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Design and Implementation of a Vehicle Tracking Mechanism using Wireless Network Infrastructure

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ABSTRACT

This study presents the design and implementation of a vehicle tracking system with the goal of assisting victims of road accidents in obtaining prompt assistance from the rescue team. This is accomplished by sending tracking data to the rescue team's mobile equipment. The system was developed utilising available electronics components, installed in a vehicle. Accident situations were recreated by dropping loads of different sizes from a height and loads linked to a rope to shatter the glass on the automobile in order to determine the minimal impart energy necessary to break the glass and the likelihood of a catastrophic accident. If an accident occurs, the GPS engine sends the coordinates of the crash site to the rescue team's mobile equipment through the SIM900 module's GSM engine over a GSM frequency for tracking. The system's tracking accuracy was determined using a standard GPS device, the GERMIN GPSMAP78s, to get the GPS coordinates of the scene and tracking them using the Google map API. When tracked using Google map, the tracking information obtained, when compared with the GARMIN GPSMAP78s, were exact, indicating that proposed device is capable of transmitting accurate tracking information in a short period of time, thereby saving lives.

1. Introduction

Transportation is a means of getting around. It is the act of moving people or products from one place to another. Its growth has made our obligations, assignments, and other everyday tasks easier. Road transportation is more prevalent in Nigeria than air, rail, and water transportation. This mode of transport has the greatest mortality and severity rates. According to the Nigeria Pilot [1], road accidents are the second leading cause of violent death in Nigeria, out of 193 nations. In 2008, road traffic injuries were the fourth biggest cause of mortality globally. Every year, around 1.3 million people die on the world's roadways, and 20 to 50 million people are injured, many of them become disabled. Unless action is done, about 1.9 million people would die yearly in traffic accidents [2]. According to Adeloye et al. [3], one in every four road fatalities in Africa happens in Nigeria and that Nigeria has the highest number of traffic fatalities. These are recorded accidents, although there are more unreported. According to Bari et al. [4], the main causes of road accidents include speeding, intoxicated driving, and not wearing a helmet or seat belt. The current method prioritized passenger safety above quick accident assistance. Road accidents have occurred in both industrialized and developing nations, causing loss of life and property [5].

This study proposes a way to aid road accident victims as quickly as possible by building an electronic gadget "vehicle tracking mechanism" using wireless network. Whenever an automobile collision occurs, this gadget sends out a short message service (SMS) with tracking information. This system does not prevent accidents but can save lives by alerting a rescue crew.

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Abbreviations

API	Application Programming Interface	LCD	Liquid Crystal Display
AT	Attention	LED	Light Emitting Diode
CO	Carbon (II) Oxide	LPG	Liquefied Petroleum Gas
CPU	Computer Processing Unit	SMS	Short Message Service
GDP	Gross Domestic Product	TTL	Transistor-Transistor Logic
GPS	Global Positioning System	UART	Universal Asynchronous Receiver Transmitter
GSM	Global System for Mobile communication	WHO	World Health Organisation

2. Literature Review

Vehicle tracking systems were originally utilised in the shipping sector to monitor each vehicle's whereabouts. However, with the rapid advancement of technology, automated vehicle monitoring systems are now being used to track and show vehicle positions in real-time. For improved service and cost-effective solutions, this present presents a vehicle tracking system employing GPS/GSM/GPRS technology.

Many studies have been done on accident emergency tracking systems. In [6], an efficient vehicle monitoring system for any site was designed and implemented. In their work, an Arduino board was utilised to coordinate the actions of GSM/GPS devices. However, no implementation was carried out.

In [7], the author built a tracking system for recognising automobiles in demanding settings, such growing traffic on freeways and sensor malfunctions. Instead of monitoring full cars, the system monitored vehicle characteristics to overcome partial obstruction.

A tracking system that employs GPS to pinpoint the position of an item, person, or other asset was developed by Khan and Mishra as cited in [8]. The data may be sent to a distant user through GSM modem. An ARM CPU coordinated the GSM/GPS modem's activity. The system can be operated by SMS, but no indication of how crashes may be discovered.

