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Detection of Drowsiness using Electroencephalograph Sensor

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ABSTRACT

Drowsy driving is a one of the most common cause of accident. The risk and danger that results due to drowsy driving are alarming. The drowsy driving usually happens when the driver has not slept enough, it can also happen due to continuous shift work, sleep disorders, medications, alcohols, illness. In this study, we have proposed development of a drowsiness detection system using a portable electroencephalograph (EEG) and a mobile device. This proposed mobile app is expected to minimize the accidents caused by drowsy driving [1]. By using Electroencephalogram (EEG) sensor, the condition of drowsiness is detected by recording the electrical activity that occurs in the human brain and is represented as a frequency signal. This frequency signal is transmitted to the mobile app using Bluetooth and will give an alarm notification when the drowsiness is detected. If the driver does not respond within a given time (e.g. greater than 1 minute) then it sends alert to the emergency contacts [1]. The brainwave from the EEG sensor is classified into four features, namely Delta, Theta, Alpha, and Beta waves.

KEYWORDS: *Drowsiness, Electroencephalogram (EEG), Accident Prevention, Brain Wave, Mobile Application*

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1. INTRODUCTION

Generally human needs 6-8 hours of sleep for normal activity. However, they can have fewer sleeping time because of their activity or work, which take a lot of time that cause sleepless or make them drowsy. This condition marked when eyes feel sore, slowly blinking, yawns or the body feels trembling that affect people activities; one of them is driving. Some people who drive even often ignore their physicsal condition. When the physical condition of the driver is not feeling well or even just drowsy, it can endanger themselves, passengers, or other drivers. And it is hard to predict when the driver may feel drowsy. Feeling sleepy while driving is very dangerous as it affects one's ability to drive safely. Drowsiness makes the driver difficult to pay attention to the road, slows down the reaction time if they want to brake or steer suddenly and also affects your ability to make good decisions. Drowsiness can cause micro sleep or someone experiencing unconsciousness for a few seconds and cannot respond to the situation. To find out whether someone is experiencing micro sleep can be seen from several aspects, one of them through brain waves. The human brain has a continuous electrical activity that represent frequency signal known as Electroencephalogram (EEG). Here the brain waves are divided into several frequency regions, namely: Delta (0.5-4 Hz), Theta (4-8 Hz), Alpha (8-13 Hz), Beta (13-30 Hz) and Gamma (30-45 Hz). In this study, a drowsiness detection system will be created to prevent driver negligence that can cause accidents. Therefore, when the driver has given signs that she/he is drowsy the system can warn the driver to be more conscious. The system uses EEG sensor to detect human brain waves and analyse it whether the waves show the drowsiness or not. The brain signals are classified into five states using Support Vector Machine (SVM). In this paper, we proposed a mobile system to detect and warn driver drowsiness using a fast classifier, the KNN. The system compares several features and shows which combination of features that provides the best recognition rate or accuracy. The brainwave from the EEG sensor is processed using Fast Fourier Transform (FFT). These features are classified using K-Nearest Neighbour (KNN) classifier. The system produces the best performance with theta highest accuracy of 95.24% using the value of k=3 and four brain waves as features, namely Delta, Theta, Alpha, and Beta waves.

2. METHODOLOGY

A. Electroencephalography

Electroencephalography (EEG) is the method to record the electrical activity generated by the brain using the electrodes placed on the surface of the forehead. For faster application, electrodes are mounted in elastic caps similar to bathing caps, ensuring that the frequency data can be collected from identical scalp positions across all respondents. Whenever the brain wave is in a particular range, the frequency patterns change gives insight into cognitive processes.

Delta (1 – 4 Hz) – The delta waves are used to measure the depth of sleep [7]. The more the delta rhythm, the deeper the sleep [6]. Increase in delta power is found to be associated with increase in concentration on internal working memory tasks.

Theta (4 – 7 Hz) – The Theta wave is associated with a range of cognitive processing such as memory encoding, retrieval of memory as well as cognitive workload [7]. Whenever we are confronted with difficult tasks (for example counting backwards from 100 in steps of 7 or when recalling the way home from work) theta waves become more prominent. Theta is also associated with increased fatigue levels.

Alpha (7 – 12 Hz) – The Alpha wave is associated with calm state [7]. Whenever we close our eyes and in the calm state we are in alpha state. It increases when we are in a state of relaxing. Biofeedback training often uses alpha waves to monitor relaxation of brain. It is also associated with inhibition and attention.

Beta (12 – 30 Hz) – The beta wave become stronger as we plan or make movements of any body part [7]. This increase in beta is also noticeable as we observe movements of their surroundings. Our brain tries to mimics their body movements, which indicated that there is an intricate "mirror neuron system" in our brain which is potentially coordinated by this beta frequencies.

Gamma (>30 Hz, typically 40 Hz) – The Gamma wave reflects attentive focusing and serves as carrier frequency to facilitate data exchange between different regions of brain [7]. Gamma wave is also said to be associated with rapid eye movements so-called micro-saccades which are considered integral parts for sensory processing and information uptake.

