A novel approach to Drowsiness Detection for Driver

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Abstract

In this paper, a drowsiness-detection system based on eye blink and head movement is proposed and implemented. On driver's drowsiness detection, the system will a) alert the driver via a wake call (Buzzer), b) reduce the speed and stabilize the vehicle driven by driver. It may also detect the occurrence of an accident and find accident location using crash sensor and GPRS respectively and notify emergency contact about the location of accident with the help of GSM communication module. This system monitors eye movements and head movements of drivers to warn them when they fall asleep. The driver's eye is continuously monitored using an IR sensor and head movement using an accelerometer. The normal eye blink rate will have no effect on the output of the system.

Keywords: *Drowsiness, IR Sensor, GSM module, Accelerometer 345, driver, Raspberry pi*

1. Introduction

"Drowsy driving" and "fall-asleep" crashes are common and often result in fatalities and serious injuries because drivers fail to use maneuvers to avoid or mitigate crash severity. Teenagers as a group are at highest risk for crashes related to drowsy driving. Drowsiness is a state of sleepiness and it becomes a problem when it interferes with normal daytime activities. This usually happens when a driver has not slept enough, but it can also happen due to untreated sleep disorders, medications, drinking alcohol or shift work. Drowsy driving occurs

When a person who is operating a motor vehicle is too tired to remain alert. As a result, the driver may have slow reaction times, reduced vigilance and impaired thinking. In the worst case, the driver may fall asleep behind the wheel. Falling asleep at the wheel is clearly dangerous, but being sleepy affects your ability to drive safely even if you don't fall asleep. Drowsiness makes drivers less able to pay attention to the road, slows reaction time if you have to brake or steer suddenly and affects a driver's ability to make good decisions.

The stages of sleep can be categorized as awake, non-rapid eye movement sleep (NREM), and rapid eye movement sleep (REM). The second stage, NREM, can be subdivided into the following three stages: a) transition from awake to asleep (drowsy) b) light sleep c) deep sleep [2]. Drowsy driving is the dangerous combination of driving and sleepiness or fatigue. Researchers have attempted to determine driver drowsiness using the following measures: vehicle-based measures, behavioral measures and physiological measures. It is necessary to derive effective measures to detect driver drowsiness and alert the driver during the peak drowsiness periods of 2:00 am to 6:00 am and 2:00 pm to 4:00 pm in order to avoid accidents. During these time frames, the circadian rhythm shows higher chance of getting drowsy and drivers are three times more likely to fall asleep.

The objective of this work is to implement a drowsiness detection system to the vehicular driver based on sensors data in order to detect and alert when the driver have drowsiness signs. To achieve this objective, different technical parameters and algorithms that allow to process signals of the state of drowsiness were identified in the literature survey and compared in the research gap section. In this work, a drowsiness detection system for drivers is presented.

2. Literature Review

2.1 Innovative Work Behavior(IWB)

Through Jason Gui [1], developed the Vigo which can monitor eye blinking patterns and "nudge" its users when they start nodding off. The Driver Attention Detection System (DADS)[2] developed by Mathew Parks is a proactive infrared line detection device that warns drivers of erratic or inattentive driving behavior. DADS uses basic comparison, checking and verification algorithms to detect the swerving and erratic behavior of persons exhibiting drowsy, inattentive behavior.

Chin-Teng Lin, et al. [3] proposed an EEG-based drowsiness estimation technology based on ICA, power-spectrum analysis, correlation analysis, and a linear regression model and evaluated it in a VR-based driving environment. It was an online portable embedded system for noninvasive monitoring of the cognitive state of human operators in attention-critical settings. Edmund Wascher et al. [4] investigated the interaction of time on task, task load, and cognitive controllability in simulated driving scenarios, using an either re-active or pro-active driving task. A routing and tracking system proposed by R. Manoj Kumar et al. [5] provides a keypad wherein a security code is set as per the owner's choice. When someone tries to start the car in the absence of the driver, an alarm which the driver owns is rung.

In another study carried out by Abdulhamit Subasi et al., 5-s long sequences of full-spectrum electroencephalogram (EEG) recordings were used for classifying alert versus drowsy states in an arbitrary subject [6]. Xun Yu developed a real-time, nonintrusive driver drowsiness detection system [7] by building biosensors on the automobile steering wheel and driver's seat to measure driver's heart beat signals. Heart rate variability (HRV), a physiological signal that has established links to waking/sleepiness stages, is analyzed from the heat beat pulse signals for the detection of driver drowsiness.