In [9], an intelligent accident identification system utilising GPS and GSM modem was proposed. The proposal is basically a suggestion of how to detect an accident scene, send a message to a main server, and have the main server locate the closest ambulance to the accident zone.

Malaysian UCSI University student Lau [10] devised a bus monitoring system. The tracking technology shows children where a bus is on a predetermined itinerary. The pupils can track the bus using an LED screen and a smartphone app. Students at large-campus institutions benefit from real-time bus tracking systems. They may now study, sleep, or relax instead of waiting for a late bus. Less time waiting for a bus enhances student comfort and efficiency.

An anti-theft tracking system may help prevent or detect unauthorised access to expensive gadgets. A car tracking [11] and anti-theft [12] system based on GPS/GSM technology has been proposed. The proposed system [11] uses a Kalman filter [13] to decrease positional errors; hence, improves position accuracy. When a vehicle's ignition is switched on, the owner gets a confirmation SMS. If the car is illegally accessed, the owner sends an SMS to disable it. A laptop running Google Earth is used to monitor the vehicle's position and condition. A smartphone can do the tasks that a laptop does.

Some consumers are interested in vehicle monitoring systems based on social media sites like Twitter and Facebook [14]. Each in-vehicle gadget has a Twitter account and can regularly determine the vehicle's position in the social network. An online interface displays a vehicle's position on Google maps, as well as its state (door open/closed, ignition on/off). Users may also send orders to the in-car device through the web interface to restart or shut down the vehicle. The suggested solution is easier to use on a smartphone with social networking capabilities. So, the method would be more efficient for users of social networks and smartphones, who can quickly track the vehicle's whereabouts.

Ramya [15], developed an embedded controller for vehicle in-front obstacle detection and cabin safety alert system. The goal was basically to design an embedded system for vehicle cabin safety and security by modifying and integrating the existing modules. This system monitored the level of the toxic gases such as CO, LPG and alcohol inside the vehicle and provided alert information in the form of alarm during the critical situations, and also sent SMS to the authorised person through the GSM. An IR Sensor was used to detect the static obstacle in front of the vehicle and the vehicle got stopped if any obstacle was detected.

The present study examines how an improvised sensor can distinguish between serious and deadly accidents and how long it takes for tracking information to reach the rescue crew.

3. Methodology

The proposed unit is divided into two parts, which ensure accident victims are rescued within the shortest time possible. The accident detecting/location unit installed in a car, which is the vehicle tracking mechanism and the rescue team mobile equipment, which can be a laptop, android phone or tablet that has internet facility with Google Map APP installed in it. Fig. 1 shows the communication network of the proposed unit.

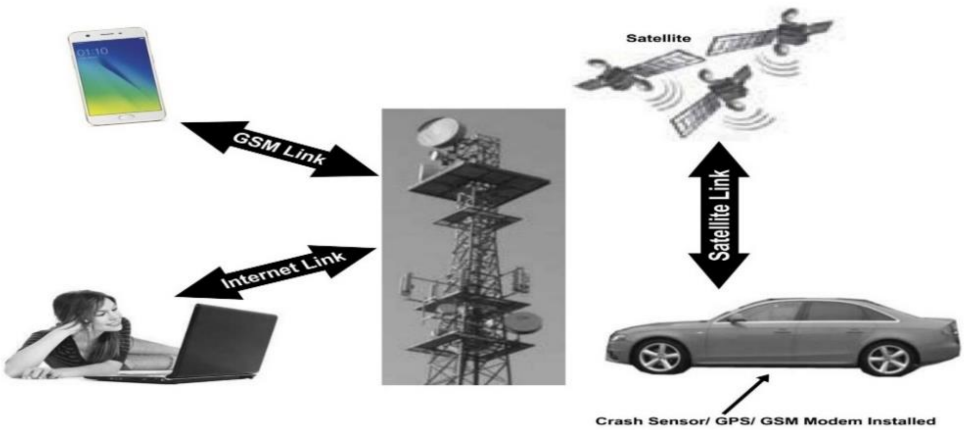

Fig. 1 Communication Link of Vehicle Tracking System.

