Prototyping of Multi-Factors Based Vehicle Accident Detection and Reporting System Relying on GPS and GSM

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Abstract : Several car accidents are reported everyday worldwide, and many fatalities and injuries occur that can be predicted and prevented. This paper does not focus on those accidents that get reported, but instead it focuses on the accidents that do not get reported and result in major injuries and fatalities that can be avoided by simple notification that can be sent to the right people at the right time, so that help can be sent even if the people in need of it are not capable of requesting it. The proposed system can be considered as a tool for the safety of the car passengers in addition to the already existing seat belts. The optimum speed of arrival of the help is achieved in this work by implementing GPS such that a website link that contains the exact location of the accident is sent in order to find the location of the accident instantly without having the people involved in the accident to have to report their location. This paper aims mainly to design a system that can detect one of three cases, the first one is when there is an accident and the air bags do not deploy, while the second case is when there is an accident, and the air bags are deployed, and the third case is an SOS message in case there was a need for it. Of course, there might happen a small accident that does not require the system to send a notification, so there is a switch that can be pushed in order to prevent the system from sending faulty alarms.

Key words: GPS, GSM, GPRS, Car accident, MPU IMU 6050.

خلاصة:

يومياً يتم الإبلاغ عن العديد من حوادث السيارات في جميع أنحاء العالم، وتحدث العديد من الوفيات والإصابات التي يمكن التنبؤ بها والوقاية منها. هذه الورقة لا تركز على تلك الحوادث التي يتم الإبلاغ عنها فقط، ولكن تركز بدلاً من ذلك على الحوادث التي لا يتم الإبلاغ عنها وتؤدي إلى إصابات ووفيات خطيرة يمكن تجنبها من خلال إخطار بسيط يمكن إرساله إلى الأشخاص المناسبين في الوقت المناسب، بحيث يمكن إرسال المساعدة حتى لو كان المحتاجون إليها غير قادرين على طلبها. يمكن اعتبار النظام المقترح أداة لسلامة ركاب السيارة بالإضافة إلى أحزمة الأمان الموجودة بالفعل. يتم تحقيق السرعة المثلى لوصول المساعدة في هذا العمل من خلال تنفيذ نظام تحديد المواقع العالمي (GPS) بحيث يتم إرسال رابط موقع يحتوي على الموقع الدقيق للحادث من أجل العثور على مكان الحادث على الفور دون أن يضطر الأشخاص المتورطون في الحادث إلى الإبلاغ عن موقعهم. تهدف هذه الورقة بشكل أساسي إلى تصميم نظام يمكنه اكتشاف واحدة من ثلاث حالات، الأول هو عندما يكون هناك حادث ولا يتم نشر الأكياس الهوائية، في حين أن الحالة الثانية هي عندما يكون هناك حادث، ويتم نشر الأكياس الهوائية، والحالة الثالثة هي رسالة SOS في حالة وجود حاجة إليها. بالطبع، قد يحدث حادث صغير لا يتطلب من النظام إرسال إشعار، لذلك هناك مفتاح يمكن دفعه لمنع النظام من إرسال إنذارات معيبة.

1. Introduction

Car accidents are a major public concern since the statistics imply that the lives of more than three thousand people around the world are threatened daily because of road accidents. Also, road accidents lead to large economic wastes as calculated in road accident injury arounds to about 518 billion USD annually. The huge economic losses are a burden for the countries [1]. Car accidents are a concerning matter because of the high rate of death worldwide. Out of all possible causes of death that include all ages of human beings, road accidents are number 11. Road safety is a huge concern that it wouldn't be false to assume it is as great as some of the life-threatening diseases. Lots of research has already been taken on the matter of road safety that cover many aspects of the reasons of accidents that include environmental psychological, and physical aspects [2] [3]. One of the issues is the variety of advertisements on the roadside, which may distract the drivers from observing the road. Other causes of accidents may include talking over the mobile or text messaging. Radio information is also a factor that may affect the focus of the drivers. New studies prove that when a driver gets distracted, the attention is led astray, which causes bad decisions at all times, and leaves a bad impact on his driving skills. This distraction affects the primary duty of the driver, which is focusing on the road and having a stable decision-making process [4]. When accidents occur, it is required to provide assistance to people involved in the accident. Recently, wireless technologies are having more success in their various application uses like never before. Nowadays, cars are equipped with some survival technologies that function as a protection from accidents, one of these technologies is the air-bag system, which get inflated automatically when an accident is detected by the sensors around the car that are dedicated for this purpose [5][6]. In other mobiles there is an accident alarming system that sends an alert message to a nearby hospital in order to send ambulances to the exact location of the accident [7][8].

