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Driver Alert System Using Accelerometer and MSP430

Md Ateeq ur Raheman[1], K. Jyotsna[2], V. Naveen Kumar[3], P. Sai Kumar[4]

[1]PG student, Department of Electronics and Communication Engineering,
VNR Vignana Jyothi Institute of Engineering and Technology, Hyderabad, India
ateeqmd3027@gmail.com

[2]Assistant Professor, Department of Electronics and Communication Engineering,
VNR Vignana Jyothi Institute of Engineering and Technology, Hyderabad, India
jyotsna_k@vnrvjiet.in

[3]Project Engineer, Research and Consultancy Center,
VNR Vignana Jyothi Institute of Engineering and Technology, Hyderabad, India
naveenkumar_v@vnrvjiet.in

[4]PG student, Department of Electronics and Communication Engineering,
VNR Vignana Jyothi Institute of Engineering and Technology, Hyderabad, India
peddapallisaikumar@gmail.com

Abstract: *In this paper, we describe a real-time safety prototype system that controls the vehicle speed and warns the driver under driver fatigue. The purpose of such a model is to advance a system to detect fatigue symptoms in drivers, warns the driver and controls the speed of a vehicle to avoid accidents. A prototype system aims at developing a low cost, low powered product oriented design, in which acceleration 'g' values from accelerometer sensor are monitored. The accelerometer is interfaced to a MSP430F5438A Microcontroller. The acceleration 'g' values are monitored and if it exceeds the predefined threshold limit than audio prompts (warning the driver) are generated and speed of the vehicle is controlled. And also on the LCD warnings are displayed. If the threshold exceeds the maximum level which indicates accident has occurred than airbags are opened. As and when the threshold value is reached a message is sent to the concerned authority so that they can take necessary action.*

Keywords: *MSP430F5438A Microcontroller, Driver fatigue, Accelerometer, Audio prompts.*

1. INTRODUCTION

Road accidents may occur due to loss of attention of the driver. Real-time monitoring of the driver's alertness level is necessary. Sleep-deprived driving is the operation of a motor vehicle while being cognitively impaired by a lack of sleep. Sleep deprivation is a major cause of motor vehicle accidents, and it can impair the human brain as much as alcohol can. According to the National Sleep Foundation's 2005 Sleep in America poll, 60% of adult drivers – about 168 million people – say they have driven a vehicle while feeling drowsy in the past year, and more than one-third, (37% or 103 million people), have actually fallen asleep at the wheel! In fact, of those who have nodded off, 13% say they have done so at least once a month. Four percent – approximately eleven million drivers – admit they have had an accident or near accident because they dozed off or were too tired to drive [1]. The National Highway Traffic Safety Administration conservatively estimates that 100,000 police-reported crashes are the direct result of driver fatigue each year. This results in an estimated 1,550 deaths, 71,000 injuries, and $12.5 billion in monetary losses. These figures may be the tip of the iceberg, since currently it is difficult to attribute crashes to sleepiness.

Numerous studies have found that sleep deprivation can affect driving as much as (and sometimes more than) alcohol. British researchers have found that driving after 17 to 18 hours of being awake is as harmful as driving with a blood alcohol level of 0.05%, the legal limit in many European countries. Men under 30 are more likely to be in an accident caused by sleep deprivation [1], [2].

We have developed a low cost, low power, portable embedded system which detects driver's drowsiness.

This paper is organized as follows: in section 2 the related work about the detection of driver fatigue is presented. Section 3 and 4 describes the proposed method. Experimental results are shown on section 5 and finally section 6 presents the conclusion and future scope.

2. RELATED WORK

Some research works have already been performed in order to detect driver's fatigue. Driver's fatigue state detection can be broadly classified into three categories: First one use physiological characteristics, second one use facial image features and the third one use the sensors which are not attached to the human body.

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The first one detects the change of driver's physiological characteristics such as brain waves, heart rate and pulse rate [4], [5]. In spite the detection accuracy is good, but some special devices must be attached on driver's body. It is intrusive and causing annoyance to the driver.

The Second one detects eyelid movement, head movement, and yawning based on some image features. People in fatigue show some visual behaviour easily observable from changes in their facial features like eyes, head and face [3]. But from person to person these features vary (few people eyes are small and others have big eyes) and detection accuracy is less. And also if there is some other distraction (kids on board playing), which cannot be detected by facial features.

The Third one detects the fatigue of a driver irrespective of their facial features, Accelerometer sensor is fixed on a vehicle, steering abrupt movements are monitored and also the threshold limits of acceleration are compared. If the values exceed the threshold, warning message is displayed on the LCD and audio prompts are generated to warn the driver. In this method including drowsiness, rash driving is also detected.

