, electronic health records and detection algorithms. State of art sensors will be used to gather important physiological signals, and seizure detection algorithms will be used in combination with electronic health records to accurately predict the onset of a seizure. This project will develop an easy to use, non-invasive method of epilepsy detection, with an end goal of improved road safety.

1. Introduction
The automotive industry is currently focusing increasingly on the driver, their state of health, and situational awareness. This is of particular importance in the context of autonomous and semi-autonomous vehicles, where handover of control between driver and vehicle may occur multiple times in a single journey.

The key question being investigated in this study is how can eHealth, wearables, fitness applications and other sources of healthinformatics and data be integrated into a vehicle to improve overall road safety? This work may also allow for the inclusion of the vehicle as a node on an eHealth network.

The amount of information potentially available on a well-developed eHealth network could be very significant, and not all of it is entirely relevant to a car occupant, so it will be important to identify and prioritise the data that is useful for consumption by the vehicle systems. At the same time, in the event of an accident, there would be a considerable amount of data available that could provide useful information to first responders that could improve outcomes for accident victims.

Extensive research was required to gain an understanding of how eHealth networks work, how vehicles monitor driver health, how wearable devices can be used to profile the health of an individual, and also how a symbiosis of these technologies might be realised. From this research is was clear that it would be more feasible to focus on individual diseases or disorders rather than the overall health of the driver. By focusing on a specific disorder with attributes that are possible to measure and quantify it allows for accurate detection of that disorder. Epilepsy is an excellent choice for this study as it is a neurological disorder that can greatly impact individuals that drive, and there are a number of physiological signals that are clear indicators of seizure such as Electroencephalogram (EEG) [1] and discovered more recently Electrodermal Activity (EDA) [2].

2. Background
Currently in Ireland there an estimated 42,000 individual affected epilepsy with 1 people in every 100 experiencing affects at least once in their life [3]. There are many aspects of life that epilepsy impacts. One of the major impacts on quality of life that individuals living with epilepsy suffer with is the restrictions on driving, as epileptic attacks are the most frequent medical issue responsible for the loss of consciousness at the wheel. There are strict EU regulations governing whether people with epilepsy can drive. In Ireland, drivers are banned from driving if a seizure has occurred within the previous year; epileptic drivers can only be issued with 3-year licenses, and are required to have regular check-ups [4]. This, coupled with the fact that anyone found to have epilepsy cannot drive commercially means that it can greatly impact the life and livelihood of those impacted by the disorder.

When it comes to the detection of seizures, EEG and video analysis is still the state of art method of detection. However, for everyday use, a number of methods and detection algorithms have been recently developed. These algorithms monitor the EDA and the response produced by the sympathetic nervous system when a seizure occurs [5]. The algorithms have been further developed to include accelerometer data which gives greater accuracy [6][7].

3. Vehicle testing
The project is currently at the stage of vehicle testing, whereby a group 30 individuals will be monitored using a number of sensors, these sensors will be used to monitor the physiological signals of the driver, their heart rate, GSR, brain activity, and a number of other signals. While at the same time using a number of specialised cameras to monitor the driver’s head and eye movements. This data will be recorded in conjunction with data from a number of external cameras.

4. Patient Monitoring
It is clearly not advisable or possible to have people suffering from chronic cases of epilepsy take part in these vehicular tests. Another method must be put in place to monitor these individuals. By monitoring individuals using a wearable device, specifically the Empatica E4, a state of the art device designed for seizure detection, through the use of EDA, PPG and accelerometer data, coupled with the detection algorithms mentioned previously, it is hoped that an accurate detection model can be achieved. With the addition of personal health...
records created for each individual, it is hoped that this fusion of data will allow for greater accuracy in the early detection of seizures.

**Figure 1:** High-level overview of proposed seizure detection method.

Figure 1 is a high-level overview of the proposed system. Here the E4 wearable device is gathering physiological signals from an individual, this data is sent to a smartphone which uses detection algorithms to monitor vital signs. If signals are detected that could possibly be classified as those indicative of the onset of a seizure then the application can cross reference the EHR to check if medication has recently been taken, appropriate action can then be taken for the given situation.

5. Data fusion

By fusing the data gained from individuals who suffer from regular seizures and Electronic Health Records a simulated model for epilepsy can be developed. It is hoped that this model is capable of predicting whether a seizure is occurring, or if uncharacteristic physiological signals are taking place for some other reason.

With the addition of data gathered from the vehicle, a model can be created to detect if an individual at the wheel might be having a seizure while at the wheel. If this is the case, then the emergency transfer of control to the autonomous of the semi-autonomous vehicle may be required to prevent accident or injury. Steps can also be taken to notify first responders that an issue may have arisen.

6. Summary

The research suggests that the loss of consciousness due to seizure while driving is indeed an issue, not only is this dangerous for the driver but it is also dangerous for other road users. Simply banning these people from driving will severely impact on the quality of life and in some cases affecting individuals’ livelihoods.

There are a number of detection algorithms capable of detecting seizures using EDA and accelerometer data, with the addition of electronic health records and camera data from vehicles it is hoped that individuals previously unable to drive will be allowed to take to the road in a safe manner, while also creating safer roads for all road users.

7. Acknowledgments

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8. References