2. Related work

The large dependence on cars has increased road jams and accidents. The goal here is to get notified of road accidents, and to shorten the time wasted waiting for a clear path, and to acquire an easy-going path for urgent commute. A spontaneous accident detection scheme is beneficial in acquiring the exact place of a car crash, and to reach the crash location quickly. Here are related works on the same goal. In [9], the discussed system detects crashes by utilizing both a sensor for vibration and a Micro Electro-Mechanical System, which is abbreviated (MEMS). In [10] an Arduino controller board was used to acquire the incoming information from both the sensor of vibration, and the distance sensor that is an ultrasonic board. A sensor for heart beats was used as well. A GPS technology board was used to send car crash coordinates to a data acquisition center. These data were compared instantly with a regular data set that is previously saved inside the Arduino controller board. If mismatch happened, then it sent a notification by using Internet of Things, which is abbreviated (IoT). In that case, the car is stopped instantly. Various information was displayed through the use of an LCD. In [11] the proposed system can detect the accident, then the exact coordinates of the car are sent to a phone number that was is predefined in the programming. This process is done using the GSM network. This system had a disadvantage, which is that system will only detect the crash if velocity of moving car is under a certain value for a certain duration of time, which means that when the car is not moving due to a traffic jam, then the system sends an SMS, which is a faulty one. In [12] the researchers explained the importance of smart helmet to ensure safety for the motorcyclists, a system was also implemented by utilizing a raspberry pi board and open CV. The main goal was to introduce the importance of wearing the helmet properly to ensure safety on the road. In [13] the proposed system is rather in a different focus, that is because it aims at theft prevention, but some technologies used in that design are crucial for

The system proposed in the work. The GSM technology was used to provide a signal to the buzzer and alarm the owner of the vehicle about possible theft attempt, so another SMS sent from the opposite direction can prevent the engine from starting. In [14] a microcontroller-based board alerts the police units through a GSM board so that they can triangulate the position. In [15] the suggested system measures the eye closure ratio and considered it the crucial variable to decide the level of drowsiness the man behind the steering wheel. That system used a camera in order to take pictures of the eyes of the driver. In [16] the system introduced an IoT approach in the vehicle for preventing the accidents and keeping the drivers safe.

3. Proposed system

The system that is shown in figure (1) implements Short Message Service (that is abbreviated SMS) based controlling scheme for supervising car accident using an Arduino Mega board, which includes an ATmega2560 Micro-Controller Unit (MCU). The microcontroller acts as the bridge between the Global System for Mobile communications (GSM) board - that contains a SIM 808 communication module, this module may also activate General Packet Radio Service (GPRS) communication which is helpful with various sensors and triggers for monitoring the occurrence of car accident. The GSM board includes the Subscriber Identity Module (SIM) card slow that the device can utilize to send a notification in case of car crash.

This automation system consists of 3 parts: The Mobile Station (MS) which is implemented in a car to be monitored, the Base Transceiver Station (BTS), and the other mobile station which could be a personal number of emergency number in a hospital. The 3 parts are shown in Figure 1. MS is a phone that can use SMS, BTS is an equipment that simplifies communications.

Table 1: General features of SIM808 board.