3. SYSTEM DESIGN

a. Hardware Architecture

Figure.1 shows the Hardware Architecture of the monitoring system. The hardware system includes Microcontroller, Accelerometer Sensor, Audio speaker, LCD Display, GSM modem and Motor. In this paper MSP430F5438A Microcontroller is chosen to complete the core control; ADXL330 Accelerometer sensor is used to measure acceleration values which are calibrated to measure the driver fatigue state; APR9600 Voice module is used to generate audio prompts like warning the driver to drive slowly or take a break or have a cup of tea; GLCD HD66753 to display a warning message; GSM Modem SIM300 to send messages to the owner of a vehicle or to the police or the rescue team; and Motor is used to control the speed of a vehicle.

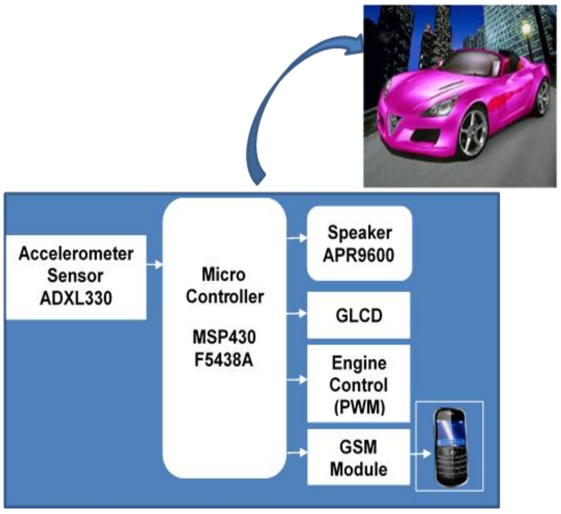

Figure1: Hardware Architecture of the monitoring system.

The setup is mounted on a prototype car, initially when the setup is powered this car runs at a predefined speed. An obstacle is placed in the path of the car, which generates the first threshold limit through an accelerometer sensor. After the first threshold is generated audio prompts are generated like "Drive slowly" or "Take a break or "Have a cup of tea" and also visually on LCD, these messages are flashed which alerts the driver, before it's too late and also the car speed is reduced to prevent an accident. A message is also sent to the owner of the car through GSM modem informing him that driver is driving carelessly or is feeling sleepy. Again another obstacle is placed in the path of the car, which causes the car to fall and second threshold limit is generated. This threshold indicates an accident has occurred. A message is sent to the police, rescue team and the owner of the vehicle informing them that an accident has occurred, so that they can take necessary action. Automatically the car ignition is stopped, to reduce the impact of an accident.

i. MSP430F5438A Controller

TI's MSP430F5438 is used as the processor of this Driver Alert System. The processor was chosen because of its good features and integrated peripherals. Its portability and low-power consumption design can satisfy the prolonged outdoor work. MSP430F5438 Microcontrollers (MCU) from Texas Instruments (TI) is a 16-bit, RISC-based, mixed-signal processor designed specifically for ultra-low-power. It is combined with a flexible clock system by using a Von-Neumann common memory address bus (MAB) and a memory data bus (MDB) [6], [7]. Figure. 2, shows the block diagram of this microcontroller. MSP430F5438 has the right mix of intelligent peripherals, ease-of-usage, low cost, and the lowest power consumption for thousands of applications.

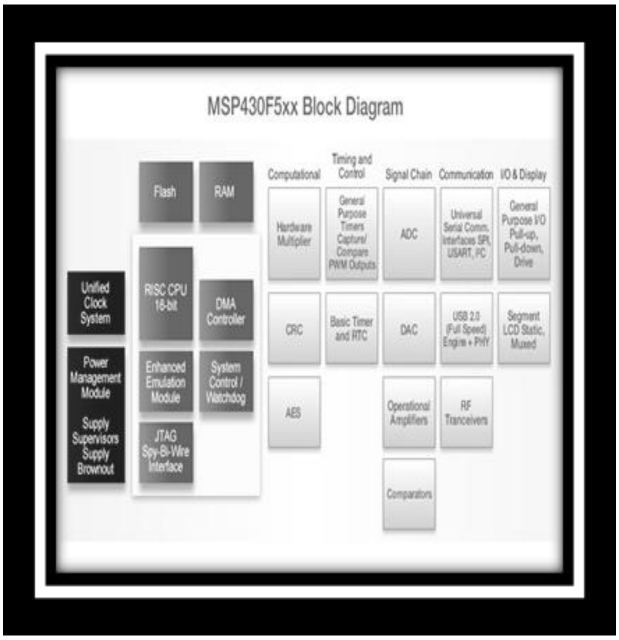

Figure2: Block diagram of the MSP430F5438A Microcontroller

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Its flexible clocking system, multiple low-power modes, instant wakeup, and intelligent autonomous peripherals enable true ultra-low-power optimization, dramatically extending battery life. Its power modes are shown in Table 1. The system is running in Active Mode. If the process is finished, the system will be in Standby Mode.

