5

The Development of an Advanced Road Vehicle Safety Device

**Uzoma Ifeanyi Oduah,*
Onyedikachi Alanwoko and Shola Folarin
University of Lagos, Nigeria

Department of Physics, Faculty of Science
Email: uoduah@unilag.edu.ng; uzoma_i_oduah@yahoo.com
Telephone Number: +2348033421101; +2349024084477

Abstract

We hereby present an advanced road vehicle safety device. The device tackles the problem of loss of lives, arising from late medical attention to care for accident victims after an accident as a solution that enables fast response to persons involved in ghastly vehicle accidents. It uses ultrasonic sensor to detect the changes in the body of the vehicle due to a mechanical impact from an accident and sends a signal to the microcontroller which is connected to a buzzer. The buzzer in response to the signal triggers an alarm and simultaneously a Short Message Service (SMS) and recorded phone call are sent to registered contacts in the device. Arduino ATMega328P microcontroller monitors and activates the system when there is impact detected by the ultrasonic sensor. Then the buzzer outputs the warning sound to alert while the Global System for Mobile communication (GSM) module sends SMS alert and places a call when there is significant impact on the vehicle. This device senses any Izod Impact causing up to 10cm penetration at the impact zone of the vehicle. The system has a response time of 0-3 seconds for activation of the buzzer and 5-10 seconds for the GSM module.

Keywords: Road Vehicle Safety, GSM Module, Microcontroller, Short Message Service (SMS), Ultrasonic Sensor.

1. Introduction

Road accidents are unarguably one of the main sources of death especially in low income countries with poorly constructed road networks. According to global status report on road safety 2018 by World Health Organization (WHO) in December 2018, the number of recorded annual road traffic deaths stood at 1.35 million. Most of the recorded deaths might have been averted if the accident victims received prompt medical attention after the accident. Government authorities have implemented some policies with the aim to reducing the number of road accidents and death indices. Among them are the improvement of road quality standards and introduction of more legal policies encouraging careful driving behavior as shown by Bila (2017).

However, less attention has been given to one of the issues, a quick emergency medical care that may be critical to reducing the number of fatalities caused by traffic accidents. In a research paper focusing on number of road accident deaths in Spain, a sample of more than 1400 accidents were recorded to have occurred on Spanish roads in May 2004. An analysis was carried out to know the extent to which a reduction of the time interval between the crash, and the arrival of the emergency services to the crash scene is related to probability of death. The results suggest that a 10 minutes reduction of the

medical response arrival can be statistically associated with an average decrease of the probability of death by one-third, both on motorways and conventional roads (Sanchez-Mangas, 2010).

According to Braun (2019), if there is quick medical response to road accident victims, the death toll rate reduces drastically. Methods have been put in place to reduce the death rate due to road accidents by considering different factors. The existing technologies in this space are designed to assist in preventing injuries and vehicle accidents. These include airbag system, bulletproof device, automatic emergency braking system, backup cameras to improve view while pulling out, blind spot detection, lane departure warning, forward collision systems, adaptive headlights, electronic stability control, traction control system, auto steering, anti-reckless teen driving tech, drowsiness video sensor, phone suppression technology, etc.

All the existing vehicle safety devices are targeted more on pre-accident controls and none for post-accident management. The airbag system operates simultaneously during accident to prevent injuries to the accident victims. There is therefore an urgent and very important need for a safety device that will cater for post-accident events for victims of road vehicular accidents towards their quick rescue and resuscitation. This paper presents the development of road vehicle safety device focused on post-accident management that will further reduce response time for medical personnel in event of road accidents. Quick medical response can be improved and facilitated by the use of the developed advanced road vehicle safety device. With this device installed in vehicles, quick medical responses can be ascertained. Since it is the function of the device to instantly notify medical centers, about persons who have been involved in a serious accident, then fast medical response is assured, considering the fact that the device is electronically controlled. It is obvious that the number of fatalities caused by road accident is strongly due to late medical response hence the urgent need for this developed advanced road vehicle safety device.

2. Materials and Methodology

The block diagram for the development of the advanced road vehicle safety device is as shown in Figure 1.

