International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 5 Issue 10, October - 2021, Pages: 13-24

Design and Construction of Microcontroller based Vehicle Accident detection and reporting System

BABALOLA A.D., OLOKUN M.S.

Department of Computer Engineering
Federal Polytechnic, Ile Oluji
Ondo State, Nigeria

Abstract— *The rapid growth of technology and infrastructure has made lives easier. The advent of technology has also increased the traffic hazards and road accidents take place frequently resulting in loss of lives and properties aided by poor health care facilities. This work focuses on design and construction of vehicle accident detection and messaging system using GSM (Global System for Mobile Communication) /GPS (Global Positioning System) modules. It can be used as a crash or rollover detector for the vehicle during and after a crash. With signals from accelerometer, a severe accident can be recognized. When a vehicle collides with an object, the Vibration sensor will detect the signal or if it roll over, a Micro Electro-Mechanical System (MEMS) sensor will detect the signal and send it to ARM controller. Microcontroller sends the Short message through the GSM / GPS Modules which will include precise coordinate location of the accident to nearest police control room or Road Safety rescue team so the team can immediately trace the location through the GPS after receiving the information.*

Keywords: GSM (Global System for Mobile Communication), GPS (Global Positioning, System), MEMS (Micro Electro-Mechanical System), Microcontroller.

1.0 INTRODUCTION

In Nigeria, the high demand of automobiles has increased the traffic hazards and the road accidents. Life of the people is under high risk. This is because of the lack of best emergency facilities available in our country. An automatic accident detection and reporting system is introduced in this paper. This design is a system which can detect accidents in real time and sends the basic information to first aid Centre within a few seconds covering geographical coordinates, the time and angle in which a vehicle accident had occurred. This alert message is sent to the rescue team in a short time, which will help in saving the valuable lives. A Switch is also provided in order to terminate the sending of a message in rare case where there is no casualty, this can save the precious time of the medical rescue team. When the accident occurs the alert message is sent automatically to the rescue team and to the police station. The message is sent through the GSM module and the location of the accident is detected with the help of the GPS module. The accident can be detected precisely with the help of both Micro electro mechanical system (MEMS) sensor and vibration sensor. The Angle of the rolls over of the car can also be known by the message through the MEMS sensor. This application provides the optimum solution to poor emergency facilities provided to the roads accidents in the most feasible way.

When the system is installed in a vehicle, it can detect when an accident occurs in two ways. The first way is when the car tilts due to a hit and the other when it detects overwhelming effect. This device consists of a microcontroller, accelerometer, impact sensor, relay and a GSM/GPS module in which the SIM card number is known only to the designer, vehicle owner, Police Force and Road Safety Authority. Anytime a new message is received the microcontroller process the data, deletes this message to free up SIM memory and then preform the required action based on the information received. This hardware is fitted in the vehicle in such a manner that it is not visible to anyone who is inside or outside of the vehicle.

2.0 LITERATURE REVIEW

Athuljith (2015) designed an automatic accident alarm system. This intelligent vehicle tracking system comprises of a microcontroller unit, 3-axis accelerometer, GSM and GPS unit. The accelerometer monitors the orientation of the vehicle about the three axis, it also keeps the log of the vehicle for the last few minutes and acts like a “black box” recording the speed and accident orientation of the vehicle, which can be used to track the cause of the accident. When an accident is detected, the location of the vehicle is recording using GPS. The accident data is sent through SMS to the numbers of specified authorities. When an SMS is received by those, the companion app installed on their device detect the SMS and alert them. If the rate of vibration exceeds the threshold value it will automatically send the message. In the cause of a delay in the emergency unit receiving the alert message due to network issues or when the phone is charge of receiving this alert is low on battery, this device does not cater for this circumstance.

Khyati and Swati (2017) developed an Accident Detection and Messaging Conveyor System using GSM and GPS Modules. The main element of the prototype model of an automatic vehicle accident detection and messaging are GSM, GPS module and Arduino UNO. This prototype can likewise distinguish liquor utilizing mq3 sensor which is fundamentally utilized as a breath analyzer. It detects the Ethanol content in the driver’s breath and gives its yield to the engine. In the event that the level of the ethanol is beyond

