Design and Simulation of an Automated Road Safety Enhancement System by Testing the Physical Fitness of Driver

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Abstract. Most of the road mishaps occurred due to the mistakes of driver. The lack of physical fitness is one of the reasons for these kinds of accidents. Alcohol consumption and sleeping during driving also leads to accidents. The biological signals such as ECG, EEG and Heart Rate are considered to be good indicators to check physical fitness. To avoid the road mishaps, a micro-controller based system to sense the above mentioned parameters and to make a decision based on the sensed data is proposed in this paper. It consist of various sensors to detect biological signals, sleeping attitude and presence of alcohol in the blood of the driver. The micro-controller is programmed to make decision based on the sensed data. If the physical fitness of the driver is tested and verified successfully, can drive the vehicle. If not, the system automatically locks the engine and a message will be delivered to the control centre via wireless technology. The design and real time simulation of the proposed system is carried out in Proteus® and the micro controller programming is done in mikroC®.

1. Introduction
The mistake by driver is one of the reasons for major road accidents. The performance of the driver depends upon his current physical condition. This may be because of the driver fatigue and distraction [1]. Alcohol consumption and sleeping during driving also leads to accidents. The biological signals such as ECG, EEG and Heart Rate are considered to be good indicators to check current physical level of the driver [2]. To avoid this mishaps, a micro-controller based system to sense the above mentioned parameters and to make a decision based on the sensed data is proposed in this paper. The proposed system will detect various biological parameters and check whether the physical fitness of driver is good or not. The proposed system will be very useful for elderly car driver or driver with chronic diseases. It ensures safety driving and reduces the chance of road mishaps.

In past decades, many researches have performed to detect the fatigue and drowsiness of driver. Many of them are based on EEG signal bands (α, β and γ bands) [3]. These bands are occurred by the brain activity and it varies with respect to drowsiness or fatigue. For EEG based assessment, an algorithm is developed to assess driver fatigue based on the changes in EEG bands. Then estimated the drowsiness level by independent component analysis (ICA) of EEG and found the optimal locations to place EEG electrodes. Compared four algorithms
based on the four EEG Bands [4]. The result showed that a slight decrease of alpha activity and a significant decrease of beta activity were associated with fatigue. The fatigue during driving causes sleepiness.

Previous researchers has proved that the ECG is very helpful to identify the fatigue and sleeping [5]. The ECG signal obtained from the electrode that placed on chest. Then, R-R interval and QRS complex of measured ECG signal will be compared with the clinical one. So the drowsiness can be identified. The fatigue of driver leads to sleeping. So the detection of sleeping along with the fatigue detection is essential. The sleeping can be detected from eye blinking activity and Heart Rate (HR). The eye blinking activity can be sensed by eye blink sensor. While sleeping, the duration of pulse signal obtained from sensor is high and number of blinking is less. Heart Rate and HR variability can calculated from ECG signal by using computing algorithm. The HR during sleeping will be 40-50 bpm (Beats per Minute).

Alcohol impaired driving also leads to road mishaps. Alcohol taken long before driving can still affect the driver, even several hours later. This is because the body can only metabolize alcohol at a fixed rate, no matter how much has consumed. This leads to lack of coordination, poor decision-making and drowsiness. The detection and prevention of alcohol impaired driving achieved by water-cluster-detecting (WCD) breathe sensor [6]. The WCD breathe sensor detects breath by measuring electric currents of positively or negatively charged water clusters in breath that are separated by using an electric field. The WCD breath-alcohol sensor couples the WCD breathe sensor with an alcohol sensor and simultaneously detects the electrical signals of both breath and alcohol in the breath.

![Figure 1. Schematic representation of proposed system](image)

In this paper, a microcontroller based automatic system is proposed to monitor the physical fitness of driver. Here, the vital signals such as EEG, ECG and Eye Blinking are detected using sensor network connected to the microcontroller. These three parameters help to produce more accurate detection of fatigue. An alcohol sensor also used to avoid the alcohol effect on driving. The microcontroller makes decision based on above sensed vital information. The result continuously displayed on the LCD display. If the physical fitness of the driver is tested and verified successfully, then he can start the vehicle else the system automatically locks the engine and a message will be delivered to the main control centre via wireless technology. So, the
control station can provide medical aid to drivers. When physical fitness changes dangerously, an audio alert will give through audio buzzer for the attention of driver. The proposed system also consist of a sleep prevention device to awake the driver from sleeping.

