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Fatigue Driving Detection Method Based on EEG Analysis

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ABSTRACT

Driving an automobile under high stress level reduces driver's control on vehicle and risk-assessment capabilities, often resulting in road accidents. Driver's anxiety therefore is a key factor to consider in accident prevention and road safety. This emphasizes the modern computing techniques to assist drivers by continuous stress level monitoring. Development of such a system requires designing a project, which can recognize the drivers' affective state and take preventive measures to account for escalating stress level. The Electroencephalography (EEG) Signal is used to detect the distraction when it occurs. The system uses the one channel EEG sensor device which can provide a Nerosky Mindwave signal such as Alpha, Beta, Gamma. On the other hand, attention and distraction value can be generated as well. This prototype system tested by the car driver achieved its purpose of detecting a distraction event and the signal is send to buzzer. In this we also used ultrasonic sensor to detect the near object and when the driver receives the call from the person, then the call automatically cut and sends the message to the person to not disturb while driving through GSM. In case of emergency the person calls again then the speed of the vehicle slows down automatically by using driver circuit and relay. This study tried to resolve those problem by implemented peripheral interaction concept for mobile phone user interface. Peripheral interaction is an activity where human interact with an object using periphery of attention. The purpose of implementing peripheral interaction for application user interface is to reduce the amount of attention, therefore the user can finish their main activity without being distracted.
Keywords: Microcontroller (AT89S52), EEG Sensor, Ultrasonic Sensor, GSM, Buzzer.

I. INTRODUCTION

An Embedded system is a computer system with a dedicated function within a larger mechanical or electrical system, often with real time computing constraints. It is Embedded as part of a complete device often including hardware and mechanical parts. Embedded systems control many devices in common use today. Examples of properties typical of embedded computers when compared with general-purpose ones are low power consumption, small size, rugged operating ranges, and low per-unit cost. This comes at the price of limited processing resources, which make them significantly more difficult to program and to interface with. However, by building intelligence mechanisms on the top of the hardware, taking advantage of possible existing sensors and the existence of a network of embedded units, one can both optimally manage available resources at the unit and network levels as well as provide augmented functionalities, well beyond those available.

A Microcontroller (sometimes abbreviated μC, uC or MCU) is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. Program memory in the form of Ferroelectric RAM, NOR flash or OTP ROM is also often included on chip, as well as a typically small amount of RAM. Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general-purpose applications. Microcontrollers are used in automatically controlled products and devices, such as automobile engine control systems, implantable medical devices, remote controls, office machines, appliances, power tools, toys and other embedded systems. By reducing the size and cost compared to a design that uses a separate microprocessor, memory, and input/output devices, microcontrollers make it economical to digitally control even more devices and processes. The rate of deaths and injuries due to traffic accidents are increasing year by year. After alcohol, driver drowsiness is the second leading cause of the road accidents. Driver drowsiness is the cause of thousands of road accidents each year. The driver fatigue is a contributory factor in up to 20% of road accidents and up to one quarter of fatal and serious accidents. Driver drowsiness can cause several physical and economical losses. Drowsiness refers to feeling sleepy or tired or being unable to keep your eyes open. In this state the person's drowsiness and driving is a very hazardous and it is very difficult to identify. If the driver failing to concentrate on driving it reduces the driver reaction time and impairs steering behavior. There are various methodologies used for the selection drowsiness. Using physiological signals is one of the common driver drowsiness detection methods. Physiological signals are more suitable to find the driver sleepiness.

The physiological measure is a direct measure of driver fatigue. Electrocardiogram (EEG), Electromyogram (EMG), Electro encephalogram (EEG), Electrooculogram (EoG) and eye movements are possible measures for physiological signals. EEG signals are considered to be a very good measure of drowsiness because of their strong correlation electroencephalogram (EEG) is used to evaluate the electrical activity in the brain. Brain cells communicate with each other through electrical impulses. These brainwaves are used for EEG. The power spectrum analysis of this EEG signal is used for the drowsiness detection of the driver. When the driver moves from alert state to drowsy state there is a significant increase in alpha and theta band powers. These changes occur more dominantly in the occipital and parietal regions when compared to the other regions.

