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EKG/ECG based Driver Alert System for Long Haul Drive

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Abstract

Background/Objectives: This paper deals about the designing and development of a driver alert system based on EKG signals to detect the driver drowsiness and thus to reduce accident rate. **Methods:** Conductive sensor attached to the hand which continuously monitor driver's heart rate and disseminate warning message through mail and SMS to the owner or respective authority. The structure system contains four parts including signal acquisition unit, signal conditioning unit processing unit and Message delivery system. **Findings:** The signal acquired from the conductive plate contains noises. Removal of the noise signals from the ECG signals is important and critical. One of the novel ideas in the work is the development of conductive sensor using conductive plates and integrated signal conditioning module AD8232 to measure the heart rate. Use of an integrated signal conditioning module makes the system small and cost effective. This system uses a Tiva C series microcontroller for processing unit and Raspberry-pi as message delivery system. **Conclusion/ Improvements:** Non intrusive nature of this system helps to detect driver's heart rate without making inconvenience to him. Mail and message sending features of the system helps the respective authority to take immediate actions. Improvement can be done to the system by adding the GPS functionality for tracking the location of vehicle.

Keywords: ADAS, Drowsiness, ECG, EKG, Heart Rate (HR)

1. Introduction

According to the surveys conducted by World Health Organization on road safety, over 1.3 million people die in road accidents in a year while almost 20 to 30 million road accidents resulted in serious injuries to traveller. Almost 1000,000 vehicle crashes are reported in US itself each year according to the police reports and national highway traffic safety administrator reports. The estimated reports of US national sleep foundation on 2009 shows that 28 percent adult drivers fell asleep while driving and 54 percent them drove vehicle while drowsy or felt sleep. When considering statistics in India, according to National Institute of Disaster Management, ministry of home affairs (NIDM), there is a road accident occurring in every 80 seconds and in every 10 minutes a death is reported due to road accident. Human factors like talking on phone, dialling phone, drunken driving during night time and drowsiness or environmental factors like inexperienced drivers, night time driving at high speed, bad environmental conditions like cold waves, fog, dust storms, driving under the sedation of drugs, restless working schedules, drunken driving during night times and the improper placement of traffic signals are possible causes for an accident. Also it is observed during survey that in most of the accident cases the victims are left unattended till the police come. This is another reason for the increase in death rate in accidents. Various prevention techniques like widening the path ways, giving proper awareness to drivers, installation of traffic signals and traffic lights at proper places, etc can be taken as prevention technique to avoid accidents. Considering accident due to human factors, drowsiness is the reason for 10 percent and 20 percent of traffic accidents and 57 percent of truck accidents caused due to this problem. Drowsy driving is major, but often unrecognized, traffic safety problem. Stress, fatigue, boredom, sedation of medicines, drugs and alcoholism can leads to drowsiness.

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Above all statistics shows that the main reason for most of accidents is drowsiness.

Frequent yawning, trouble in keeping head up, frequent eye blinking, heavy eyelids, forgetting the things happened before few minutes, drifting from the lane position etc are common characteristics of drowsiness. Drowsiness causes aggressive nature, processing information problems, increased moodiness and short term memory, day dreaming etc. There are mainly three preventive methods that can be taken for avoiding the drowsy driving. The first and foremost thing is to take proper sleep before driving. Taking power naps while long distance driving will also avoid drowsy driving. Avoiding alcohol and drugs while drive is another preventive measure can be taken. Still people think like they can overcome the drowsiness and won't take care while driving. This leads to drowsy driving and accidents. Curbing the accidents is very critical as the accident is not only affecting the drivers but also their families. So for avoiding the behavioral based accidents, many researches are going on.

Employing proper driver alert system either on road or vehicle can reduce accidents to an extent. The existing driver alert systems are categorized into three types; Behavioral based, Physiological variation based and Vehicle based driver alert systems[1].

Behavioral based driver alert systems work on the principle of image processing. In such systems the images captured by the camera is analyzed to detect the behavioral variation in driver. Image processing system analyses the rate of closure and opening of the eyelid or the movement of head or blinking of eyelid or yawning rate. This methods are non intrusive and not annoying to the driver. In physiological variation based driver alert systems, the physiological signals like ECG, EOG and EEG[2] are analyzed and the necessary alert actions take place. In systems based upon the Electro-Oculogram (EOG)[3], electrical signals generated by the eye movement are evaluated. This method is more efficient than image processing systems. But the electrode attachment to the head causes annoyance to the driver. It's not necessary that driver must wear the head mounted system always. One of another existing method is the use of electrical recording of the heart. The inductive sensors attached to the driver seat or seat belt is used for detecting the Electrocardiogram (ECG)[4]. Vehicle based driver alert systems are monitoring the parameters like pressure on accelerator pedal, deviation from the lane, steering angle deviation etc. When significant change in these parameters occurs, it detect as driver is drowsy and necessary action are taken.