Band	Quad-band 850/900/1800/1900MHz
GPRS	Yes: GPRS mobile station class B
Bluetooth	Bluetooth 3.0
Dimensions	24.0*24.0*2.6mm
Weight	3.30g
control	Control via AT commands
Power supply	Supply voltage range 3.4 ~ 4.4V at 2A
Operation temperature	40℃ ~85℃

Both MS and BTS are already utilized in the country, so the research focuses only on designing and implementing of the accident monitoring system, which includes an Arduino Mega2560 board, a GSM/GPRS Sim808 board, a set of MPU6050 Gyroscope / Accelerometer sensors for SOS trigger input, and a data line from the airbag computer in the car in the event of airbag deployment

SMA antenna interface: there is a GSM antenna interface, a GPS antenna interface onboard and a BT antenna interface. The pins of RXD is the RXD of SIM808 and the pins of TXD is the TXD of SIM808 for communication between the Arduino board and the GSM board. For audio (optional) there is two 3.5 jack interfaces for microphone and speaker. Also, it contains USB interface: This interface is just used to update the firmware of SIM808 module.

The Global Positioning System (GPS) is a technology that got popular since it has many uses. It was developed by the Department of Defense (DoD) in America for only military use in the beginning. Then got released for the public use. It is implemented in a huge number of applications such as location tracking, arrival timing, direction estimation, speed reading, regional surveying, roads traffic monitoring, security, and more.

4. System Implementation

3.1. Arduino Mega 2560

This is a microcontroller - based board that contains the ATmega2560 microcontroller. It's a low-power 8-bit AVR microcontroller that includes 256 KB of flash memory, 8 KB

of SRAM, 4 KB of EEPROM, 86 lines for input or output, some timers and counters, and several PWM pins. It operates on a voltage between 4.5 V - 5.5 V. It contains everything that is required in this work

3.2.GSM sim808

SIM808 board is a four band GSM board that includes GPS as well. The small design that also includes GPRS shortens the time and reduces the costs. Some details listed in table (1)

In our project the used GSM board is the SIM808 EVB-V3.2 module GSM/GPS/GPRS development board. This board features the following interfaces: three power input interfaces: DC044 interface and V_IN and a lithium battery interface the power supply should be 5v to 26 v at 2A,

The spatial range from earth to any GPS satellite can be calculated by knowing the time of travel to the receiver. The receiver needs to acquire the distance from at least four satellites, then it can estimate its location in 3D. In this system the GPS protocol National Marine Electronics Association (NMEA)-0183 is used.

3.3.MPU IMU 6050:

MPU6050 is a nine-axis gyro and motion sensor that has 3 axis gyroscopes and a 3-axis accelerometer. And a wide Digital Motion Processor (DMP), where either Inter Integrated Circuit (I^2C) or Serial Peripheral Interface (SPI) communication technologies can be used to connect this board to other sensors. The output of this sensor board is a 9-axis signal that has to be processed to analyze the acquired data. Angle changing detection in industrial aspects has a lot of applications. For example, the detection of the horizontal angle of an object, or its tilting angle, which benefits in making it simpler to balance a car or a four-rotor aircraft, and it can be utilized in order to identify

The altitude of an object. By the effect of the angle change, a specific control algorithm is utilized, and the Proportional Integral Derivative (PID) algorithm is used to negate the tilt and pan effects of the object. So, the detection of the car crash can be analyzed through the status of the electronic MPU IMU board. In the MPU6050, (VDD) supply pin should be supplied by 3.3V, (CS) is a chip select pin. Data communication can be utilized by using either SPI or I^2C protocol.

MPU6050 has three 16-bit Analog to Digital Converter (ADC) that is used to acquire the acceleration parameter value of the 3 axes, which is then converted to a single digital output signal for the microcontroller to process. The range of the gyroscope boards

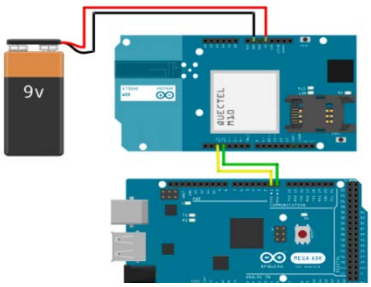

Figure 2. Arduino Mega connection with GSM board

readings is (±250, ±500, ±1000, ±2000) degrees. The range of accelerometer boards readings is (+2G, +4G, +8G, +16G). There is an on chip 1 MB First in First out (FIFO) memory that can be used by writing data into it and then reading the data from it to act as a data cache.