The design and real time simulation of the proposed system is carried out in Proteus and the microcontroller programming is done in mikroC. The rest of the paper is organized as follows. Section 2 deals with the overview of the proposed system which consist of schematic diagram, block level representation, details of various blocks, circuit diagram and their process flow diagram. Section 3 details the simulation result and analysis. Section 4 depicts conclusions and future scope followed by references.

2. Overview of Proposed System

Fig 1 shows the schematic representation of proposed system. It consist of Health Monitoring System (HMS), Main Control Centre (MCC), GPS and GSM network. The HMS is placed on vehicle 1 & 2, which monitors the present heath condition of drivers of vehicle 1 & 2 respectively. The HMS also record the current location of vehicle with the help of GPS that helps to identify the location of vehicle by the MCC. All the HMS are connected to MCC via GSM network. When the driver meet with a serious health problems, the HMS automatically send message to MCC. Then the MCC inform the ambulance for medical aid and also inform the police.

![Figure 2. Block diagram of proposed system](image)

The detailed block diagram of the proposed system is given in Fig 2. The major block in this system is HMS. It contains Sensing Network Unit (SNU), Display & Alert Unit (DAU) and micro-controller. As soon as the vehicle is started, the HMS will turn ON. Then micro-controller check for the fitness and alcohol consumption rate of driver by analysing the sensed signals by SNU. The SNU senses biological signals such as EEG, ECG, Eye blinking and Alcohol effects. If the fitness test and alcohol test verified OK, can drive vehicle. Otherwise the ignition switch will be turned OFF. The HMS also monitor the health changes continuously during drive. When a health problem is detected at the time of driving, then DAC is given an alert to drivers. The DAU also consist of an audible alert and a sleep preventing devices in order to avoid sleeping...
while driving. When a serious health problem is detected by the HMS, an alert message will be sent to the MCC by means of GSM network. The MCC is a central monitoring station under the control of motor vehicle department, which observe the drivers through HMS equipped in each vehicle. The MCC has the contact with hospital and police. So, it can provide medical assistance or any help to drivers, when the emergency message is received from HMS.

2.1. Health Monitoring System (HMS)

The HMS is a micro-controller based system to check physical fitness and alcohol consumption of driver by analysing the biological signals. The biological signal are obtained from driver’s body by SNU unit associated with the micro-controller. The fig 2 consist of sensors to detect EEG signal, ECG signal, Eye blinking signal and alcohol effects. Here an innovative non-intrusive sensors for effective detection signals are used [7]. The fitness detection algorithm stored in the micro-controller memory helps to compute the above signals [8]. When the vehicle starts, the HMS begin to operate. Initially it check for the physical fitness level and check if any hazardous level of alcohol is consumed by the driver. If both are ok, then the driver can proceed the driving, otherwise he can’t proceed. The HMS continue its operation to monitor the health changes during driving. If any serious health problems detected, the micro-controller send emergency messages to MCC using GSM network. The DAU unit in the HMS give messages and alert to driver with the help of LCD display and audible alert using buzzer. The HMS also consist of a sleep detection and prevention system. The simulation diagram of the HMS is shown in fig 3. The detailed operation of SNU and DAU are given in the following section.

2.1.1. Sensing Network Unit (SNU)  
The SNU consists a group of sensors. They are EEG and ECG sensors, Eye Blinking detection and Alcohol detection sensors. The EEG sensor consists of different electrodes that placed on the skull which detects the four brain waves (α, β and γ). When the fatigue occurs, the brain waves will changes. The changes can be detected by comparing the sensed brain waves with its clinical waves using comparator. While changes occurs, the output of comparator will be high. Next, the important signal is ECG signal which

Figure 3. Circuit Diagram of HMS
is detected by the electrode that placed on the chest of the driver [9]. Then the R-R interval and QRS complex in the sensed ECG signal will be identified by algorithm stored in the microcontroller. By counting the QRS per minute, Heart Rate and HR variability can be measured. Next the important sensor is alcohol sensor which is placed in front of driver’s face that detects the alcohol effect from the breathing air. It produce a high pulse for the alcohol detection. The last one is, Eye Blinking sensor which produce pulse signal. By computing, no of eye blinking, eye blinking duration and Heart Rate of driver, sleepiness can be detected [10]. For a sleeping person, number of eye blinking is low, the eye blinking duration is high and the HR is in between 40-50 bpm. All the sensors are connected to various ports of micro-controller that are shown in fig 3.