But the improper illumination in driver cabin and environmental condition variations affect the efficiency of the systems based on image processing. The small range of camera capturing area is also a problem. Camera location also should be proper so as to detect the face of driver. Since the height of each driver differs, this will affect the reliability of the system as well. The movement of the driver from the seat, the sweating of the driver, driver cloth thickness etc is affecting the efficiency of the system in case of inductive sensors attached to seat belt. Design of a new system is needed to overcome the disadvantages of the existing. In this paper an EKG based driver alert system for long haul drive is presented. EKG signals obtained using Conductive plates placed in hands are used monitor the health condition. The health condition such as driver drowsiness or normal stage is analyzed by evaluating the signal and alerts the driver when ever required. The extended feature in the system sends an alert message indicating the location of the vehicle to the owner or respective authority when a critical condition occurs.

2. Drowsiness and Heart Rate

Autonomous nervous activity alters during stress, fatigue and drowsiness. Autonomous nervous activity combines the sympathetic and parasympathetic activity of nervous system. Increase in sympathetic activity and decrease in parasympathetic activity is the characterization of wake up period[5]. Tiredness or drowsiness state is characterized by increased parasympathetic and decreased sympathetic activity of nervous system. Heart rate variability signal analyzing is one of the methods to measure the autonomous nervous system activity. Sympathetic activity is characterized by the frequency band 0.04 Hz to 0.15Hz called low frequency band and parasympathetic activity characterized by frequency band 0.15Hz to 0.4 Hz called high frequency band[6]. Low frequency to high frequency ratio measures balance between sympathetic and parasympathetic activity. This can measure from heart rate variability signals. Instantaneous change in heart rate referred as Heart rate variability. R-R interval in heart rate variability signal is referred as heart count. At

the beginning of sleep, low frequency to high frequency ratio in heart variability signals decreases. Also sudden decrease in heart rate occurs. This fact is considered for the detection of drowsiness.

3. System Architecture

The system architecture of driver alert system includes signal acquisition module, signal conditioning module, processing module and message delivery module. Signal acquisition module is meant for the capturing signal from the driver's hand. Conductive plates used in signal acquisition attached to hand. Noises due to movement and other artifacts are also included in the acquired signal. An efficient and cost effective signal conditioning is needed for avoiding these noises.

Processing unit is the most important module of the system. Processing module takes care of signal monitoring and analyzing. Processing system functionality includes the controlling of message delivery system also. Figure 1 shows the system architecture.

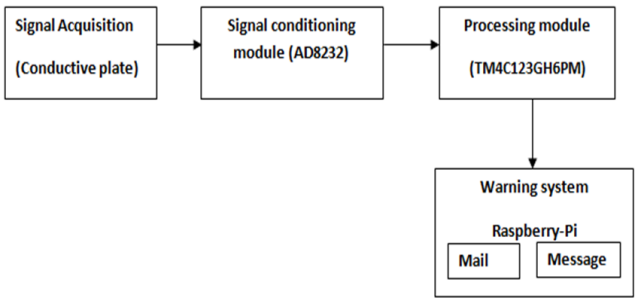

Figure 1. System architecture.

4. Signal Acquisition System

The conductive plates used in signal acquisition are attached to hand. The acquired signals will be in the range of 0.05 to 100 Hz in frequency and 1 to 10 mV in amplitude[7]. The signals acquired may contain noises. The selection of the conductive plate used for the signal acquisition is very critical. The medical conductive electrode being used is efficient to detect the low amplitude signal in the range of 1-10 mV. Copper plates are more conductive than aluminum plates. Also the conductivity is almost 98 percent in the case of copper plate. A fabric conductive electrode with high input impedance is another better option. Figure 2 Shows signal acquisition system setup.

Figure 2. Electrode placement diagram for signal acquisition.