II. PROPOSED METHODOLOGY

A system has been proposed to monitor the driver behaviour and to detect when he/she is asleep and to alert. EEG method of detection is used to alert. This method has proven to be the most reliable and efficient. The process starts from the driver. The Electrodes are placed over the head of the driver.

The regions that are to be concentrated are the occipital and parietal regions of the brain, since they have the most correlation with the drowsiness of the brain. The signals emitted from the brain due to the neural activity are captured by the electrodes. These signals are amplified and processed by an EEG Amplifier.

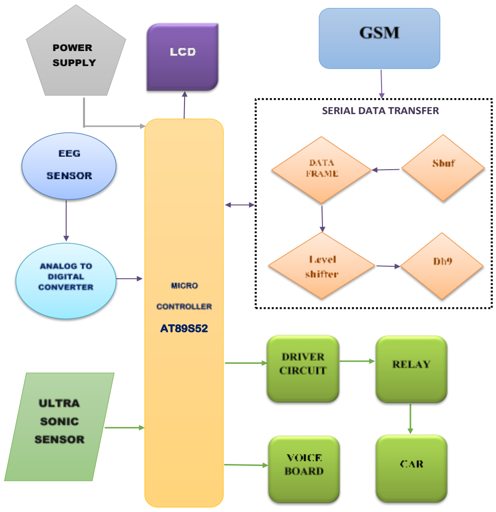

Fig 1: Block diagram of mental fatigue detection

This processed signal is free from noises and the frequency is adjusted. This signal is stored in the form of datasets for further processes. This dataset is fed to the MATLAB software for computing the power spectrum of the signal. The MATLAB software processes and converts the values to signals. It is difficult to compute the Power spectrum when the signal is in time domain. So, the time domain EEG signal is converted into frequency domain signal. This frequency domain signal is converted into respective power spectrum with the help of Fast Fourier Transform (FFT). The feature extraction is done from this spectrum.

The signal is then sent to Microcontroller which is responsible for the alert system. If the driver is sleepy the power spectrum will be less than that of the threshold set in the controller. If the driver moves from an alert state to sleepy state the power spectrum is only little less than the threshold. This makes the first alert, buzzer to be switched ON to wake up the driver. If the driver is in a very sleepy state, then the second alert, GSM is switched ON. The GSM will send a message to the person in-charge of the /the car owner/ to the driver. This ensures safety.

When the driver is in extreme drowsiness, the power spectrum is very much less than that of the threshold. At this time the relay connected with an ultrasonic sensor is switched ON. The ultrasonic sensor is placed in the rear bumper of the car. The ultrasonic sensor measures the distance of any other vehicle behind the car. If there is a safe distance the relay acts then turn off the ignition and the car stop, else if the vehicle is near the car, it will give a long buzzer alarm to ensure the driver wakes up.

A. HARDWARE DESCRIPTION

1. Micro Controller
2. EEG Sensor
3. GSM
4. Voice Board
5. Ultrasonic Sensor

6. LCD
7. Relay

1. Microcontroller:

1) The AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the Indus-try-standard 80C51 instruction set and pin out.

2) 

Fig 2: AT89S52 microcontroller

2. EEG Sensor:

An EEG machine measures the electrical activity in the cerebral cortex, the outer layer of the brain, during an EEG test. EEG sensors are placed on a participant's head, then the electrodes non-invasively detect brainwaves from the subject.

Fig 3: EEG Sensor

EEG sensors can record up to several thousands of snapshots of the electrical activity generated in the brain within a single second. The recorded brainwaves are sent to amplifiers, then it is sends data to the cloud to process the data. The amplified signals, which resemble wavy lines, can be recorded on a computer, mobile device, or on a cloud database. Cloud-computing software is considered a critical innovation in EEG data processing, as it allows for real-time analysis of recordings at scale in the early days of EEG measurement, waves were simply recorded on a graph paper.