the limit then motor stops (brakes) else the motor is ON. A piezoelectric sensor is utilized to detect the vibration at the time of the accident and gives it output to the buzzer. If any value of vibration sensor is changed beyond limit then buzzer will start. If the buzzer is ON for more than 10 seconds, the GPS module is triggered ON. In case of a minor accident, where the driver does not need any external assistance, he/she will press the switch within 10 seconds due to which the buzzer will be OFF and the GPS will not be triggered. The GPS (global positing system) detect the latitude and longitudinal position of a vehicle. The latitudes and longitude position of the vehicle is sent as a message through the Global System for Mobile Communication (GSM) to the preset numbers.
Fogue (2012) presented a paper on Automatic Accident Detection: Assistance through Communication Technologies and Vehicles. In this article, e-NOTIFY system is presented, which allows fast detection of traffic accidents, improving the assistance to injured passengers by reducing the response time of emergency services through the efficient communication of relevant information about the accident using a combination of V2V and V2I communications. The proposed system requires installing OBUs in the vehicles, in charge of detecting accidents and notifying them to an external CU, which will estimate the severity of the accident and inform the appropriate emergency services about the incident. This architecture replaces the current mechanisms for notification of accidents based on witnesses, who may provide incomplete or incorrect information after a long time. The development of a low-cost prototype shows that it is feasible to massively incorporate this system in existing vehicles.

Shailesh et al., (2015) developed a Wireless System for Vehicle Accident Detection and Reporting using Accelerometer and GPS. Developed a wireless system using MEMS accelerometer and GPS/GSM unit for accident detection and reporting. When any accident occurs, this wireless device will send automated message to emergency medical services (EMS) and family members giving the exact position of the spot where the crash had occurred. So they can provide proper medical treatment to patients. This system is used to record information related to accident like temperature data, position data etc. so that it can be used to analyze the accident easily and to settle many disputes related to accident such as insurance settlements. This system is also used to detect whether the driver was in drunken state and the vehicle would not start thereafter. The whole system is based on arm controller. This controller is used to co-ordinate all the activities in the system. The system consist of ARM7 microcontrollers units, MEMS accelerometer, GPS device, GSM module, temperature sensor, gas sensor and alcohol sensor, an accelerometer is used to detect GPS collect the current position values which include latitude (N or S), longitude (E or W), date and time. The location values are given to microcontroller. Controller gives this information to GSM module. By using GSM module, we can send the message to family members or EMS. Here the serial communication interface UART is used for the communication between then microcontroller, GSM and GPS module.
Thrivikraman (2002) Development of User alerting system for vehicle accident detection system: an application for accident detection in vehicular networks through OBD-II (On-Board Diagnostics) devices and android based Smartphones was designed. It attempts to contact the ODB-II device defined. In case it is found the different protocols supported are checked to determine which one is valid for the current vehicle. If bidirectional communication is established successfully, the application will start the system monitoring process. If either the airbag is triggered, or the deceleration detected is greater than 5 GPS we consider that an accident has occurred. If the data channel is available, then it retrieves GPS and accident details followed by sending critical data and making an emergency call immediately. The proposed system in deals with an automatic accident detection system involving vehicles which sends information about the accident including the location, the time and angle of the accident to a rescue team like a first aid center and the police station. This information is sent in the form of an SMS alert. But in the cases where there are no casualties a switch is provided which can be turned off by the driver to terminate sending the alert message. A GSM module is used to send the alert message and a GPS module is used to detect the location of the accident. The GPS and GSM module are interfaced to the control unit using serial communication. The accident itself is detected using two sensors- Micro Electro Mechanical System (MEMS) sensor and vibration sensor. MEMS sensor also helps in measuring the angle of rollover of the car. A 32-bit ARM controller is used as the main high-speed data-processing unit. The vibrations are sent from the vibrating sensor to the controller after passing through an amplifying circuit. Similarly, the roll over angle is sent from the MEMS sensor to the controller.

Matthews and Adetiba (2014) developed a system called Vehicle Accident Alert and Locator (VAAL). A particular country is divided into areas are sub- divided into sectors, in every sector, there are police stations. If an automobile crash occurs in a particular sector, the information flow is sown as labelled numerically in the diagram. The GPS/GSM module works with an installed crash detector. This module is constantly being tracked by the GPS satellite constellations in the orbit. These satellites make it possible for ground GPS receivers installed in a vehicle to pinpoint the geographical location and obtain the exact latitude, 1-10 meters. In case of automobile crash, the crash detectors sends an activating signal to the GPS/GSM module, this module, this module is programmed to fetch from the memory, personalized plate number of the particular vehicle involved; coupled with the GPS information (i.e. latitude. Longitude, speed etc.). An SMS message is sent to a communication database server (CDS). The CDS automatically compare the information received (plate number in this case) with the mapped information in the memory. The communication database server fetches the above information alongside the GPS data received and send them to the appropriate agencies such as nearest FRSC, Police Station, and medical centers for immediate development of paramedic officials as well as all emergency units within the vicinity of the crash. The road officials could communicate with the vehicle to find out the exact physical situation of the event, if there are person in the vehicle to respond accurately to these questions, the paramedic with the FRSC informs the nearest