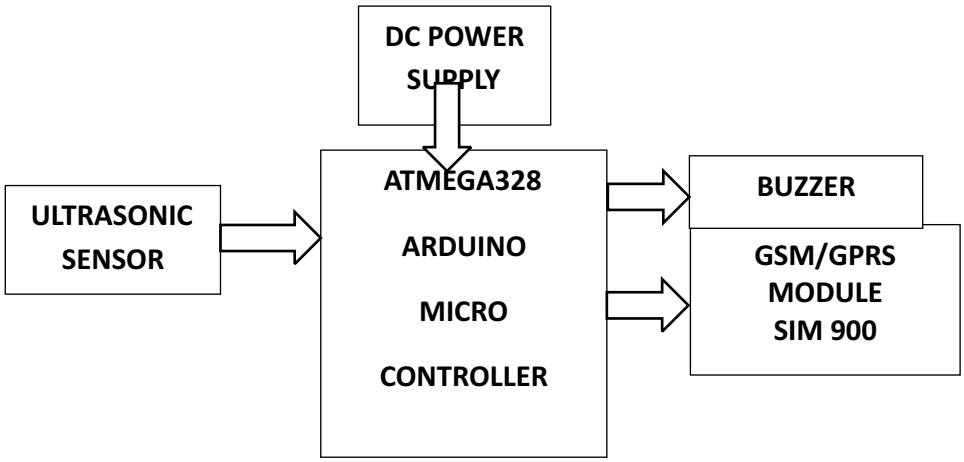

Fig. 1: Block Diagram of the advanced road vehicle safety device.

The developed device uses an ultrasonic sensor which will be installed in the User's vehicle. The sensor gets activated when there is a mechanical impact, which causes a huge dent with penetration of up to 10cm, on the vehicle's body. Upon activation, the sensor sends a signal to the Arduino's microcontroller which transmits a signal to the GSM Module. The GSM module responds by sending SMS and placing a recorded call to any stored medical agencies phone number and also to other preferred registered contacts of the vehicle owner. Short Message Service is a common economically affordable service used for receiving and sending messages in text.

It uses the GSM network to transfer information according to previous study by Makhijani et al (2015). GSM/SMS method of transmitting data is quite popular due to convenience and low-cost factor. A single text message consists of up to 160 characters. SMS mobile originated is a term used when a message is sent by a mobile, however when a message is received by a mobile it is termed SMS mobile terminated. Remote data communication and monitoring is supported by SMS due to its bi-directional data transfer and its stable performance as shown by Oancea et al (2011).

2.1. Ultrasonic Sensor (HC-SR04)

A transducer that works on the principle similar to the sonar or radar and estimate attributes of the target by interpreting is called an ultrasonic sensor or a transceiver. There are different types of sensors that are classified as active and passive ultrasonic sensors that can be differentiated based on the working of sensors. This sensor utilizes the measured distance of parts in the vehicle to identify how compact the vehicle is. If

the vehicle is hit with enough force to compress it causing up to 10cm penetration depth, the ultrasonic sensor which senses how compact the vehicle is sends a signal to the microcontroller which sends an SMS indicating there have been an accident. A paper by Carullo (2001) describes an ultrasonic sensor that is able to measure the depth of the dent from a reference point on a vehicle.

2.2. The Power Supply Unit

The device is designed such that it can be powered by the battery of the vehicle which produces about 15V for most vehicles. The Arduino requires at least 5V for it to function, and a maximum of 40mA. The GSM module on the other hand can take current up to 2A. A power supply unit is used to convert the vehicle's battery output voltage to that required by the device in order to keep the device working. The power supply unit used is as discussed by Chen et al (1993).

2.3. The Microcontroller

The ATMEGA 328 microcontroller was used in this device. The microcontroller was mounted on a hardware known as Arduino. Usually, a microcontroller functions as a type of microprocessor furnished in a single integrated circuit and needing a minimum of support chips as described by Guofa (2019). The microcontroller includes a central processor, input and output ports, memory for program and data storage, an internal clock, and one or more peripheral devices such as timers, counters, analog-to-digital converters, serial communication facilities, and watchdog circuits. The Microcontroller applied in this device is responsible for all the processing/ calculation within the device. It is sometimes referred to as a mini computer. The microcontroller was used to control the buzzer and also to transmit the information to the GSM module. Further details on microcontrollers and their applications are as discussed by Anusha et al (2015), Yeole et al (2015) and Sam et al (2013).