The serial data interface can be accessed through either the I^2C, which has a maximum rate of data transfer up to 400 K. bps, or the SPI, which has a maximum rate of data transfer up to 1 M. bps.

3.4.The Liquid Crystal Display:

A 4 x 20 Liquid Crystal Display (LCD), it is a display that consists of flat plates that use the modulation of light inside the liquid crystals. It does not send out light and signals by itself, but it relies on two sheets of polarized material with a solution of liquid crystal. If current is passing by, then crystals get arranged so that the light is prevented from passing. Usually, all types of displays require a lot of input / output pins of the microcontroller to be used and reserved in

order to display a message that has a meaning to the user, who makes correct choices in each specific condition based on the displayed message. There exists a board that can be utilized with the LCD display that allows the user to minimize the number of used pins from over eight pins to only two pins by using the I^2C communication protocol. This board is added as a shield to the LCD such that it's not apparent to the user.

4. Detailed Description and Flowchart of The System

4.1.The GSM SIM808 board

The GSM board requires four lines in order to operate, where two of them are the power lines (Vcc and GND), where these two lines are not provided from the Arduino board, but from an external battery since the GSM board requires a high amount of current consumption in order to guarantee a successful call with an end point such as a cellphone.

The other two lines are the transmitting line Tx and the receiving line Rx, where these two lines must be connected to their counterparts in the Arduino board, such that the Tx and Rx lines of the GSM board are connected to the Rx and Tx lines of the Arduino board, as shown in Figure (2) here, where the operation of the GSM board is controlled by the AT commands sent from the Arduino board

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5.2.The MPU IMU 6050 Gyroscope board:

The MPU IMU 6050 gyroscope requires four lines in order to work, two of them are the power lines (Vcc and GND) that are taken directly from the Arduino board, while the other two line are the i2c lines SDA and SCL, which are the data line and the clock lines respectively, where these two lines on the gyro board should match those on the Arduino Mega board. The connection of this sensor board with the Arduino Mega controller board is shown in figure 3.

5.3.I2C LCD 20x4 board

As its name implies, the i2c LCD board requires i2c communication lines to be connected with the Arduino Mega board in order to function properly as shown in figure 4. The same i2c lines are already used by the Arduino Mega board in order to communicate with the gyro board, but that issue is resolved by giving the LCD a different i2c address than that of the gyro board. The LCD is used to display various information to the user, such as the (x and y) angles of tilting, status of the airbags, and the coordinates of the location of the accident upon occurrence. That is all that is concerned with the hardware part of the work. In order for these parts to work together, a program written in Arduino must be transferred into the Arduino Mega board, where the steps are illustrated in the following flowchart

6. Flow Chart of circuit

The programming line codes for this work is written using the Arduino Integrated development Environment (IDE). The steps for this system to operate are:

1. All input and output pins are initialized by deciding their roles and other parameters.
2. The baud-rate of both the GSM board and the Arduino board is specified.
3. A repetitive loop begins to check whether the GSM board is connected to the network or not.

4. Arduino starts gathering various information from multiple sensors, which are:
   4.1. MPU IMU 6050 tilt and pan data
   4.2. Airbag sensors data
   4.3. The emergency SOS data
5. Arduino starts comparing the data

