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Model of Internet of Things (IoT) Based Vehicle Accident Real Time Reporting System

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ABSTRACT

No matter how conscientious the safety efforts are, accidents are going to happen, sometimes due to human or system error. The rising rate of loss of life and property due to road accident warranted the need for a way of getting prompt and immediate report of accident occurrence to the concerned agencies for proper rescue operation. This work Model of Internet of Things (IoT) Based Vehicle Accident Real Time Reporting System is an accident reporting model. The system is meant to inform the users of the occurrence of the accident information – time and place scene within the quickest possible time using SMS platform through Internet of Things (IoT) based system. The major components of system are vibration sensor, GSM module and Global Positioning System. The issues of false alarm are taken care of with the addition false alarm which the driver uses stop the triggering of SMS to the concerned authorities.

Keywords: IoT, GPRS, Vibrator, GSM, Vehicle Accident

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1. INTRODUCTION

An accident is a sudden and unplanned event, often with lack of intention. It typically implies a usually negative outcome which may have been avoided or disallowed had circumstances leading to the accident been predictable earlier, and acted upon, prior to its occurrence. The largest cause of unnatural deaths in the world today (apart from diseases) is road accidents.

The International Road Federation, Geneva Programme Centre reported that approximately 2.4 billion people have died in road accidents across the world, with a yearly record of 1.3 million deaths and daily record of 3,000 deaths (irf.global, 2017). Nigeria still remains one of the worst hit countries and has suffered severe losses to fatal car accidents. Nigeria is ranked second-highest in the rate of road accidents among 193 countries of the world (Agbonkhese, 2013). The latest WHO ranking on death rate due road accident 2021 placed Nigeria 15.8/100000, (IHME, Global Burden of Disease 2024). The rising rate of loss of life and property due to road accident warranted the need for a way of getting prompt and immediate report of accident occurrence to the concerned agencies for proper rescue operation and record purposes especially when such accidents occur at locations where necessary rescue operations are insufficient or unavailable. Records of accidents and their places of occurrence could indicate the geographical areas in need of infrastructural amenities.

The Internet of Things (IoT) refers to the use of intelligently connected devices and systems to leverage data gathered by embedded sensors and actuators in machines and other physical objects. Also, Internet of Things (IoT) is an arrangement of interrelated computing gadgets, mechanical and digital machines, objects, individuals that are given one kind of an identifier and the capacity to exchange information over a system. IoT is a new concept that has evolved from the convergence of wireless technologies. The definition of the Internet of things has evolved due to convergence of multiple technologies, real-time analytics, machine learning, commodity sensors, and embedded systems. Cisco Systems estimated that IoT was "born" between 2008 and 2009, with the things/people ratio growing from 0.08 in 2003 to 1.84 in 2010 (*Dave, 2011).* Wireless communication is the transfer of information or signal between two or more points that are not connected by an electrical conductor. In IoT, devices equipped with WiFi allow the machine-to-machine communication.

Using IoT technique, an automatic vehicle location information system can be built. Such a vehicle location system will use Global Positioning System (GPS) technology for locating the geographical coordinate of the vehicle. The vehicle location can be viewed on an electronic map via the internet, with specialized software such as a mobile android application. These systems go beyond simple reporting of a vehicle's location, offering fleet managers a wealth of information about their vehicles and their drivers (Trackyourtruck.com, 2017).

There are some companies that provide Vehicle Tracking Service (VTS) which have some common features like tracking the vehicle using satellite GPS &Global System for Mobile (GSM) communication. But there is no system in Nigeria which can automatically detect the occurrence of accident and also communicate information about the accident to the road safety agencies or other emergency contacts through GSM. The motivation of this research is to create a system that automatically detects the occurrence of an accident and communicates such information to the road safety and any other emergency contact(s). A platform will also be created for accident information storage and retrieval.

1.2 Statement of the Problem

Delay in alerting the road safety and other emergency agencies result in accident victims losing their lives at crash sites even when they would have survived had the emergency agencies been alerted on time. In the same vein, there is lack of information correlating the use of certain road networks with their rates of accident occurrence, hence the inability of motorists to avoid danger roads and the inability of government to prioritize these danger roads on their list of infrastructural amenities.

1.3 Aim of the Study

The aim of this research work is to develop a model of Internet of Things based Vehicle accident Real Time Reporting system that should be able to detect the occurrence of an accident and communicate the relevant agencies.