hospital or medical centers of the extent of medical attention needed by the victims. All information from sectorial database are sent to a centralized database for backup.

Aditi (2016) proposed a Real Time Vehicle Accident Detection and Tracking Using GPS and GSM. In this project, the accident detection unit is fitted inside the front and rear bonnet of the car. This accident detection unit consist of PUSH ON SWITCHES. In case of accident, if the car is hit to some other vehicle or an object then PUSH ON SWITCHES senses obstacles and send signal to interrupt pins of microcontroller. Microcontroller is the central processing unit CPU of our project. Once microcontroller gets signal from push on switches, then it will immediately turn on the buzzer. A key will be provided for the driver. If the accident is very normal, or driver has hit the wall in some situations like parking then driver will press the key. This will inform the microcontroller that this is a very normal accident. But if driver is not in situation to press the switch or if the accident is really a major accident then driver will not send this information to the GSM modem, is used to send this information via SMS. SMS will be sent to the family member of the driver, so that they can take immediate action to help the persons suffering due to this accident.

3.0 EQUIPMENT USED

The following list of hardware are required for the system.

1. Arduino Nano
2. GSM+GPS Module (SIM808)
3. Accelerometer (ADXL335)
4. Resistors
5. Vibration sensor (SW-18010P)
6. Relay Module
7. Jumpers wires
8. Header pins
9. Vero board

3.1 ARDUINO NANO

The Arduino Nano is an open- source hardware based on the ATmega328P microcontroller which has 32 KB ROM (with 2 KB used for the boot loader). The ATmega328P has 2 KB of SRAM and 1 KB of EEPROM. This development board has 14 digital pins which can be used as an input or output, using pin Mode (), digitalWrite (), and digital Read (), functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-5- ohms. In addition have specialized function which are used for serial communication, PWM output, and external interrupt. Apart from the small size, this board has more merits as it comes with 8 analogs inputs, each of which provide 10 bits of resolution (i.e. 1024 different values).

The Arduino development board is the heart of this project, as all others board sensors/subsystems are connected to it. This board makes decision based of the instruction given. This instructions are written on an IDE produced by the Arduino foundation and the programming language used on the Arduino C.

Figure 1: Arduino Nano

3.2 GSM Module (SIM808)

SIM808 module is a computer Quad-Band GSM/GPS module which combines GPS technology for satellite navigation. The compact design which integrated GPRS and GPS in a SMT package will significantly save both time and costs for customers to develop GPS enabled applications. Featuring an industry-standard interface and GPS function, it allow variable assets to be tracked seamlessly at any location and anytime with signal coverage. It features ultra-low power consumption in sleep mode and integrated with charging circuit for Li-Ion batteries, that make it get a super long standby time and convenient for projects that use rechargeable Li-Ion battery. It has high GPS receive sensitivity with 22 tracking and 66 acquisition receiver channels. Besides, it also supports A-GPS that available for indoor localization. The module is controlled by AT command via UART and supports 3.3v and 5v logical level.

Figure 2: SIM808 Module

Table 1: Pin connection between Arduino Nano and SIM808 module.

SIM808	Arduino Nano
TX	Pin2
RX	Pin3
GND	GND

3.3 GSP Module

GPS satellites circle around the earth twice in a day in a very precise orbit and transmit signal information to earth. GPS receivers collects this information and uses triangulation to find out the user's exact location. The GPS receiver compares the time when a signal was transmitted by a satellite with the time it was received. The time difference tells the GPS receiver about the user location. With distance measurements with the help of a few more satellites, the receiver can determine the user's position more precisely and displays it on the map. To find the location on the earth the whole is divided into some coordinates where the location can be easily captured by a module called GPS module. Here the GPS used is SIM28ML. This GPS module will find the location of the vehicle and the information fetched by the GPS receiver is received through the coordinates and the received data is first send to Arduino and the information is transmitted to the saved contact through GSM module. The frequency is operated in the range of 1575.42 MHz and the output of GPS module is in NMEA format which includes data like location in real time.