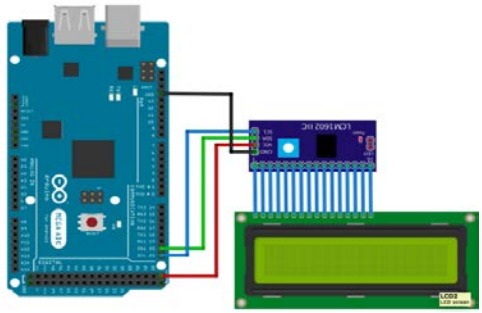

Figure 4. i2c LCD with Arduino mega

acquired through the sensors with predefined threshold levels specified in order to detect whether the circumstances are normal for a driver or there is an accident.
6. In case the sensor readings are all within the regular values, then the system reverts back to updating the acquired information as mentioned in step 4 and continue operation sequence from there until an accident is detected.
7. Upon accident occurrence, the sensors data will be above the threshold level, and therefore the Arduino will start the alarming sequence in the next step.
8. The alarming sequence starts with getting a fixed GPS location (longitude and latitude) at the time of the accident.
9. Then a Google maps link is created from the GPS information in order to send the

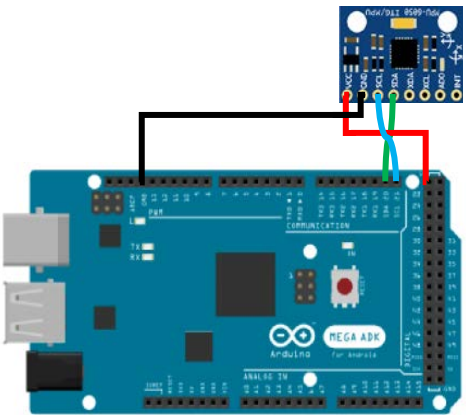

Figure 3. Arduino mega connection with MPU IMU 6050 gyroscope board

location data in a method easy to understand and locate.
10. Then an SMS gets sent to the predefined number previously specified by the vehicle driver, which contains the location of the accident sent as a link that can be accessed on the other end in order to acquire the exact location even if the person reading the SMS does not know how to understand location coefficients such as longitude and latitude.

The previous steps are illustrated in the flowchart in figure 5, also, a complete system connection shown in figure 6, and a screenshot of the received SMS in a

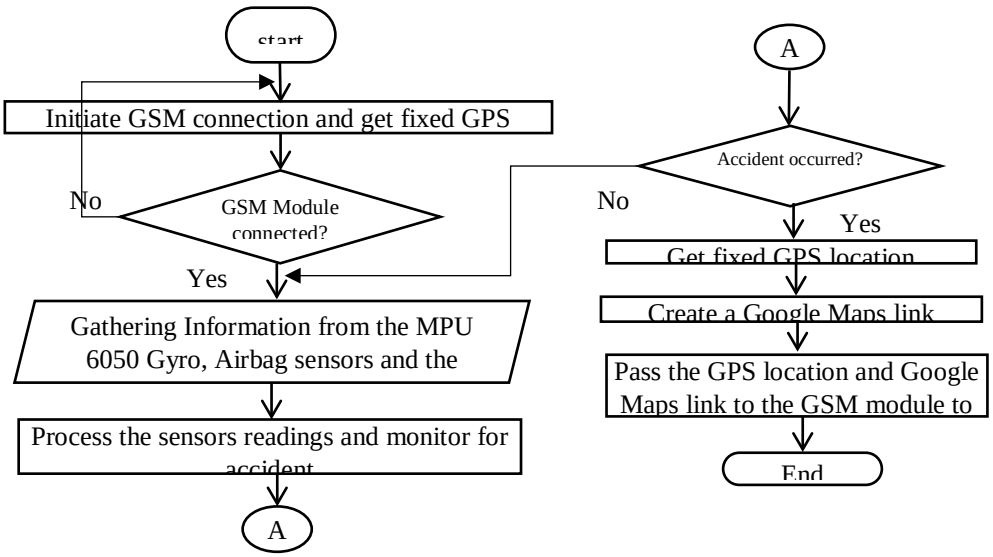

Figure 5. System operation flowchart

smartphone from Google maps is shown next, as long as the front view and the back view of the implemented system in figures 7, 8 respectively.

7. conclusion:

The proposed system had been tested and it works properly. It decreased the time it takes for the ambulance to arrive the location of the car accident by a great extent. Especially, in the case where there were no witnesses to report the incident, where the system did the work instead and performed it more efficiently by sending the exact coordinates of the incident. Stand byer citizens might not even know the name of the streets or the intersections to report to the ambulance.