5. Signal Conditioning Module

Bio-signals that are acquired using conductive plates is filtered and amplified for making it suitable for further processing. An integrated signal conditioning module AD8232 is used for this purpose. AD8232 is an integrated module housing a high pass filter, a low pass filter and instrumentation amplifier to eliminate the noises introduced in the signal due to movement and other artifacts. Instrumentation amplifier is used to amplify the signal to fit the specifications of micro-controller's ADC. The integrated architecture of high pass filter and the instrumentation amplifier allows both large gain and filtering in a single stage and makes signal conditioning block cost-effective and small. For removing unwanted noises, signal is fed to a two-pole high pass filter of cut-off frequency 0.5 Hz and then to a low pass filter of cut-off frequency 24Hz. Signal from AD8232 is obtained via NI DAQ and viewed on Lab VIEW signal express. Figure 3 shows the experimental setup for signal conditioning module testing.

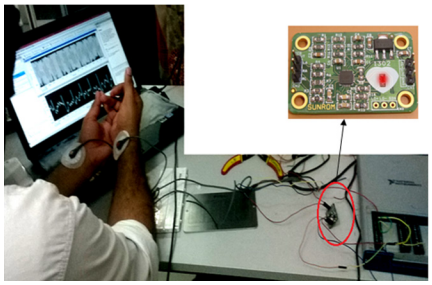

Figure 3. Experimental setup for signal conditioning module testing.

6. Processing Module

TM4C123GH6PM microcontroller is used as the processing module. Output from the signal conditioning module is fed to the ADC for sampling, quantizing and to convert into digital for counting the high pulse signal and thus the heart rate. Sampling rate of ADC is adjusted to 20000 micro seconds to get 50 samples in a second. Timer interrupt in periodic mode is used for this purpose. Communication between the processing module and message delivery module is established by means of interrupt. Figure 4 shows the entire system setup.
Figure 5 shows the software flow chart of counting heart.

7. Message Delivery System

Processing unit raise an interrupt by raising high voltage on GPIO pin to alert the mail delivery system i.e. nothing but raspberry pi module. When raspberry pi receives the interrupts, it services it and sends an e-mail, which indicates that driver is not in condition to drive. Raspberry-pi using SSMTP to sends mail to authorized person. The SSMTP configuration file contains the sender's authentication details. A shell script is used to trigger the mail which contains receiver's mail id. Figure 6 shows the SSMTP system flow.

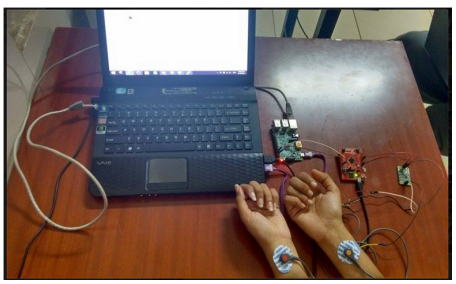

Figure 4. Experimental set up of entire system.

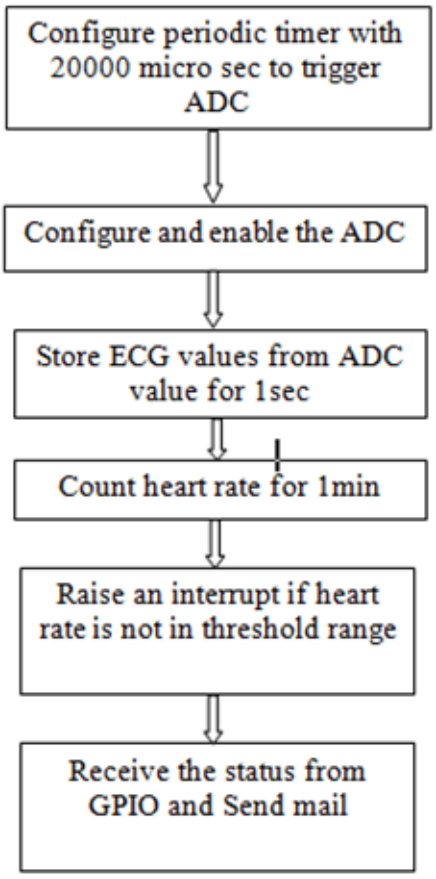

Figure 5. System flow chart.