In order to detect the drowsiness state of the driver, detect when the frequency patterns lies in range of Delta (1-4Hz) and Theta (4 – 7Hz).

B. KNN Algorithm

K-Nearest Neighbour (KNN) algorithms for data classifications[5]. The purpose of KNN algorithm is to be used in a dataset where data points are separated into several classes to predict the classification of new sample points [5]. It does not need any training data to generalize. In other words the training process is very minimal and very fast. KNN is based on the similarity of features (feature similarity), which is evaluated from how closely a feature of the new sample data resembles training data to classify the given data points.

C. Sensor Controller

The sensor controller consists of the EEG sensor connected to an Arduino along with the Bluetooth. The Arduino is used since it is cost effective and very lightweight [3]. The Bluetooth, which is connected to the Bluetooth of the mobile device is used since it requires less power and has short range, which is sufficient for the drowsiness detection system.

The Arduino reads the sensor value of EEG, which is in micro voltage using embedded C. The values are classified into four state using KNN classifications [11]: Delta (1 – 4 Hz), Theta (4 – 7 Hz), Alpha (7 – 12 Hz) and Beta (12 – 30 Hz). This value is sent to the App through the Bluetooth.

D. Driver Alert

The Mobile App is developed using React Native Sdk. The React Native is used so that we can create App for both IOS and Android using same code base. The sensor value is retrieved from the Bluetooth and the value it compared with the possible range. If it comes under Delta or Theta range then an alarm is shown to the user waits for the driver to respond.

If the driver responds then he/she is alert hence does not take any further actions.

If the driver does not respond then an emergency message is sent to the contacts entered by the user.

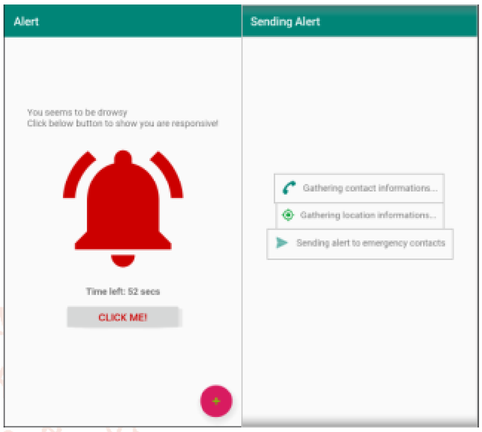

Fig 1: Drowsiness detection app Driver Alert UI

E. Location

The current location of the driver is obtained using available GPS in the mobile devices. It retrieves the GPS data i.e., latitude and longitude. Then using Google Location Service the latitude and longitude information is converted to human readable address. If the GPS is not available the Network location is obtained.

F. Emergency Contacts

The mobile app can be used to manage the emergency contacts in a local database. Driver can modify the data according to their needs. The emergency contacts can also include contact of Ambulance or nearby police station.

Once the location is retrieved from the mobile device the emergency contacts are fetched from database, then the SMS alert is send to the contacts using SMS service[1].

3. ARCHITECTURE DIAGRAM

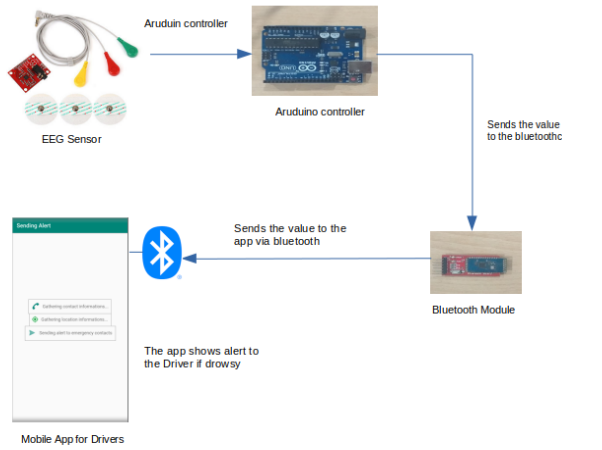

Fig 2 Architecture Diagram for Drowsiness Detection System

4. FUTURE ENHANCEMENTS:

In future, we can further enhance the safety by integrating the system to the existing safety features of the cars especially for self-driving cars.

To enhance it with the advent of automatic driving vehicle the driver can drive the car with less interaction, but it stills requires their attention and it can be used only in certain conditions. Therefore, we can integrate the drowsiness detection system to the cars self-driving command [2]. When the drowsiness of the driver is detected it automatically changes the car to self-driving mode if it is in manual mode and it parks the car safely.

This system can also be integrated with the E-Driving assistance to improve the driving experience of the driver.

5. CONCLUSION

We have proposed development of a drowsiness detection system using a mobile Electroencephalograph (EEG) and a mobile device for drivers. The drowsiness state of the driver is detected using EEG sensor. Any changes in the brain activity is detected using the sensor and alert the driver when drowsy, which helps in preventing the accidents. If the driver does not responds to the alert then the location information is obtained from the mobile devices and is converted to human understandable form using Google location services and an alert message along with the location of the driver to the emergency contacts. The system also maintains the log of driver state for monitoring purpose to enhance the security.

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