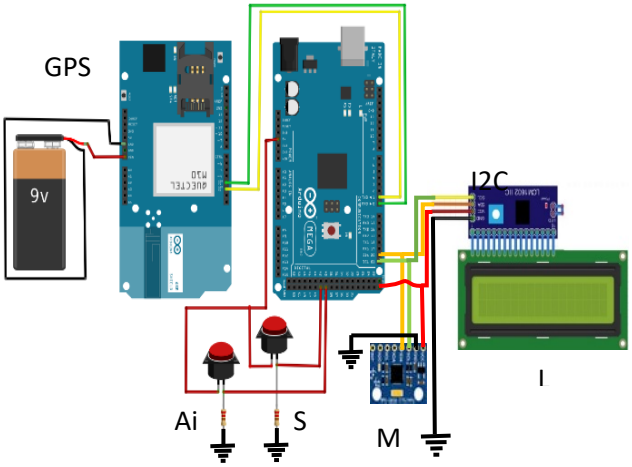

Figure 6. complete system

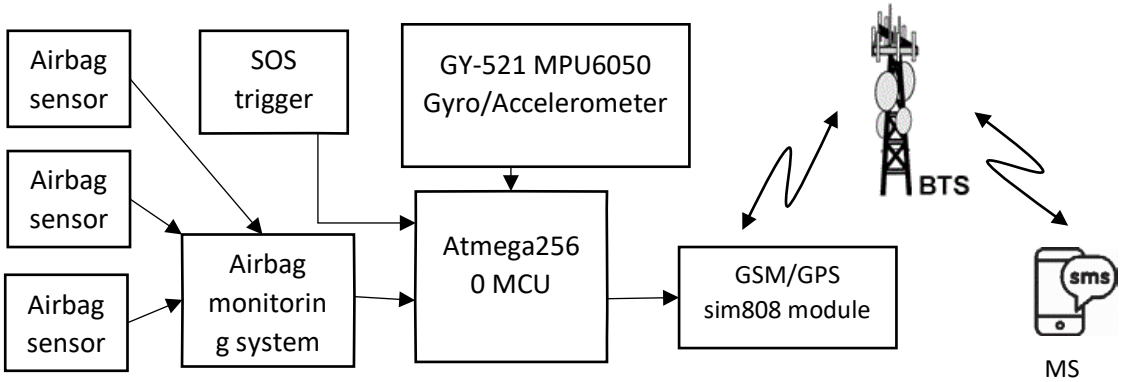

Figure 1. Block diagram

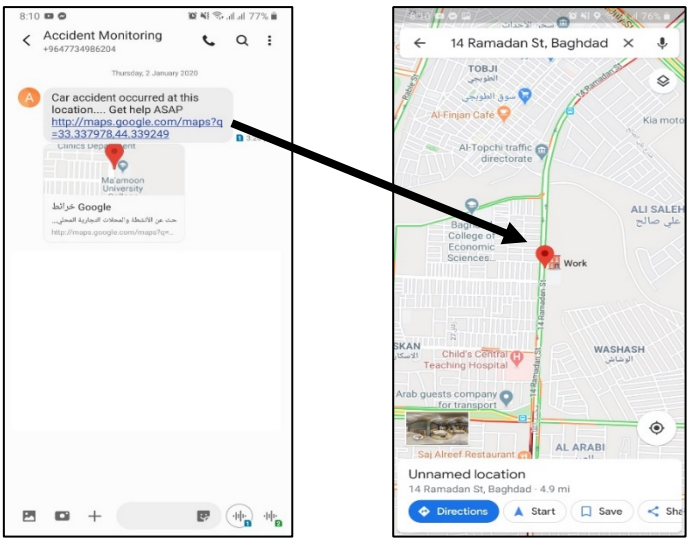

Figure 7. *A screenshot of the received SMS, and the resultant*

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