Table 1: MSP430F5438 Power Modes

Mode	Current
Active Mode(AM)	165µA/MHz
Standby Mode (LPM3 RTC Mode)	1.5µA/MHz
Off Mode(LPM4 RAM Retention)	1µA/MHz
Shutdown Mode(LPM5)	0.1µA/MHz

ii. Accelerometer

An accelerometer is an electromechanical device that will measure acceleration forces. These forces may be static, like the constant force of gravity pulling at your feet, or they could be dynamic, caused by moving or vibrating the accelerometer [8]. The accelerometer is used to find the drift of a vehicle. It continuously monitors the how the driver applying breaks at various instances. If the driver exceeds speed limits and applies breaks improperly, it prompts the driver by giving voice commands.

iii. Audio device

Audio interfaces may include voiced commands, such as those given by Navigation systems or even simple beeps and sounds. Hotspots are the places where the audio promptings are given based on the database of Hotspots. Most vehicles are equipped with warning beeps to indicate if the driver has left driver headlights on or if the driver is not wearing seatbelt.

These beeps are useful if the driver knows what the sound means, or if the sound occurs conjunction with a visual cue. APR9600 voice module is used to generate audio prompts. The APR9600 device offers true single-chip voice recording, non-volatile storage, and playback capability for 40 to 60 seconds. The device supports both random and sequential access of multiple messages [10].

iv. Global System for Mobile Communication (GSM)

GSM (Global System for Mobile Communications, originally Group Special Mobile), is a standard set developed by the European Telecommunications Standards Institute (ETSI) to describe protocols for second generation (2G) digital cellular networks used by mobile phones. GSM Modem is a data oriented GSM transceiver system that uses a network provider to connect and transfer data. Using a network provider infrastructure has several advantages. Among them is a low initial cost (you don't need to setup an expensive transceiver rig to cover a long distance), reliable, easy to use, and has wide coverage [9].

GSM Modem is used to send messages to the owner of the vehicle, when threshold limits are reached. Two types of messages like rash driving by the driver and an accident of the vehicle are delivered to the owner. Messages are also sent to the Police and rescue team when an accident has occurred.
Using the MAX3232 generates the required negative voltage for a RS232 line and translates the TTL level signals from the MSP430F5438 levels to RS232 levels. The MAX3232 board is used for establishing RS232 communication with devices powered from 3V ~ 5V [11]. It contains RS-232 Transceiver and DB9 connector used for connecting MCU and GSM Modem.

The default serial communication parameters of most GSM modem are set as follows:

a. 9600 Baud rate.
b. 8 data bits
c. No parity bit
d. 1 stop bit

v. Motor Control

A DC motor is a mechanically commutated electric motor powered from direct current (DC). The stator is stationary in space by definition and therefore the current in the rotor is switched by the commutator to also be stationary in space. This is how the relative angle between the stator and rotor magnetic flux is maintained near 90 degrees, which generates the maximum torque.

Two DC motors are used to move the car. Speed control is done using Pulse Width Modulation (PWM). Initially both the motors will be running at a set speed (predefined). When an obstacle is placed in the path of the car which generates first threshold limit, causes the motor to slow down. When the second threshold limit is reached causes the motor to stop, which is an accident level indication.
Voltage levels of the MSP430F5438A microcontroller cannot drive the DC motors; hence the L293D motor line driver is used to drive the motor.

vi. Graphical Liquid Crystal Display (GLCD)

The HD66753, dot-matrix graphics LCD controller and driver LSI, displays 168-by-132-dot graphics for four monochrome grayscales. When 12-by-13-dot size fonts are used, up to 13 lines x 11 characters (143 characters) can be simultaneously displayed. Since the HD66753 incorporates bit-operation functions and a 16-bit high-speed bus interface, it enables efficient data transfer and high-speed rewriting of data in the graphics RAM [7].

GLCD is used to display the readings of the accelerometer and is also used to flash messages to alert the driver.