1.4 Objectives of the Study

The objectives are to:

i. Design an embedded system that can sense the occurrence of car accident based on a vibration sensor.
ii. Integrate a global positioning system (GPS) for detecting the geographical location of the accident site.
iii. Integrate a global system for mobile (GSM) communication system for alerting the road safety agencies and next of kin about the accident regardless of the time of accident or location of accident.

1.5 Significance of the Study

The proposed system will be of immense benefit to the road safety agency, government, motorists and members of the public.The road safety will get timely information when an accident occurs and be able to locate the accident scene as the accident information will be sent to their hot line.The system will serve road users by helping them alert the emergency agencies in cases of accident. They will also have information on the danger roads to avoid when travelling.They will serve members of the public by providing them with history of recorded road accidents.

2. LITERATURE REVIEW

2.1 Overview of Technologies

Internet of Things: The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction (Rouse, 2019).The definition of the Internet of Things has evolved due to the convergence of multiple technologies, real-time analytics, machine learning, commodity sensors, and embedded systems (Wigmore, 2014). Traditional fields of embedded systems, wireless sensor networks, control systems, automation (including home and building automation), and others all contribute to enabling the Internet of Things.

In the consumer market, IoT technology is most synonymous with products pertaining to the concept of the "smart home", covering devices and appliances (such as lighting fixtures, thermostats, home security systems and cameras, and other home appliances) that support one or more common ecosystems, and can be controlled via devices associated with that ecosystem, such as smart phones and smart speakers. The extensive set of applications for IoT devices is often divided into consumer, commercial, industrial, and infrastructure spaces (Perera et al., 2015). A growing portion of IoT devices are created for consumer use, including connected vehicles, home automation, wearable technology, connected health, and appliances with remote monitoring capabilities.Global System for Mobile (GSM) Communications: The Global System for Mobile (GSM) Communications is a standard developed by the European Telecommunications Standards Institute (ETSI) to describe the protocols for second-generation (2G) digital cellular networks used by mobile devices such as mobile phones and tablets.

It was first deployed in Finland in December 1991.By the mid-2010s, it became a global standard for mobile communications achieving over 90% market share, and operating in over 193 countries and territories (Huurdeman, 2003). Global Positioning System (GPS): The Global Positioning System (GPS), originally NAVSTAR GPS, is a satellite-based radio navigation system owned by the United States government and operated by the United States Air Force. It is a global navigation satellite system (GNSS) that provides geolocation and time information to a GPS receiver anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites (Department of Defense, 2008).

The GPS does not require the user to transmit any data, and it operates independently of any telephonic or internet reception, though these technologies can enhance the usefulness of the GPS positioning information. The GPS provides critical positioning capabilities to military, civil, and commercial users around the world. The United States government created the system, maintains it, and makes it freely accessible to anyone with a GPS receiver (Real Engineering, 2017).Vibration Sensor: The vibration sensor (see Figure 1) is a flexible device which uses the piezoelectric effects while measuring the changes within acceleration, pressure, temperature, force otherwise strain by changing to an electrical charge. This sensor is also used for deciding fragrances within the air by immediately measuring capacitance as well as quality (Elprocus, 2019).

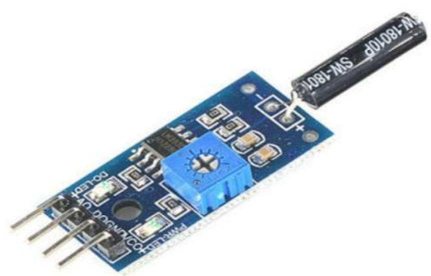

Figure 1: Vibration Sensor (Elprocus, 2019).

3. DESIGN METHODOLOGY

The methodology that was chosen for the development of a model for detecting road traffic accidents is the prototyping methodology (see Figure 2). The prototyping-based methodology performs the analysis, design and implementation phases concurrently, and all these three are performed repeatedly in a cycle until the system is completed. With this methodology, a basic analysis and design is performed, and this immediately begins on a system prototype of the programme that provides a minimal number of features. The software developer can get valuable feedback from the users early in the project. It also allows the software engineer some insight into the accuracy of initial project estimates and whether the deadlines and milestones can be successfully met (Dennis *et al.*, 2012).