Figure 3: SIM-28ML

3.4 Vibration Sensor (SW18010P)

The SW18010P vibration sensor is effectively just a delicate spring with a sturdy piece of Metal in the middle. When moved, the spring wobbles around and touches the metals, momentarily making contact. These are very useful little devices as they draw absolutely no power. SIM18010P is used for measuring and analyzing linear velocity, displacement or acceleration.

Figure 4: Vibration Sensor (SW18010P)

Table 2: Connection between Arduino Nano and SW-18010P.

SW-18010P	Arduino Nano
S	A5
+	5V
-	GND

3.5 Accelerometer (ADXL335)

Accelerometers are device that measure acceleration, which is the rate of change of the velocity of an object. They measure in meters per second squared (m/s2) or in G-forces (g). A single G – force for us here on planet earth is equivalent to 9.8 m/s2, but this does vary slightly with evaluation (and will be a different value on different planets due to variations in gravitational pull). Accelerometers are useful for vibrations in system or for orientation applications. Accelerometers are electromechanical devices that sense either static or dynamic forces of acceleration. Static forces include gravity, while dynamic forces can include vibrations and movement. The ADXL335 is a small, thin, low power, complete 3-axis accelerometer with signal conditional voltage outputs. The product measures acceleration with a minimum full-scale range of +/3g. It can measure the static acceleration of gravity in tilt seeing applications, as well as dynamic accelerations, as well as dynamic acceleration resulting from motion, shock, or vibration. Breakout board for the 3 axis ADXL335 from analog devices. This is the latest in a long, proven line of analog sensors – the holy grail of accelerometers. The ADXL335 is a triple axis MEMS accelerometer with extremely low noise and power consumption – only 320uA! The sensor has full sensing range +/-3g. There is no board regulation, provided power should be Between 1.8 and 3.6VDC.

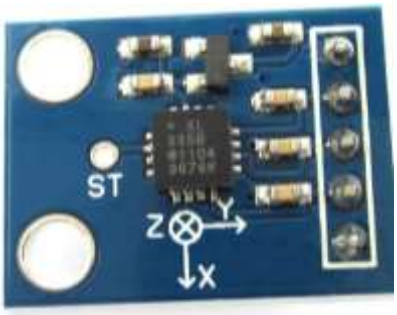

Figure 5: ADXL335 Sensor

Table 3: Connection between Arduino Nano and accelerometer.

Adx1335	Arduino Nano
VCC	5V
GND	GND
X	A0
Y	A1
Z	A2

3.6 Resistors

A resistor is a passive two –terminal electrical component that implement electrical resistance as a circuit element. Resistors act to reduce current flow, and at the same time, act to lower voltage levels within circuit. In electronics circuits resistors used to limit

current flow, to adjust signal levels, bias active elements, terminate transmission lines among other uses. This component may have fixed resistance that only change a little with temperature, time or operating voltage. Variable resistors can be used to adjust circuit elements (such as a volume control or a lamp dimmer), or as sensing devices for heat, light, humidity, force, or chemical activity.

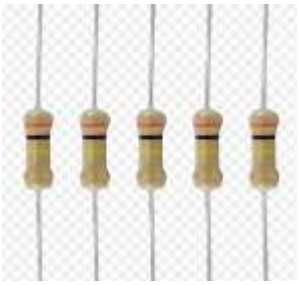

Figure 6: Resistors

3.7 Relay Module

Relays are switches that open and close circuits electromechanically or electronically. Relays control one electrical circuit by opening and closing contacts in another circuits. As relay diagrams show, when a relay contact is normally open (NO), there is a closed contact when the relay is not organized is not energized. In either case, applying electrical current to the contacts will change their state. The relay module has an on board opt-coupler which serves to separate the Arduino development board from the relay circuits in case EMF occurs in this project/ the module can be hooked up with the Arduino case.

Figure 7: One Channel Relay Module

Table 4: Connection between Arduino Nano and relay module.

SIM808	Arduino Nano
IN	Pin7
+	5V
-	GND

3.8 Jumper Wires

Jumper wires, are used to transfer electrical signals from one part of the board to the central microcontroller or to another component or part of a circuit. Jumper wires vary in size, color and types.