2.4 Alarm Circuitry

The buzzer is the main component of the alarm circuitry. The buzzer generates the warning alarm during any accident with mechanical impact that produces penetration up to 10cm on the body of the vehicle. The ultrasonic sensor receives signal and sends it to the microcontroller which in turn sends a signal to the buzzer indicating that there has been an accident. The buzzer is powered by the vehicle's battery.

2.5 GSM Module

GSM SIM900A module was used in this developed device. It is a low-cost cellphone GSM breakout board based on SIM900A module. It supports quad-band GSM/GPRS network, available for GPRS and SMS message data remote

transmission as previously described by Frenzel, (2016). The board has the desirable feature of compact size and low current consumption. Actually, it is a miniaturized cellular module. It supports quad band frequency (850/950/1800/1900) MHz. This feature makes it perfect for this project which requires long range connectivity. During operation, after connecting power module boots up, it searches for cellular network and login automatically. It has an on-board Light Emitting Diode (LED) display for connection state indication. It displays fast blinking of the LED for no network coverage and slow blinking when logged in. It requires a power supply of about 3.7V and 4.2V for optimal performance. Fault detection using GSM and its applications was reviewed by Pituk (2013).

The list of the components used for the construction of the Advanced Road Vehicle Safety Device is presented in Table 1.

Table 1: List of all components of Advanced Road Vehicle Safety Device.

S/N	Category	Description	Quantity
1	Controller	Arduino Microcontroller ATmega328	1
2	GSM Module	SIM 900A GSM Module	1
3	Buzzer	12V Electric Buzzer	1
4	Sensor	Ultrasonic Sensor (HC-SR04)	1
5	Battery	12V 7.2AH Battery	1

3. Results and Discussion

The device was tested at various steps and stages of construction. The first step was to test the ultrasonic sensor. The ultrasonic sensor and a buzzer were connected to the Arduino to first set the range and also the time it took the sensor to detect an obstruction and signal to be sent to the buzzer notifying that there is an obstruction. The range of the ultrasonic sensor was set at 10cm from any reference point on the body of the vehicle. Then the response time of the ultrasonic sensor were estimated by measuring the time it took for the buzzer to be activated after interrupting the sonic waves from the sensor using a metal panel. This test was performed because time is an important factor in rescuing accident victims. Figure 2. shows the ultrasonic sensor connected to the Arduino and a buzzer.

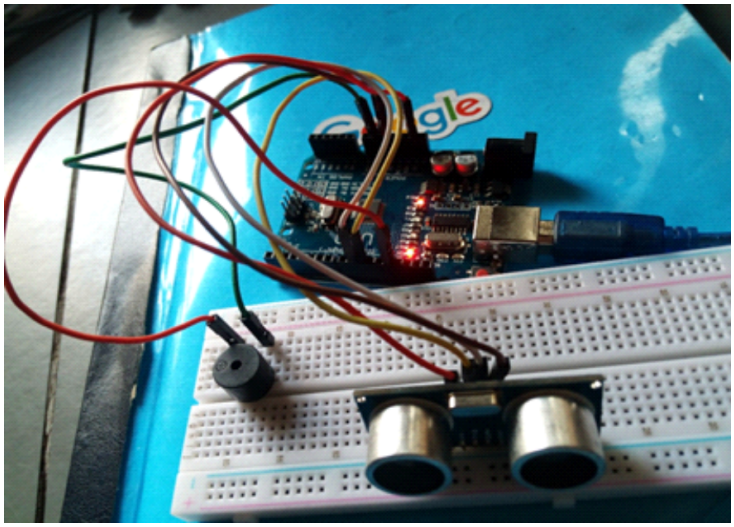

Figure 2: Arduino connected to an ultrasonic sensor and a buzzer

The second step was to test the GSM Module for sending SMS and simultaneously placing a call after the ultrasonic sensor picks up an obstacle. The SIM900A GSM Module was used and a network providing SIM was inserted as shown in Figure 3.