3. GSM:

GSM Modem provides full functional capability to Serial devices to send SMS and data over GSM Network. The product is available as board level or enclosed in metal box. The board level product can be integrated in to various serial devices in providing them SMS and data capability and the unit housed in a metal enclosure can be kept outside to provide serial port connection. The GSM Modem supports popular "AT" command set so that users can develop applications quickly. The product has SIM card holder to which activated SIM card is inserted for normal use. The power to this unit can be given from UPS to provide uninterrupted operation. This product provides great feasibility for Devices in remote location to stay connected which otherwise would not have been possible where telephone lines do not exist.

Fig 4: GSM Module

4. Ultrasonic Sensor:

Ultrasonic sensors (also known as transceivers when they both send and receive) work on a principle similar to radar or sonar which evaluate attributes of a target by interpreting the echoes from radio or sound waves respectively. Ultrasonic sensors generate high frequency sound waves and evaluate the echo which is received back by the sensor.

Sensors calculate the time interval between sending the signal and receiving the echo to determine the distance to an object. This technology can be used for measuring: wind speed and direction (anemometer), fullness of a tank and speed through air or water. For measuring speed or direction a device uses multiple detectors and calculates the speed from the relative distances to particulates in the air or water.

Fig 6: Ultrasonic Sensor

5. LCD:

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.

Fig 7: 16x2 LCD Display

6. Relay:

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and they are double throw (changeover) switches. Relays allow one circuit to switch a second circuit which can be completely separate from the first. For example, a low voltage battery circuit can use a relay to switch a 230V AC mains circuit. There is no electrical connection inside the relay between the two circuits; the link is magnetic and mechanical.

Fig 8: Relay

A.Software Description:

1. KEIL Compiler:

The main purpose of using the microcontroller in our project is because high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. By combining a versatile 8-bit CPU with in-system programmable Flash on a monolithic chip, the Atmel AT89S52 is a powerful microcontroller which provides a highly-flexible and cost-effective solution to many embedded control applications. The programs of the microcontroller have been written in Embedded C language and were compiled using KEIL, a compiler used for microcontroller programming. The communication between PC and the microcontroller was established MAX 232 standard and those programs were also done in C language.

2. Proteus:

Proteus (PROcessor for TExt Easy to USe) is a fully functional Proteus incorporates many functions derived from several other languages such as C BASIC, Assembly, Clipper/dBase it is especially versatile in dealing with strings, having hundreds of dedicated functions; this makes it one of the richest languages for text manipulation. Proteus was initially created as a multiplatform (DOS, Windows, Unix) system utility, to manipulate text and binary files and to create CGI scripts. The language was later focused on Windows, by adding hundreds of specialized functions for: network and serial communication, database interrogation, system service creation, console applications, keyboard emulation, ISAPI scripting (for IIS). Most of these additional functions are only available in the Windows flavour of the interpreter, even though a Linux version is still available.

III. EXPERIMENTAL RESULT

The Fig. 3 shows the Hardware working module. It consists of Microcontroller, EEG Sensor, Relay, GSM, Buzzer and LCD Display.