The block diagram design (Fig. 2) shows that the sensors are connected to the microcontroller, which continuously checks its input if there is a change from "logic zero" to "logic one". The function of the LCD screen is to indicate the working status of the device and display the inputted number of the rescue team. The matrix keypad helps to input numbers while the SIM900 helps to get GPS coordinate of the crash scene. The vehicle tracking mechanism is constructed using available electronic components namely resistor, capacitor, SIM900 GSM module, Atmega16, matrix keypad, and LCD Screen. These components were joined together on a Vero-board. Fig. 3 shows the circuit diagram for accident emergency SMS tracking system. The circuit is powered by the 12Vdc from the car battery, which is step down to 5Vdc, reason being that the circuit is a digital circuit and the GSM module connection pins is TTL compatible.

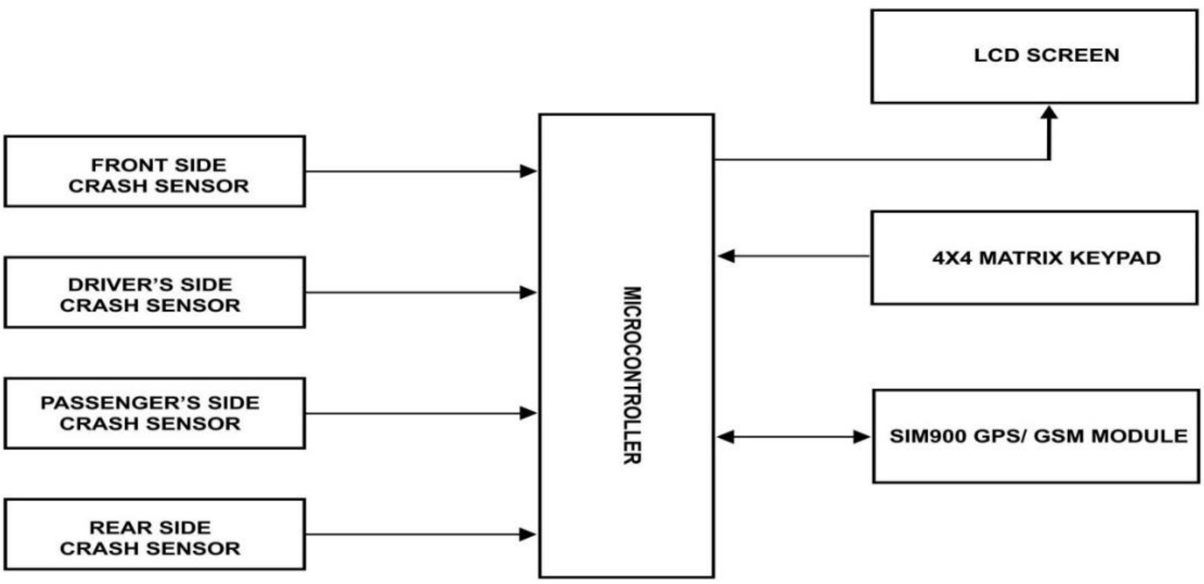

Fig. 2 Block Diagram of Vehicle Tracking Mechanism.

The crash sensor is a combination of a normally open switch and a glass. The output pin of the pin is connected to Atmega 16 as depicted in Fig. 3. The crashed sensors were connected to the PORTB pins of the microcontroller while the microcontroller was connected to SIM900 through its UART terminal. The LCD screen and the matrix keypad were connected to PORTA and PORTC pins of the microcontroller respectively. The function of the keypad is to input the identification number of the mobile equipment of the rescue team while the number is being displayed on the screen to ensure that the actual number is inputted. The design assumption was that severe or fatal accident cannot occur without causing bodily damage to the car. Hence, the choice for the improvised crashed sensor. The crashed sensor is a normally open switch, which is closed by bringing it in contact with a glass.