Helios De Rosario et al.[8] presented a study of driver drowsiness, looking for patterns in biomedical and biomechanical variables that allow characterizing the drowsiness cycle, and detecting its phases with new technologies. Puja Malvadkar et al.[9] used a webcam to acquire video images of the driver. Visual features like mouth &eyes which are typically characterizing the drowsiness of the driver are extracted with the help of image processing techniques to detect drowsiness

2.2 Research Gaps

The proposed work is motivated by the following factors:

- To prevent accident before it's occurrence. Hence, increases the safety of both person driving the vehicle and other people on roads.
- To assist emergency services and quick response teams to take quick action in case of occurrence of an accident.
- To enable effective implementation of safety regulations for four-wheel drive on roads at both day and night.
- To provide a user friendly safety device for vehicle drivers.

3. Methodology

3.1 Problem Definition

A drowsiness detection safety system is developed and experiments have been conducted. This system is designed with the objective of alerting the driver when he feels drowsy, preventing accident and automatically detecting possible accident situation and sending text messages to emergency contact using GSM module. There are various parameters available to detect the drowsiness in the driver but one of the most used indexes to calculate the level of sleepiness is PERCLOS (Percent of the time Eyelids are CLOSed), which measures the percentage of time a person's eyes are closed at 80% to 100% in a period. PERCLOS is among the most important real-time alert measures for vehicle drowsiness detection systems.

$$perclose = (closed\ eyes\ time/(closed\ eyes\ time + open\ eyes\ time)) * 100\ [10]$$

The analysis based on changing physiological measures uses sensors that measure physiological variables of the human body to analyze states of drowsiness. These variables are the eye blink rate and head movement in forward, backward, left or right direction.

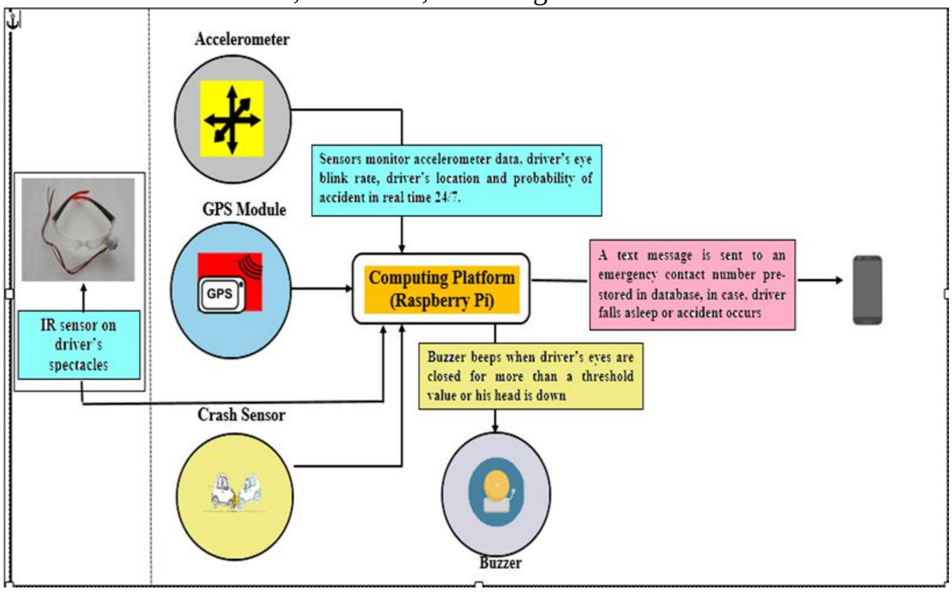

Figure 1: Architecture Diagram of the Proposed Drowsy Driver Safety System

3.2 Implementation

This section describes different aspects of the system considered in its implementation; they include tools used and devices selected for system testing in different study cases. Hardware of the system comprises of MEMS Accelerometer Sensor ADXL345, GSM module, IR Sensor Module, Crash Sensor, LCD display 16x2, Raspberry pi, GPS, buzzer, Control Motor, Power supply unit. Figure 1 shows the architecture diagram of the proposed drowsy driver safety system.

The flow diagram for the proposed drowsy driver safety system is shown in figure 2.