2.1.2. Display and Alert Unit (DAU) The role of DAU are display the alert messages, produce audible alarm, control the engine operation and activate sleep prevention device. In this system an LCD display is used to display the alert messages and computational result of sensed biological signal. This is helpful for drivers to aware about his health condition. Here a buzzer circuit is set up to give audible alarm. When an emergency health problem detected, the buzzer circuit will be activated and give an audible alert. At that time, the health problem is displayed on the LCD. This unit consist of a control circuitry to turn ON/OFF of engine. While detecting an alcohol consumption, the micro-controller will be activate the control circuitry and turn off engine. Sleep prevention during driving is also one of the highlight of the proposed system. Here use a sleep preventive devices. It consists of vibrator and has a contact with the skin of driver. When the sleepiness is detected by the micro-controller, then the device will be activated and produce vibrations. So, the chance to fall into sleep can be avoided.

2.2. GPS and GSM Network
The HMS system consist of a GPS receiver. The HMS system update and store the current location of vehicle by using GPS. This information will be sent to MCC, while the emergency medical aid is requested to the MCC. The HMS and MCC are connected through GSM network. When any health problem has occurred, the HMS automatically send a voice message/text message to MCC. The message consists information of the driver and the details and location of the vehicle.

2.3. Main Control Centre (MCC)
It is a central monitoring system maintained and monitored under the control of motor vehicle department. It consist of microcontroller, host system and communication facilities. It check for the fitness of driver is capable for driving. If the fitness is not good, take action to stop driving

![Figure 4. Block diagram of Main Control Centre (MCC)](image-url)
and give medical aid to driver. So, the road mishaps due to physical problems can be avoided. All the operations of MCC are coordinated by the microcontroller. The host system connected to the microcontroller consist of the data base of vehicle. It also provide a software support to the MCC. Communication facilities are used to inform the police station and hospital about the health issues of drivers.

When the physical fitness of driver changes dangerously, an alert from HMS of that vehicle will be sent and it will be receive at the MCC. The message consist of information about health problem, vehicle number, driver details and current location of vehicle. Then the MCC forward this message to the hospital and police station to provide service to driver. Depending on the details of HMS message, the hospital/ police station can provide their service easily.

The circuit diagram of Main Control Centre (MCC) is shown in fig 5. Here use a PIC microcontroller (PIC 18F6622) that having two serial ports. So the host system and GSM module can be connected to the microcontroller simultaneously. It also consist of an LCD display to display alert messages while receiving any emergency messages from HMS in vehicle.

2.4. Steps Involved in Decision Making of Proposed System
The major steps of decision making involve fitness checking and alcohol detection. The fitness consists of fatigue detection and sleep detection. The sequence of operation that occurred in the proposed system is shown in fig 6. Initially check for an alcohol consumption, then it check for physical fitness if and only if the alcohol detection successfully verified. Next the check for the fitness. If the driver is physically fit, then can start vehicle. In case the physical fitness and alcohol detection failed, the vehicle cant start. The physical fitness ensure the EEG, ECG, Eye Blinking are normal. So the safety can be guaranteed.

3. Simulation Result and Analysis
The design and real-time simulation of the proposed system has been carried out in Proteus. The circuit diagrams of HMS and MCC are simulated and its outputs are verified. In HMS part, different biological signal are produced using signal generator available with Proteus. The GSM module is modelled using virtual terminal. The signal computing decisions for fitness
measurement are developed and compiled using microC tool. Then the hex file of computation algorithm is loaded into the micro-controller of the real-time simulation diagram drawn in Proteus. Similarly, the MCC circuits are set up in Proteus and its controlling algorithm is developed and compiled using microC. Then the hex file loaded and result have been verified. The snap shot of Proteus simulation result and result of compilation of microC program is presented in fig 7 and fig 8 respectively.

**Figure 6. Flow Chart of proposed system**

**Figure 7. Snap shot of Proteus simulation**

4. **Conclusions and Future Scope**
A microcontroller based system (HMS) to detect fatigue and physical fitness affecting factors such as alcohol consumption, sleepiness, etc. was proposed in this system. Decision has been taken by considering the sensed signals like EEG, ECG, Eye blinking and alcohol effect. If the fitness doesn’t meet with threshold value, then the micro-controller takes action to stop driving. In addition to this, the proposed system consist a centralized remote monitoring system (MCC) to check whether the HMS module equipped in vehicles are working normally or not. The
Figure 8. Snap shot of microC compilation result of program

MCC work under the control of motor vehicle department. The design and simulation of all the blocks has been carried out in Proteus and the software code were done in microC. The simulation results were verified and tested for correction. As a future deviation, one can think of the hardware design of this system and its prototype may also has importance.

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