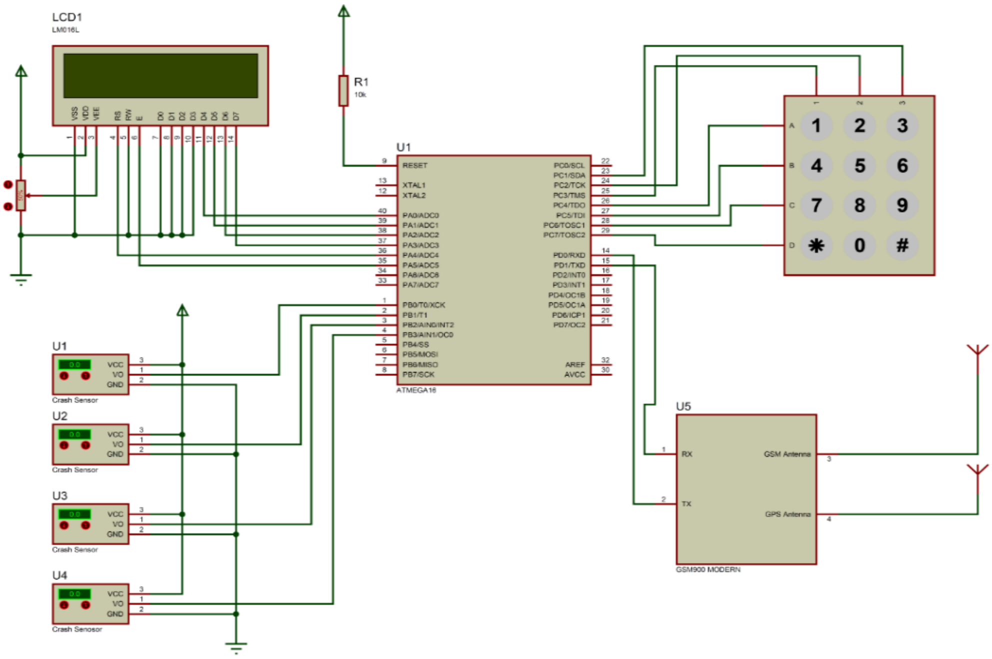

Fig. 3 Accident Emergency SMS Tracking System Circuitry.

The car bodily damage was used as a threshold to determine either severe or fatal situation by placing a glass in contact with a normally open switch to form a crashed sensor. The crashed sensors were placed under the bonnet, the two sides and the rear side of the car. When there is a car crash or accident, the glass shatters thereby releasing the switch from closed state to open state. The microcontroller input connected to the crashed sensor changes state from logic "1" to logic "0" indicating accident has occurred. The microcontroller then sends an AT command to SIM900 through its UART terminal, commanding it to get GPS coordinates of that location because an accident has occurred and send an SMS to the mobile equipment of the rescue team. The SIM900 has two parts: the GPS engine and the GSM engine. The GPS engine gets the coordinate, passes it to the GSM engine which then send the location coordinate and Google Map link for easy tracking to the mobile equipment of the rescue team. The LCD screen also displays the device working status. The software program embedded in the microcontroller helps to instruct the microcontroller. Fig. 4 shows the flow chart diagram for vehicle tracking system program.

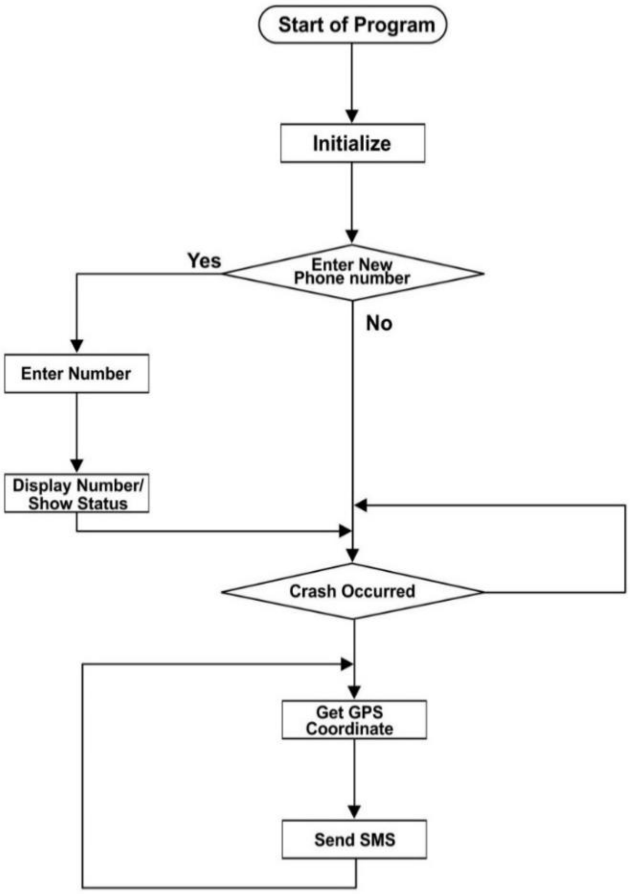

Fig. 4 Program Flow Chart of Vehicle Tracking Mechanism.