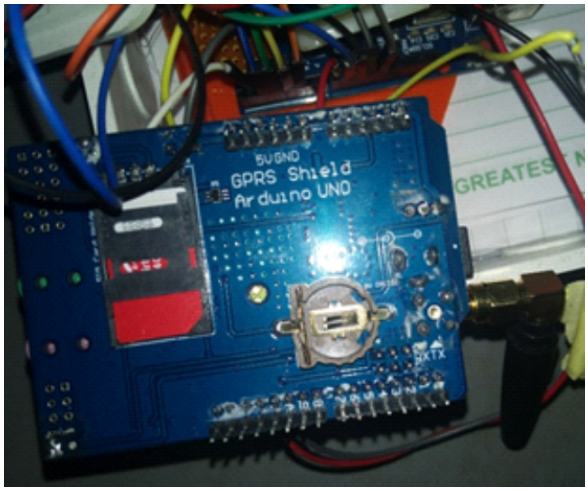

Figure 3: SIM900A with an inserted Network providing SIM card

The GSM Module was then connected to the setup in Figure 3, and the completed device tested with the use of an LCD screen. The LCD screen serves as the serial monitor of the Arduino. It indicates the present state of the GSM Module during testing. The complete connection is shown in Figure 4.

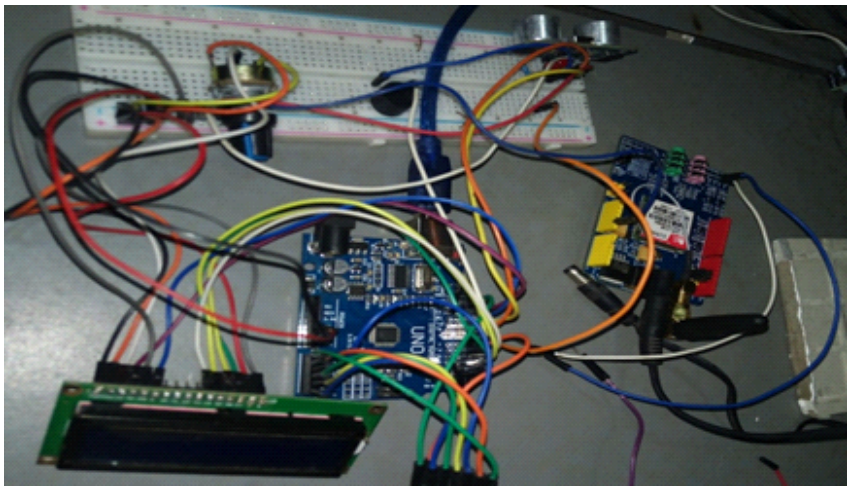

Figure 4: The complete connection showing the Arduino, the ultrasonic sensor and the GSM Module

The whole system was tested and the response times for the ultrasonic sensor and the GSM Module were recorded at different times. The average response time for the ultrasonic sensor was recorded to be almost instantaneous at nearly a second and that corresponds to the speed of operation of conventional ultrasonic sensors earlier reported by Frenzel, (2016). The ultrasonic sensor response time is good for an accident situation. The response time for the GSM Module was recorded to be an average of six seconds. The response time for the transmission of the signal from the ultrasonic sensor to the buzzer and the feedback from the GSM module which places a call are recorded and presented in table 2.

Table 2. Response Time of the Advanced Road Vehicle Safety Device

	Time 1 (Sec)	**Time 2 (Sec)**	**Time 3 (Sec)**	**Average Time (Sec)**
Ultrasonic Sensor	0.5	0.4	0.6	**0.4**
GSM Module	5.9	6.0	5.7	**5.9**

Finally, the device was packaged as shown in the Figure 5 and Figure 6.