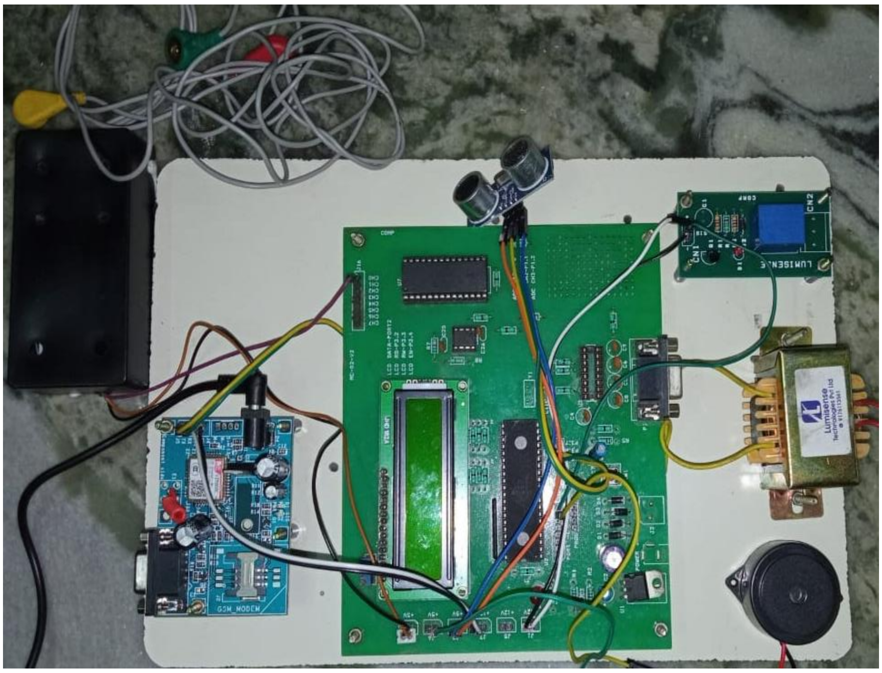

Fig 3: Hardware Working Module

The Fig. 4 shows that Normal Concentration Level result is displayed in the LCD display. The signal from EEG sensor placed above the drivers to monitor continuously and data are displayed in the LCD display.

Fig 4: Normal Concentration Result of Driver

The Fig. 5 shows that distraction result is displayed in the LCD display. The signal from EEG sensor placed in the drivers is continuously monitored and data are displayed in the LCD display. If any distraction occurs or the concentration level cross beyond the limit then the Buzzer turn on, the car speed gets slow down using the relay which is connected to the Microcontroller and the alert send to the authorized person.

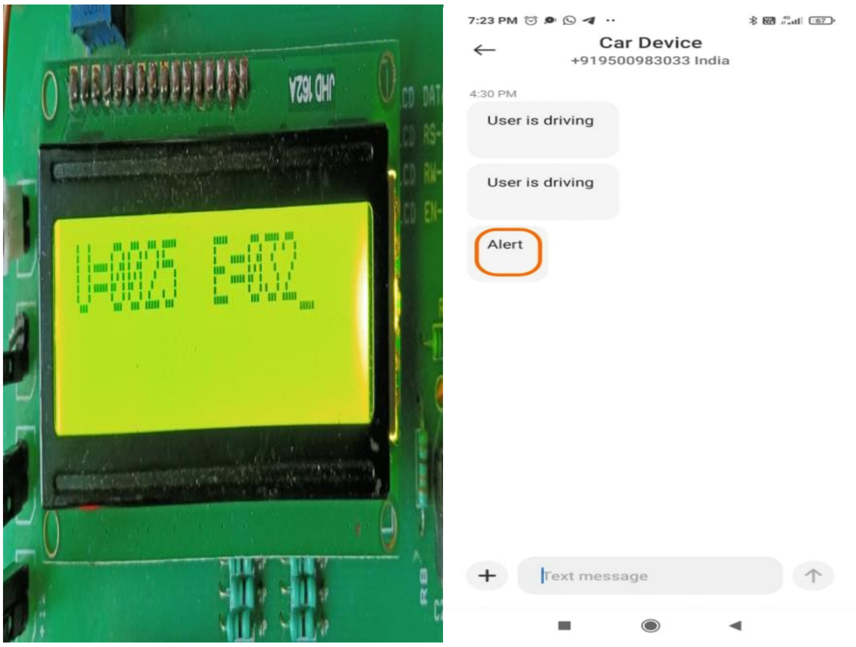

Fig 5. Distraction Result of Driver

The Fig. 6 shows the Distance of Object from user device (Car) using Ultrasonic Sensor. If the distance of object is less than the limit from user device, then microcontroller send the signal and buzzer turn on.

Fig 6. Distance of Object from user device (Car) using Ultrasonic Sensor

The Fig. 7 shows the Alert message to Person (Caller). The message send to caller as USER DRIVING and Call Ring is displayed in LCD Display to User as Driver.