4. Results and Discussion

The accident emergency SMS tracking system was tested after it was fully constructed. The time it took for the SMS to deliver and tracked the crashed scene was measured with a stop watch while the minimum impact energy required to shatter the glass was also tested.

4.1. When one of the switches was opened while the rescue team mobile equipment was many kilometres away.

One of the normally open switches was opened to indicate accident occurrence and check if the coordinate sent actually represent the crashed scene location. Time taken for the SMS to deliver and track the location was measured using stop watch. The tracking information was validated by using GPS device GARMIN with model number GPSMAP78s to get the GPS coordinate of that location where the device is being tested. This information was tracked with Google map. When compared with the GARMIN GPSMAP78s, the same location was tracked.

Table 1 shows the readings of five different locations from several readings taking within Benin metropolis, Edo state, Nigeria. Whereas, Fig. 5 is a screenshot of the SMS sent to the mobile equipment and track scene while the red spot on the tracked scene (Fig. 6) indicates crashed location. The mobile equipment used is an android phone.

Table 1 SMS Received and Readings of Test Locations using GPS Device.

SMS Alert on smartphone	GARMIN GPS Reading	Time Taken hh:mm:ss	Tracking Accuracy
Crash detected! https://maps.google.com/maps?q=6.433988+5.599273 Lat:0626Σ0393.0393N Long:00535.9564E	N06^{0}26’02.5’’ E005^{0}35’57.5’’	00:00:55	Exact location tracked using Google map
Crash detected! https://maps.google.com/maps?q=6.348974+5.631308 Lat:0629385.9385N Long:00537.8785E	N06^{0}20’56.5’’ E005^{0}37’51.9’’	00:01:00	Exact location tracked using Google map
Crash detected! https://maps.google.com/maps?q=6.321841+5.635893 Lat:0613105.3105N Long:00538.1536E	N06^{0}19’18.6’’ E005^{0}38’08.9’’	00:00:49	Exact location tracked using Google map
Crash detected! https://maps.google.com/maps?q=6.246749+5.624749 Lat:0618050.8050N Long:00537.4850E	N06^{0}14’46.6’’ E005^{0}37’35.0’’	00:00:57	Unable to tracked area. (Area not mapped out on Google map
Crash detected! https://maps.google.com/maps?q=6.391893+5.616095 Lat:0623Σ5136.5136N Long:00536.9657E	N06^{0}23’30.5’’ E005^{0}36’57.7’’	00:01:02	Exact location tracked using Google map

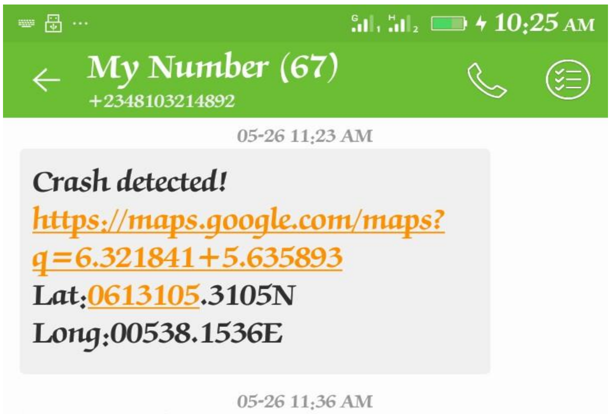

Fig. 5 SMS Received from a Crashed Scene.