Figure 8: Jumpers wire

4. METHODOLGY

This system can be subdivided into three sections which are the communication, control and port section.

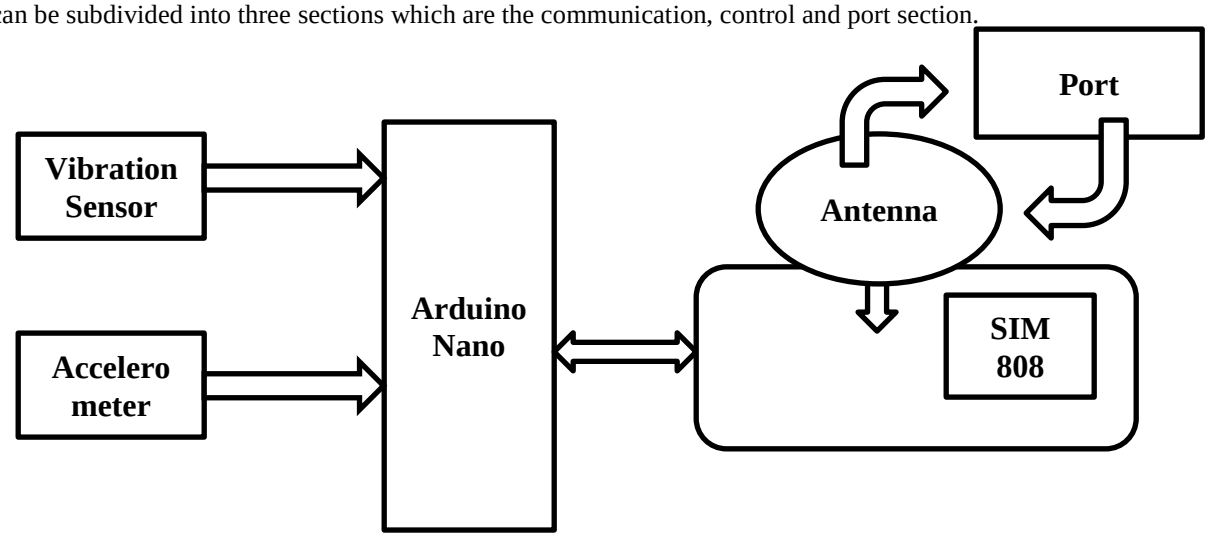

Figure 9: Block diagram of the system

4.1 Communication Section

This section of the GPS and GSM module is connected to the Arduino UART (Universal Asynchronous Receiver –Transmitter) pins. The universal asynchronous receiver- transmitter (UART) takes bytes of data and transmits the individual bits in a consecutive manner. At the destination, a second UART re-assembles the bits into complete bytes. Each UART contains a shift register, which is the fundamental method of conversion between serial and parallel forms. Serial transmission of digital information (bits) through a single wire or other medium is less expensive than parallel transmission through different wires. The UART usually does not directly generate or receive the external signals between various things of hardware. Separate interface devices are used to convert the logic level signals of the UART to and from the external signaling levels, which may be standardized voltage levels, current levels, or other signals. This communication protocol may be simplex, half – duplex, or full duplex. The Arduino board has two pins labelled “TX” and “RX”, which means transmit and receive pins. This pins can be used for UART and are sometimes hardware serial pins because the protocol is handled by the chip. Serial communication on the Arduino can be implemented with software alone, with this invention (Software Serial library) all pins can be used for UART. The Arduino board is connected to the SIM808 module via software serial.

A SIM card was inserted into the slot of the SIM808 module. The SIM card was loaded with airtime and data.

4.1.1 Port Section

Road accident alert system connects to the internet via GPRS network. A new account is created with Adafruit then a topic is created on the broker (Adafruit.io) and device connects to this broker as an MQTT client. Any time an accident is detected, the Arduino sends the accident data to the SIM808 for publish. When the broker receives this data, it updates the topic and all other clients subscribed to the topic receives the new update. The device only attempts to create a connection with the broker only when an accident occur.

To create this section, a request to io.Adafruit.com was made via a browser on a computer.

4.1.2 Control Section

The control unit consists of the sensors, relay and the microcontroller. The accelerometer consists five pins which are VCC, GND, X, Y, Z pins. The x, y, x pin of this sensor is connect to the analog pins of the Arduino, then the VCC and GND pins are connected to 5 volts and ground. At first boot of the device, the Arduino takes 20 readings each from the three data pins of the sensor then finds the average of each. This average value is then saved in memory, and average value by calling of the- accidents () function in the void loop.