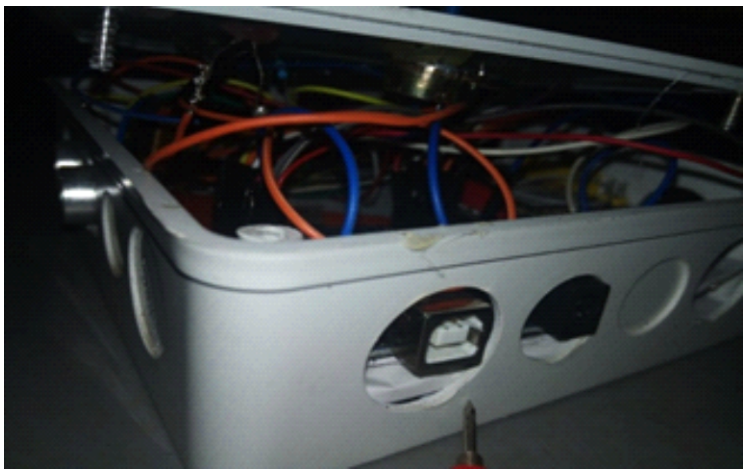

Figure 5. Packaging of the device showing the metal casing

Figure 6. Packaging of the device revealing the ultrasonic sensors

4. Conclusion

The development and implementation of the Advanced Road Vehicle Safety Device has been discussed and described in this research. This device is presently at *Proof-of-Concept* stage. The next stage is prototyping before commercialization. Users of the device are allowed to specify the message to be delivered to the recipients during installation. Also, the delivered message uses GPS to indicate the exact location of the accident. It is rather obvious that this device is fit for its purpose as the response time is small which can be a deciding factor between the life and death of an individual involved in a ghastly vehicle accident. With this device in use, the yearly death toll

caused by late medical response to persons involved in such accidents could reduce immensely. Furthermore, the developed device will also add value during forensic investigation of vehicle accidents by providing information on the impact velocity of an accident. This research is very timely as the world gradually adapts to electric vehicles which are cheaper and therefore increase the number of vehicles on the roads. A mandatory inclusion of this device on all road vehicles is proposed.

Acknowledgement

The authors are grateful to the staff of Physics Department Workshop, University of Lagos, Nigeria, for all their support and contributions towards the successful completion of this project.

References

Anusha, S., Madhavi, M. and Hemalatha, R. (2015). Home automation using atmega328 microcontroller and android application. *International Research Journal of Engineering and Technology*, 2(6): 865-868.

Bila C., Sivrikaya F., Khan M.A. and Albayrak S. (2017). Vehicles of the future: A survey of research on safety issues. IEEE Trans. *Intell. Transp. Syst.,* 18:1046-1065.

Braun M., Krebs S., Flohr F. and Gavrila D. (2019). EuroCity persons: A novel benchmark for person detection in traffic scenes. IEEE Trans. *Pattern Anal. Machine Intell.* 1-18.

Carullo, A. and Parvis, M. (2001). An ultrasonic sensor for distance measurement in automotive applications. *IEEE Sensors journal*, 2:143.

Chen, I. C. and Wilson, M. (1993). U.S. Patent No. 5,220,269. Washington, DC: U.S. Patent and Trademark Office.

Frenzel L.E. (2016). Principles of Electronic Communication Systems. *McGraw*Hill Education, New York. 360-375.

Guofa L., Shengbo E. L., Ruobing Z., Yuan L. and Cheng B, (2019), Detection of road traffic participants using cost-effective arrayed ultrasonic sensors in low speed traffic situations. Mechanical Systems and Signal Processing, 1321,. 535 – 545.

Makhijani K., Parmar A.A. Parmar K.S. and Rao H.Y. (2015). Smart Vehicle with GSM Alert System. *International Journal of Electrical, Electronics and Data Communication,* 3:50-73.

Oancea, C. D. (2011). GSM Infrastructure Used for Data Transmission. *International Symposium on Advanced Topics in Electrical Engineering*. **7:**60-77.

Pituk B. (2013). Fault Detection Approaches to Power System:

State-of-the-Art. *International Journal of Electrical and Computer Engineering*, 3:543-555.

Sam, R., Tan, M. N. M. and Ismail, M. S. (2013, October). Quad-copter using ATmega328 microcontroller. *In 2013 International Conference on Electrical Machines and Systems* 566-570.

Sánchez-Mangas, R., García-Ferrrer, A., De Juan, A. and Arroyo, A. M. (2010). The probability of death in road traffic accidents. How important is a quick medical response?. *Accident Analysis & Prevention*, 42(4):1048-1056.

Yeole, A. R., Bramhankar, S. M., Wani, M. D. and Mahajan, M. P. (2015). Smart phone controlled robot using ATMEGA328 microcontroller. *International Journal of Innovative Research in Computer and Communication Engineering*, 3(1):352-356.