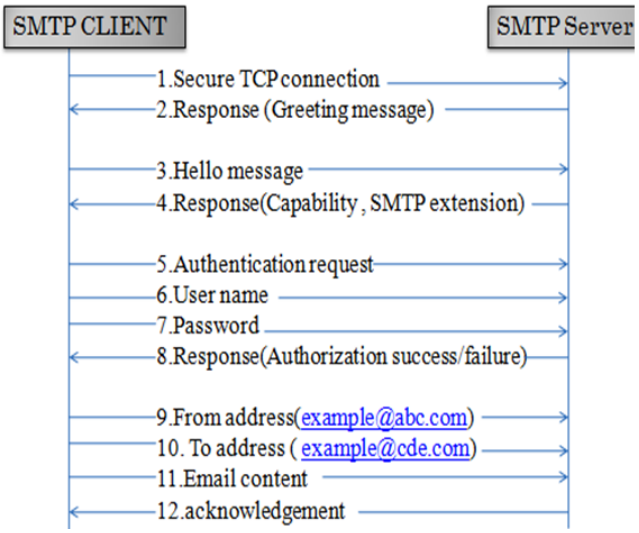

Figure 6. SSMTP message flow.

8. Results

Signal generated from conductive plates which are attached to hand, is observed by using NI DAQ board on

Lab VIEW. Figure 7 shows the heart rate signal without filtering.

Signal is further filtered to remove the noise, which is as shown in Figure 8.

AD8232 signal condition module filter is used to reduce the noise and for smoothening the signal. Signal after filtering is fed to cortex M4 for counting the heart beat which is shown in below Figure 9. SSMTP config file is already update with sender's authenticated details. Based on the count value, raspberry-pi is sending the e-mail which is as shown in Figure 10.

IFTTT app is used to trigger the SMS to phone. Simple If-Else statement is used to send the SMS. Email received in the mail box of receiver and SMS received in phone is shown in Figure 11 and Figure 12.

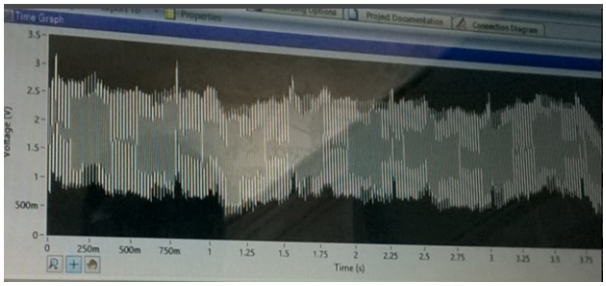

Figure 7. Acquired signal with noises.

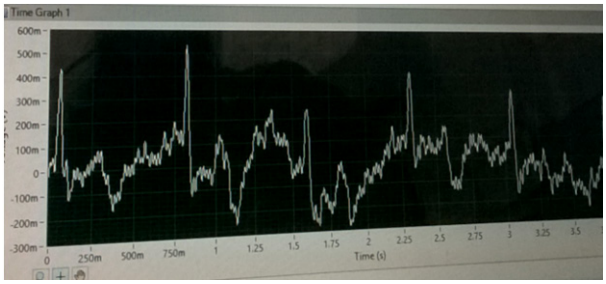

Figure 8. Heart beats obtained from signal conditioning module.

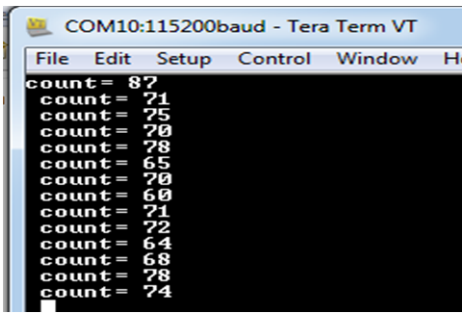

Figure 9. Heart rate output from TM4C123GH6PM processor.

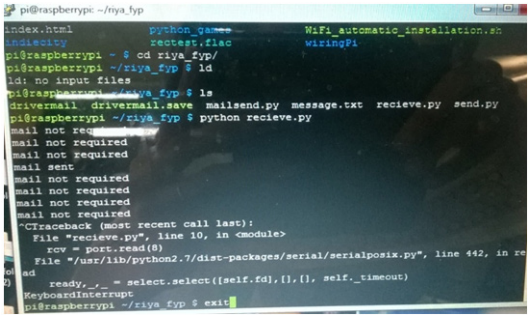

Figure 10. Integrating the transmitting section with raspberry.