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4. ALGORITHM

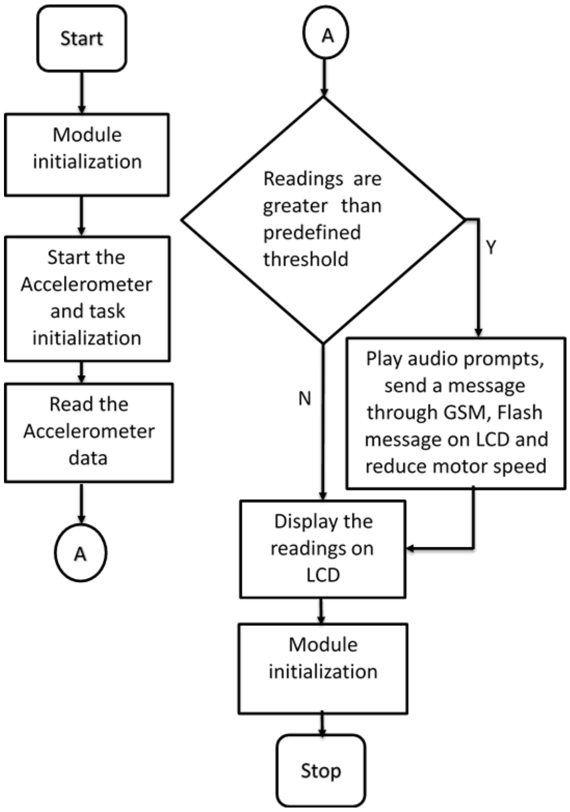

Figure3: Flow chart of the project

Flow chart of the Project shown in Figure 3:
The flow chart shows that,
Step 1: Initializing the task and modules
Step 2: Reading the accelerometer values and if it exceeds the threshold limit audio prompts, visual indication on LCD is generated warning the driver to take control of the vehicle and message is sent through GSM modem to the owner of the vehicle. And also the motor speed is reduced.
Step 3: Display the readings of accelerometer.

5. EXPERIMENTAL RESULT

The setup is powered by DC battery 12V. All the interfaces are done as shown in the Figure.4. GSM, DC motors, APR9600 voice module are interfaced to the TI MSP430F5438A Experimenter board. These board has inbuilt ADXL330 3-axis Accelerometer sensor and HD66753 GLCD.

Tests have been performed on the setup which is shown in Figure 4, a car like prototype is developed. Threshold limits are forcibly generated on this setup and tested. Drowsiness condition is created and tested on this setup, and successfully warnings and messages were delivered and speed of the prototype setup is slowed down.

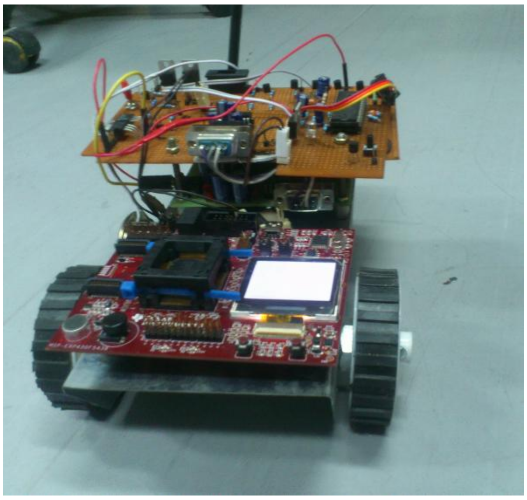

Figure 4: Complete setup of Driver Alert System

Accelerometer values are monitored as shown in Figure.5, as and when the threshold limits are reached: Voice alerts are generated, motor speed is controlled, messages are sent through GSM modem and messages are flashed on LCD to alert the driver.

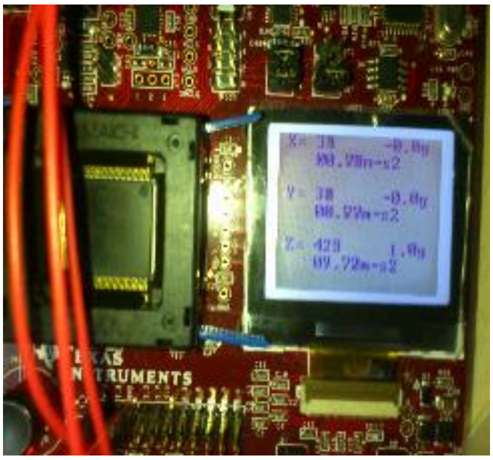

Figure 5: Acceleration 'g' values displayed on GLCD

6. CONCLUSION AND FUTURE SCOPE

In this paper we have designed a low cost, low power, product oriented design for detecting the drowsiness of the driver and alerting the driver to prevent an accident. The system is designed using a low power microcontroller MSP430 and an accelerometer ADXL330. When an accident occurs message is sent to the rescue team so that they can take an appropriate action to reduce the level of damage. The message is also sent to the owner of the vehicle, who will know the driving behavior of the driver and also an early notice of an accident as and when it happens.

This project can be extended by integrating Accelerometer, Camera and Brain waves based drowsiness detection all on a single platform which simultaneously monitors the driver drowsiness, which provides more accurate results.

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