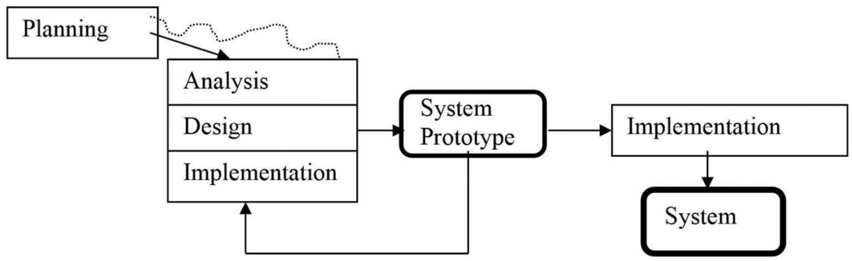

Figure 2: Prototyping Methodology(Dennis et al., 2012)

4. DISCUSSION

The proposed system will have the following system architecture that shows how the system-wide components will interact (see Figure 3). The proposed system will have a GSM/GPRS module which will enable the sending of SMS to the security agencies. The system will have two conspicuously located buttons. One will be used to disable false accident alarms while the other will be used to activate forced accident alarm. An alarm will be provided which will sound continuously for 10 seconds after an accident is presumably detected, giving the motorist an opportunity to disable a false alarm using the false alarm button

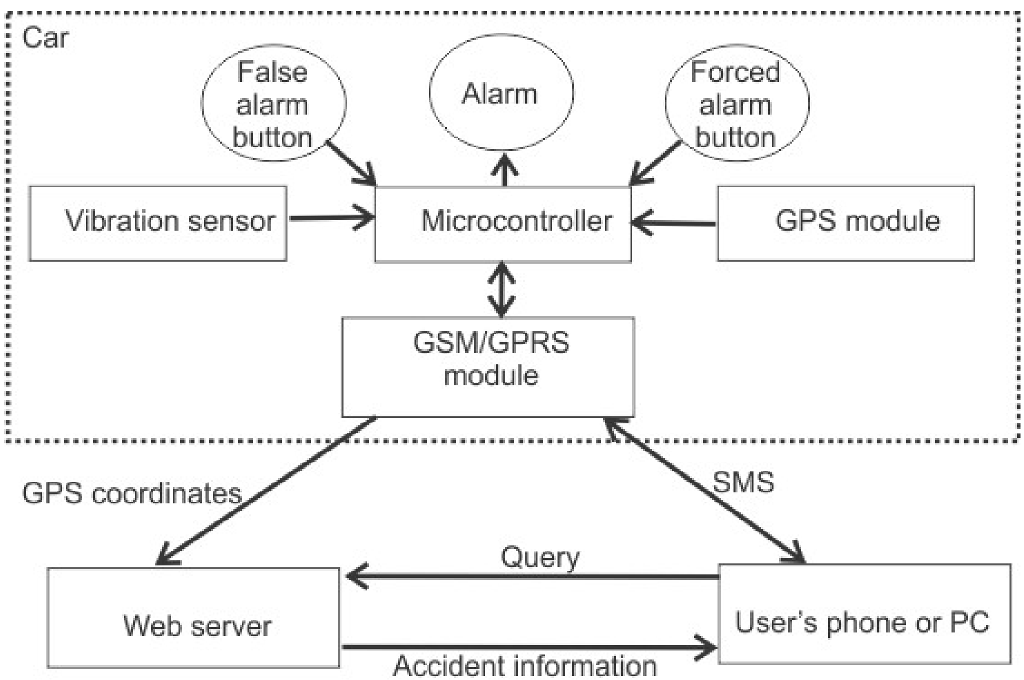

Figure 3: System Architecture of the Proposed System (Oliver's Field Work, 2019)

The SMS-based user interface
The SMS based user interface allows the user to update the emergency numbers stored in the device. If the device is owned or the emergency number of the existing user changes, the user can update the stored phone number by sending SMS to the device. The SMS sent to device should correspond to the format *KEYWORD NUMBER_1 NUMBER_2 NUMBER_3*

Where keyword is a string that tells the system that the numbers following the string are emergency contacts that should be stored in the EEPROM. NUMBER_1 to NUMBER_3 are the emergency phone numbers that will be stored by the system.