When a sharp large difference occurs, it implies that an accident has occurred. When this happens the road safety agency receives this information in the shortest time. The vibration sensor is an analog sensor, the data pin of this sensor is connected to the Arduino. The Arduino also checks this sensor and compares the values read with a set value (600) and when it is greater than, the road safety agency is also alerted of the situation. Below shows the function used in detecting a tilt from the accelerometer.

4.1.3 Power Section

The device is powered using the car battery and it is brought down to 9V by a voltage regulator. This power rail is looped to the VIN of the Arduino.

The flow chart of the accident detection system is shown in figure 10.

5. ANALYSIS AND RESULTS

This section contains the results gotten from System during test. The module number of the Emergency unit should be included in the software programming in order for them to receive the accident location values from the device. The device responds to any commands from the user and replies that same number with an acknowledgement message. This section will be divided into two part, the first one will be gotten from the device when accidents occurs, and results gotten when commands are sent to the device.

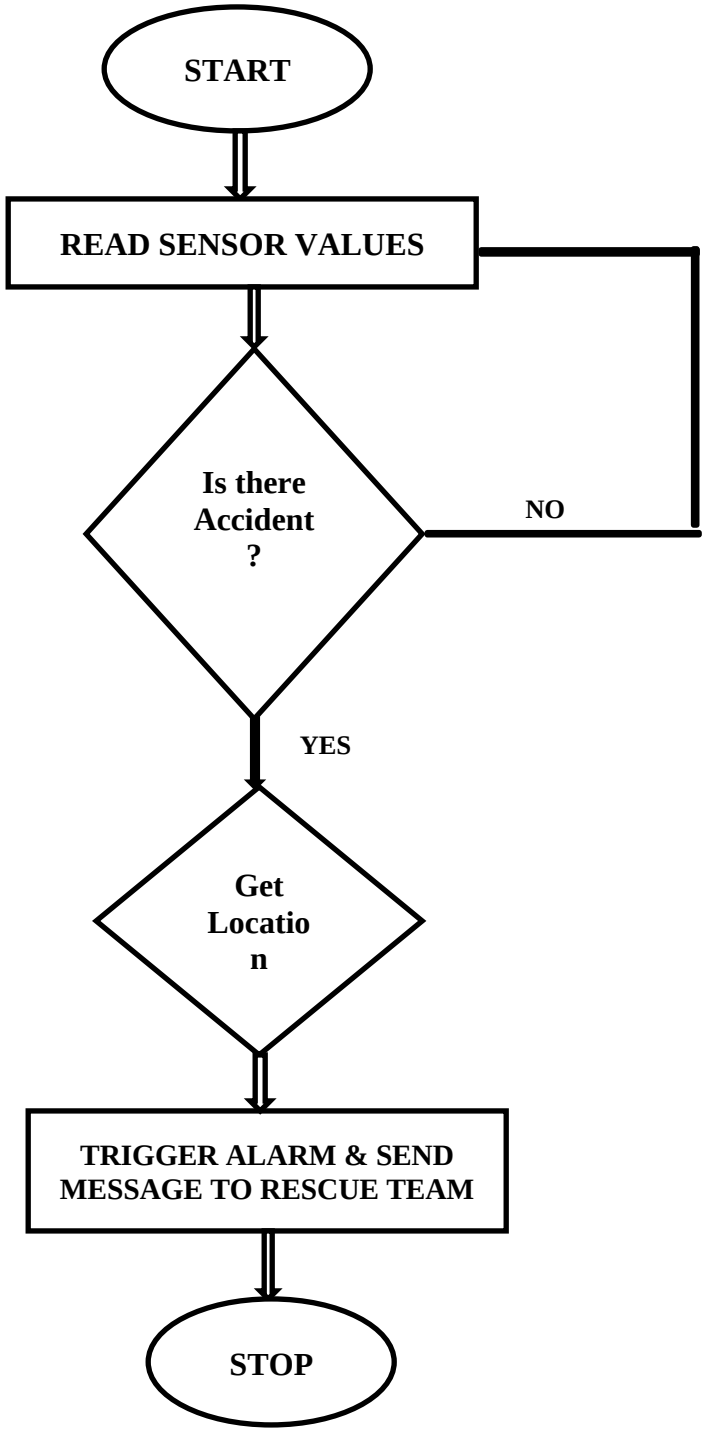

Figure 10: The flow chart of the accident detection system

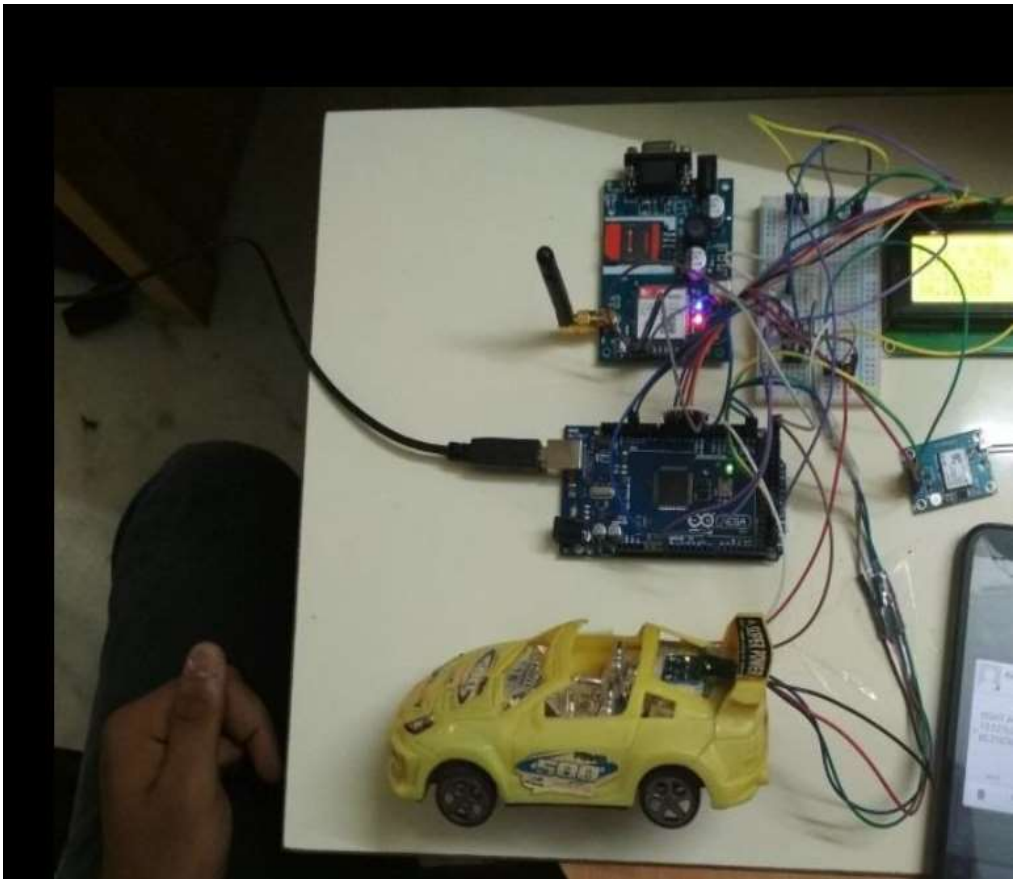

Figure 11: Implementation of the Accident Detection and Reporting System

6. CONCLUSION

In this work, the design of Microcontroller based Vehicle accident detection and reporting system is flexible, and accurate. Accelerometer, Vibration Sensor, GPS, and GSM has been utilized for vehicle accident detection and reporting. The GSM/GPS modem was configured, tested and used in implementing the tracking system to monitor the vehicle's location via SMS and online on Adafruit IO. This vehicle accident detection and reporting system provide crucial and real time information to emergency units in the earliest possible time. The crucial time between the accident and getting victim medical attention can often be the difference between life and death. This system provides better safety rather than no safety.

7. RECOMMENDATIONS

In order to reduce deaths caused by road accidents, RAA should be implemented in both private and public vehicles as nearby emergency units and FRSC are alerted in the earliest possible time when accidents occur.

For future work, the device could be further improved by the addition of the following features:

1. Replace the Arduino development board with a micro-processor (like the Raspberry pi). The raspberry pi will run a deep learning clustering algorithm that will search for vehicles close by having RAA installed and then broadcasts its location via a low frequency interface when there are no GSM network during emergency.
2. INTERFACING with the vehicle airbag system. This will optimize the proposed technology to the maximum extent and deliver the best accident detection system.

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