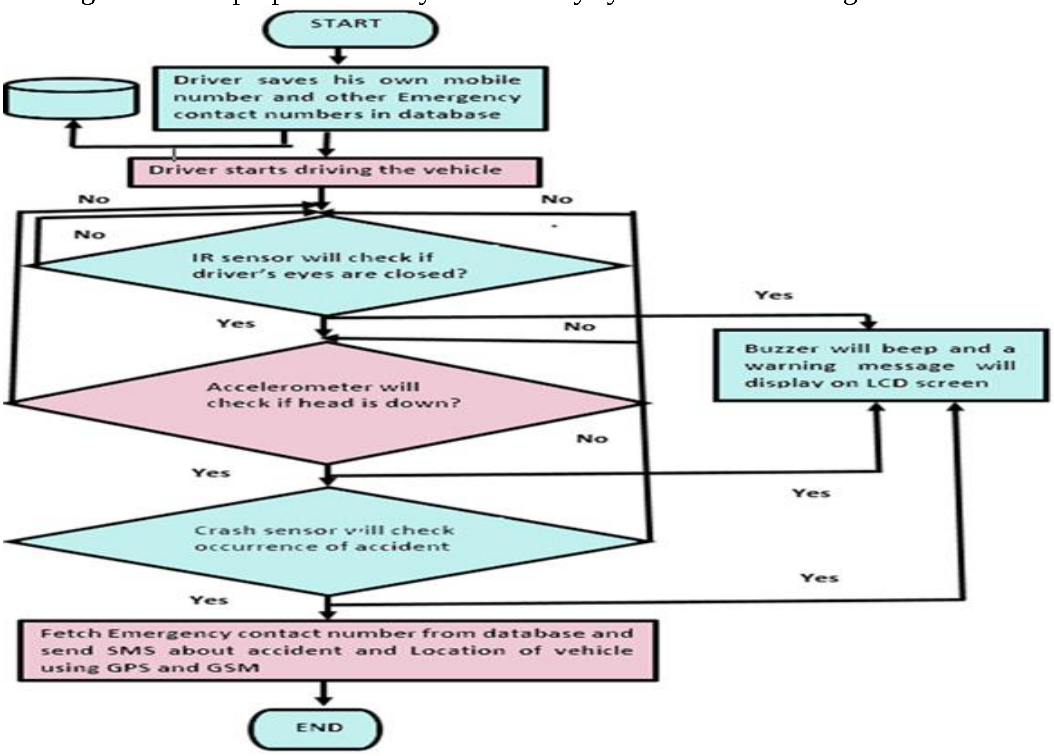

Figure 2: Flow diagram of the Proposed Drowsy Driver Safety System

The proposed system involves measurement of eye blink using IR sensor which is embedded in the eye glasses worn by driver. When driver's eyes are closed, the line of sight path of IR sensor transmitter and receiver is obstructed and IR sensor detects that driver is drowsy. The head movement of the driver is detected using accelerometer ADXL345 which is placed on driver fore-head to measure tilt angle of the head of the driver. Whenever driver feels drowsy, his/her head position will be tilted either forward or on left or right side, so accelerometer will note the reading at that time and translate the tilt angle data to displacement of mouse cursor to calculate new head position. The driver is alerted using a buzzer and the speed of the vehicle is also reduced in extreme condition. Text messages are sent to user emergency contacts pre-stored in the database. The location of vehicle is found using GPS. Crash sensor, placed on the surface of vehicle to detect collision during accident, converts it into corresponding signals within a matter of milliseconds. A DC motor is used here to depict vehicle. A log file is created which keeps a track of all the instructions or messages sent by GSM. It also maintains a record of the date and time of sending the message and mobile number from which the message is sent.

3.3 Sequence Diagram

A transformation diagram for drowsy driver safety system is also given in figure 3 which explains the sequence of data and instruction flow at different instants of time.