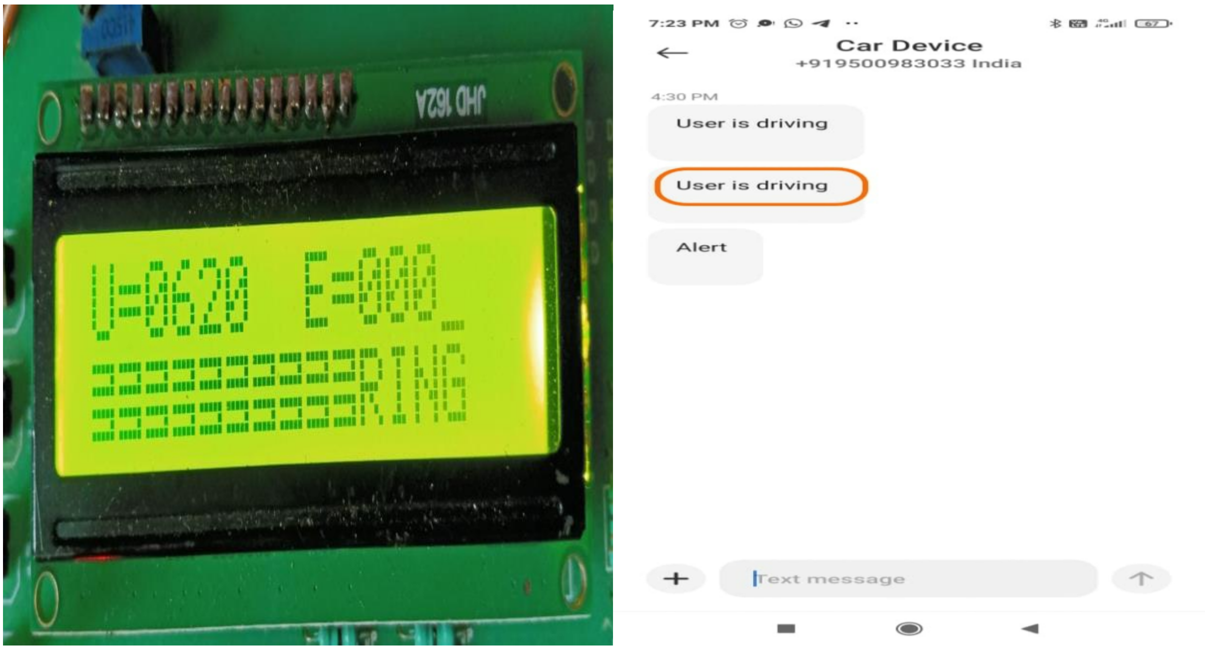

Fig 7. Alert Message to Person (Caller)

The Fig. 8 Shows the Alert Ring displaying in LCD display to User (Driver). The Alert Ring is displayed to driver, when the person call continously and also the car stops automaticaly using relay which is connected to Microcontroller.

Fig 8. Alert Ring

IV. CONCLUSION

Thus, the proposed model proves to be reliable and efficient method for the driver drowsiness detection. Since this method uses EEG signals where the recorded waveforms reflect the cortical electrical activity, the accuracy of the system is more. Instead of using large number of EEG channels we can use only four channels in occipital and parietal regions to detect drowsiness. This is significant as it is a drowsiness detection system with only a few electrodes, making it suitable for real time driving conditions. This model not only detects but also alerts the driver to avoid road accidents. When the driver becomes drowsy, the EEG signal reflects it and the driver is alerted according to his/her level of drowsiness. The system uses only simple devices to give the alert. This model doesn't only detect drowsiness caused because of sleep, but also detects drowsiness caused due to alcohol consumption, illness, etc. This method is effective and accurate and can deal with even little deviation from the alert state as it deals with the brain signals emitted from neuron of brain. This can prevent a major percentage of accidents that occur due to drowsiness. Thus, the proposed model proves to be reliable and efficient method for the driver drowsiness detection. This model not only detects but also alerts the driver to avoid road accidents. This is of less cost and can be implemented in real time easily

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