When the emergency phone numbers are updated successfully, the system gives the user confirmation by sounding a 2 beep of the alarm. The SMS user interface is also used to alert the Road Safety on the occurrence of an accident. Figure 4 below is the SMS user interface design.

Figure 4: Sample of SMS Generated to Notify Accident

Use Case Diagram of the Accident Information System
Figure 5 is a Use Case Diagram for the accident information system. As seen in the diagram, the driver is responsible for enabling the Forced Alarm, disabling a False alarm and updating the emergency numbers stored in the system; while the emergency personnel whose phone numbers have been stored in the system, are responsible for receiving the accident alert and viewing the accident log.

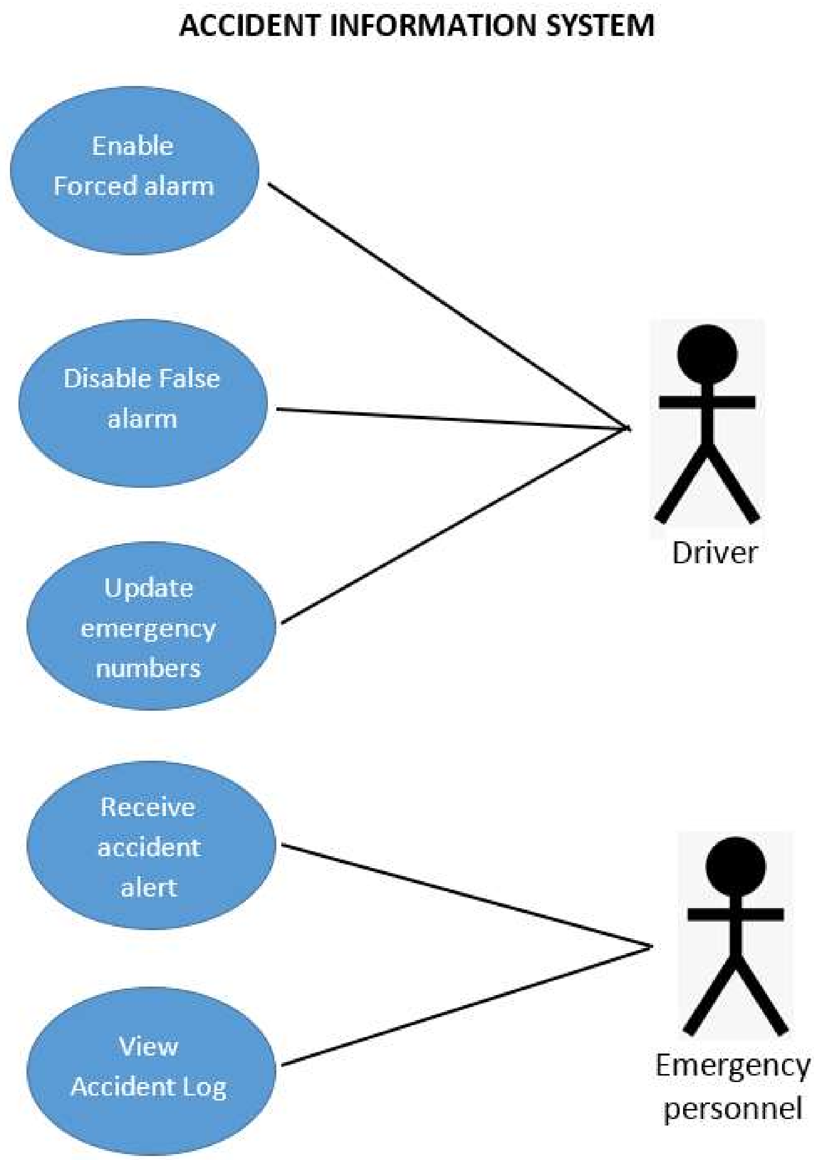

Figure 5: Use Case Diagram of the New System

Data Flow Diagram of the New System

The data flow diagram in Figure 6 shows the flow of signals in the new system. As seen in the data flow diagram, the Forced and False alarm buttons can be pressed to enable forced accident alarm or disable false accident alarm respectively. Pressing the buttons ground the microcontroller pins they are connected to making the microcontroller to sense a ground signal (logic 0) on the pins that are normally connected to 5 volts (logic 1).