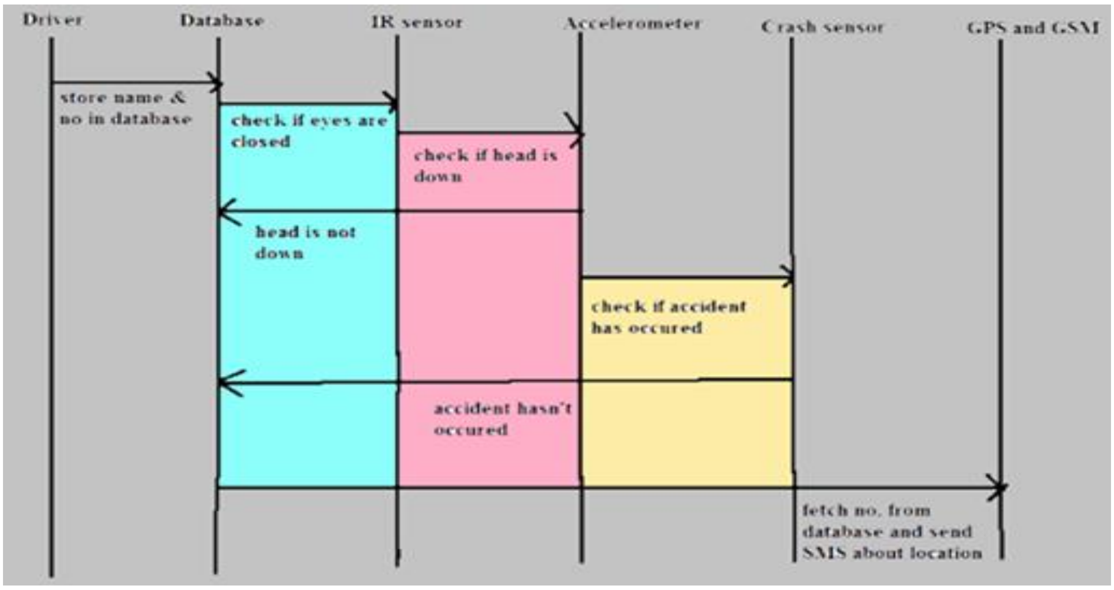

Figure 3: State Transition Diagram for Proposed Drowsy Driver Safety System

4. Results and Analysis

4.1 Experiment

This section presents the results on the detection of drowsiness under different experimental conditions. To perform the system tests, 10 drivers, 5 men and 5 women of different ages were included, each of whom was accompanied by a "co-driver" who was able to handle controlled events of sleepiness only when the external conditions in the road and close to the vehicle were safe.

Table 1. Accelerometer values for various head moments by driver

S. no	Head direction	Value at axis X	Value at axis Y	Value at axis Z
1	RIGHT	X<0	Y<0	ANY VALUE

2	LEFT	X>0.95	ANY VALUE	ANY VALUE
3	FRONT	X<0.4	Y<0	ANY VALUE
4	NORMAL	X=0	Y=0	Z=0

Table 1 presents the results of the detection of accelerometer values for various head moments by driver. The events to validate the system were the following: front and lateral assent of the head, left and right distraction and blinking. In the process of validating the system, drivers repeat different scenarios 5 times the test. The number of correctly detected events, false positives, false negatives and the efficiency of the implemented system were registered.

Table 2. Detection levels for drowsiness parameter under normal conditions

S.no	Test	No. of Observations	No. of Hits	Percentage of Hits
1	Front nodding	50	46	92%
2	Assent of the head to the right	50	48	96%
3	Assent of the head to the left	50	49	98%
4	Distraction to the right	50	47	94%
5	Distraction to the left	50	48	96%
6	Blink detection	50	48	96%

4.2 Database for the System

A database is maintained for emergency contacts of driver who may come to help him immediately when a crash is detected.

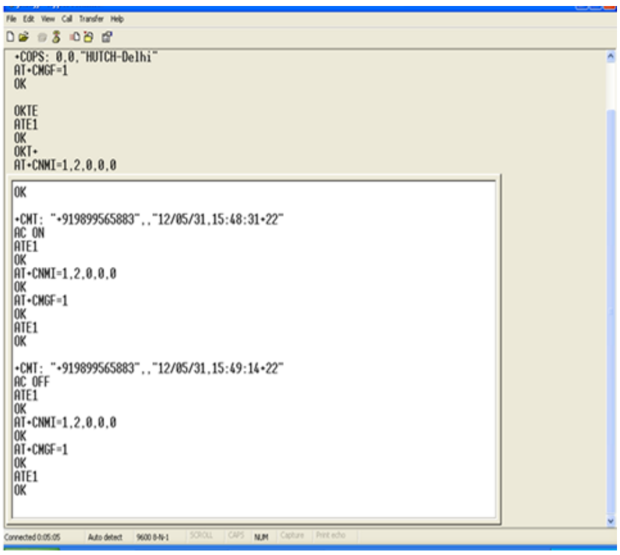

Figure 4: Snapshot of SMS Sent for Detection of Accident

5. Conclusion & Future Work

The proposed system provides a solution for night drivers when they feel sleepy while driving overnight to wake them up, for drunkards when they are over drunk, for rash driving by stopping the spark to the starter or sparkplug to cut the speed. It also displays warning messages for drivers by their loved ones when they are overdrunk or rash driving the vehicle in order to prevent accidents. In case of accident occurrence, the designed system is equipped with the capability of sending text messages to the emergency contact numbers by means of an IoT enabled application.

The future work may include a thumb sized tub to sprinkle water onto the subject's face when he/she is about to sleep. More sophisticated and less conspicuous hardware needs to be designed to hold the IR and accelerometer sensors. A steering wheel sensor may also be embedded in the system to monitor steering wheel movements at all points of time.

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