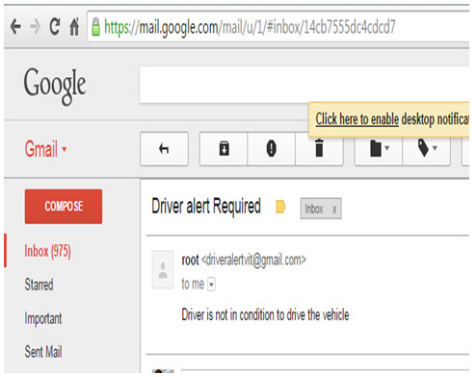

Figure 11. Email showing driver alert required.

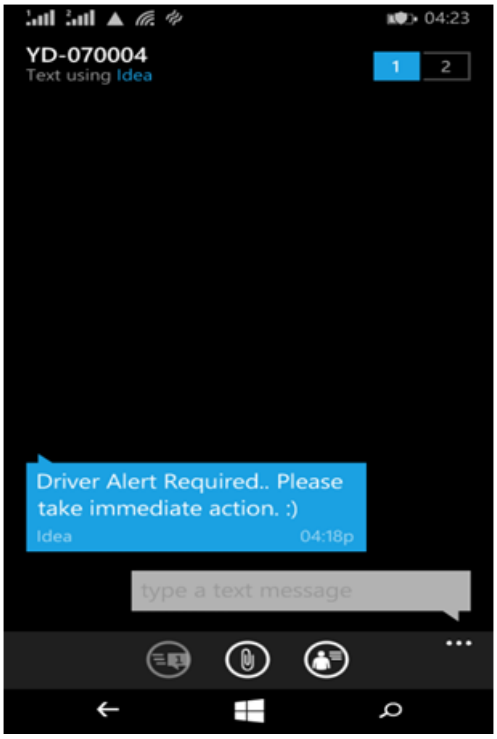

Figure 12. Message showing driver alert required.

9. Conclusion and Future Scope

This paper presents an efficient, low cost driver alert system. An embedded ECG sensor is used to measure the heart rate of the driver. The non intrusive nature of the system helps to measure the heart rate of driver without making inconvenience to the driver. The mail and message sending feature of the system helps the respective authority to take immediate action while driver is drowsy. Location identification and the identification of the vehicle which send the message is a problem. Sending IP of the board by mail will help to identify the vehicle. Getting uninterrupted internet connection is another problem. High speed Wi-Fi is not available at all locations. 3G mobile data connection is an alternative. But it's not necessary that driver should turn on the data connection. That will affect the system reliability. Another feature that can be added is GPS functionality. This will help to track exact location of the vehicle and to take necessary action immediately. Instead of attaching the sensor to hand this can attach to steering wheel for making more comfort system.

10. References

1. Begum S. Intelligent driver monitoring systems based on physiological sensor signals: a review. 2013 16th International IEEE Conference on Intelligent Transportation Systems - (ITSC); 2013 Oct 6-9; The Hague: IEEE; p. 282–9.
2. Wu R-C, Liang S-F, Chao W-H, Chen Y-J, Jung T-P. EEG-based drowsiness estimation for safety driving using independent component analysis. IEEE Transactions on Circuits and Systems. 2005 Dec; 52(12):2726–38.
3. Chieh TC, Mustafa MM, Hussain A, Hendi SF. Development of vehicle driver drowsiness detection system using Electrooculogram (EOG). 1st International Conference on Computers, Communications, & Signal Processing with Special Track on Biomedical Engineering, 2005 (CCSP 2005); 2005 Nov 14–16; Kuala Lumpur, Malaysia: IEEE. p. 165–8.
4. Matsuda T, Makikawa M. ECG monitoring of a car drive using capacitively-coupled electrodes. 30th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBS 2008); 2008 Aug 20–25; Vancouver: IEEE. p. 1315–8.
5. Vicente J, Laguna1P, Bartra A, Bailon R. Detection of driver's drowsiness by means of HRV analysis. Computing in Cardiology; 2011 Sep 18-21. p. 89–92.
6. Jung S-J, Shin H-S, Chung W-Y. Driver fatigue and drowsiness monitoring system with embedded electrocardiogram sensor on steering wheel. IET, Intelligent Transport Systems. 2014 Feb; 8(1):43–50.
7. Bhumika C, Yadav OP, Chandra V K. A survey of noise removal techniques for ECG signals. International Journal of Advanced Research in Computer and Communication Engineering. 2013 Mar; 2(3):1354-7.