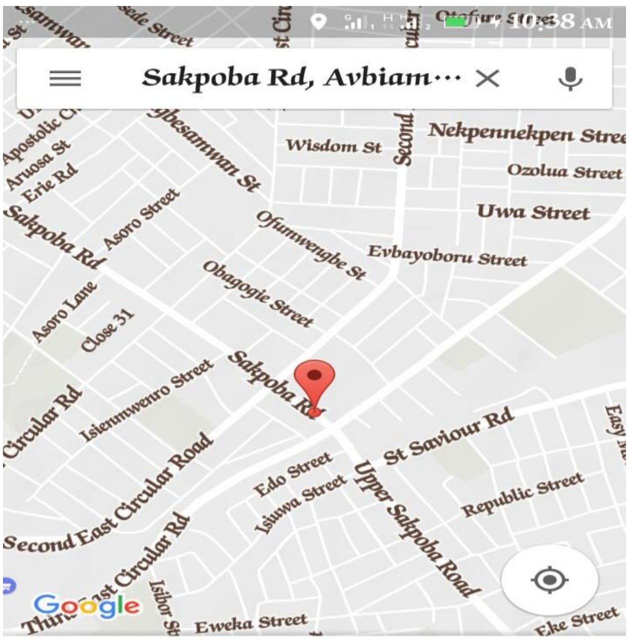

Fig. 6 Tracked Crashed Scene.

4.2. When loads were dropped on the car to determine minimum impact energy required to shatter the glass.

The minimum impart energy required to shatter the glass was tested, by dropping loads of various weight on the bonnet and striking the driver's side with loads of various weight. The assumption here is that either severe or fatal accident cannot occur without causing bodily damage to the car. Load weight of 35kg from a height of 5m was found to shatter the glass when dropped. From potential energy equation

$$E_p = mgh \quad (1)$$

Where, E_p is potential energy, m (= 35kg) is the mass, g (= $10ms^{-2}$) is acceleration due to free fall, and h (= 5m) is the falling height. By substitution:

$$E_p = 30kg \times 10ms^{-2} \times 5m = 1500J$$

4.3. When a rope was hung from a height of 8m, strong enough to suspend weight up to 100kg, and was used to form simple pendulum with various loads attached to it.

The simple pendulum swung to strike the car from the driver's side in order to shatter the glass attached. The loads swung through a height of 0.4m from the ground. From law of conservation of mechanical energy;

$$E_k = E_p \quad (2)$$

Where, E_k is kinetic energy and E_p is the potential energy.

$$E_k + E_p = \text{constant}$$

or

$$E_k + E_p \text{ at any point} = E_k + E_p \text{ at another point [16], thus:}$$

$$\frac{1}{2}mv^2 = mg \quad (3)$$

From the test, load of 20kg shatters the glass.

E_p from a height of 8m = 20x 10 x8 = 1600J

E_p from a height of 0.4m = 20 x 10 x 0.4 = 80J

$$E_k + E_p = 1600J$$

$$E_k + 80J = 1600J$$

$$E_k = 1520J.$$

The impact energy needed to shatter the glass from the side is 1520J.

5. Conclusion

The design and implementation of a vehicle tracking system with the goal of assisting road accidents victims in obtaining prompt assistance from the rescue team is presented in this study. The tracking system was developed utilising commonly available electronics components, which are installed in a vehicle. Accident situations were created by dropping loads of different sizes from a height and loads linked to a rope to shatter the glass on the automobile to determine the minimal impart energy necessary to break the glass and the likelihood of a catastrophic accident. If there is an accident, the GPS engine obtains the coordinates of the crash site, which are then sent to the rescue team's mobile equipment through the SIM900 module's GSM engine over a GSM frequency for tracking. The system's tracking accuracy was determined by utilising a standard GPS device, the GERMIN GPSMAP78s, to get the GPS coordinates of the scene and tracking them using the Google map API. When tracked using Google map, the tracking information obtained, when compared with the GARMIN GPSMAP78s, were exact, indicating that proposed device is capable of transmitting accurate tracking information in a short period of time, thereby saving lives. The sensor used in this work is based on the assumption that there is no severe or fatal accident without causing bodily damage to the car. This study did not consider a car falling in a pit or river, where the sensor will not crash. In such a scene, the sensor may not sense accident scene. Also, rural areas that are not mapped out on Google map were not captured.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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