Pressing the Forced alarm button causes the microcontroller to send 5 volts to the alarm/buzzer for 20 seconds while pressing the false alarm button causes the microcontroller to stop sending 5 volts to the alarm. On the other hand, the vibrator sensor sends 5 volts to the PIC whenever it senses an accident-causing vibration. In response to this, the PIC sends 5 volts to the alarm for 20 seconds.

The GPS module is responsible for getting the current time and location and sending the same to the PIC. The PIC sends the current time and coordinates in form of bytes to the GSM/GPRS module. The GSM/GPRS module in turn sends the current time and coordinates to the web server and the emergency mobile numbers. The emergency numbers are updated by sending an SMS to the GSM/GPRS module from the user's phone. The user can also query the web server to get stored accident information.

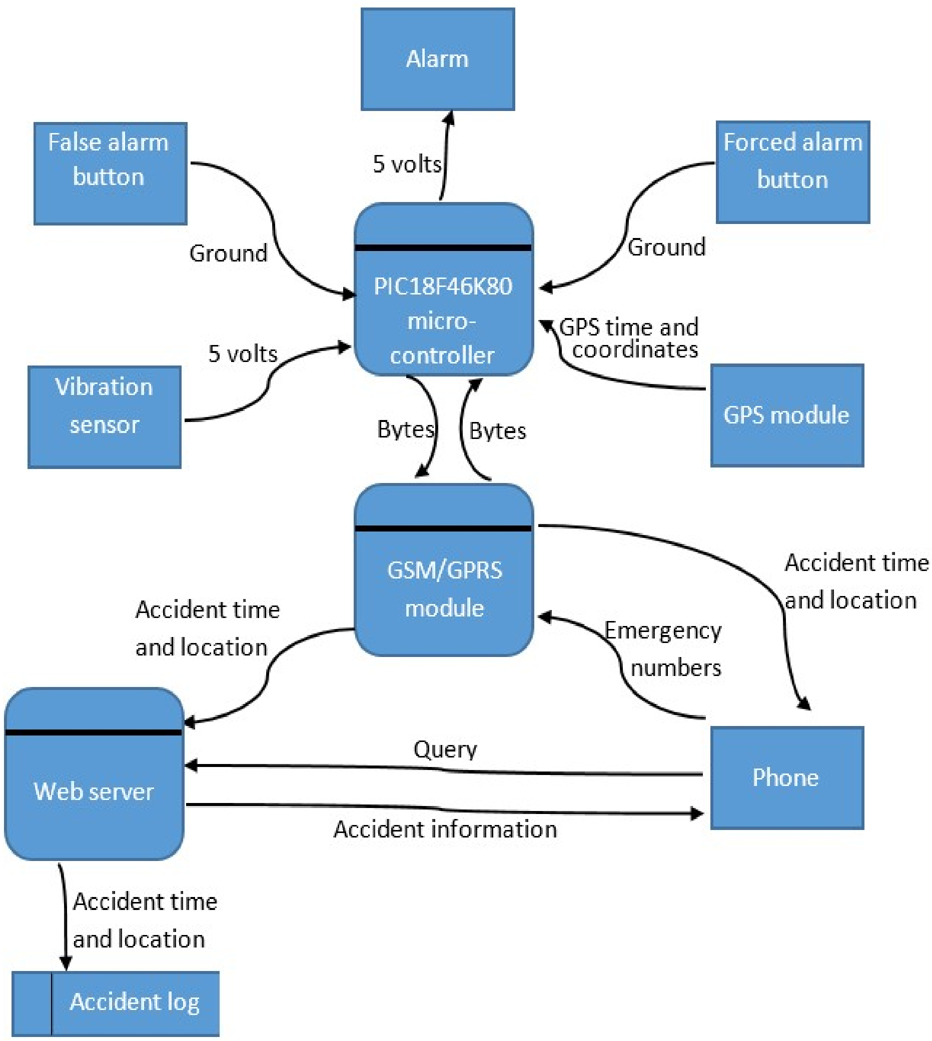

Figure 6 Data Flow Diagram of the Proposed System

5.CONCLUSION

In this research, a model of an accident information system was developed to alert users of the occurrence of accident and record the accident information on a web server for future reference by relevant authorities. Specifically, inline with our stated objectives, our model has the capabilities to:

i. sense the occurrence of vehicle accident based on a vibration sensor;
ii. detect the time and geographical location of the accident site;
iii. alert the emergency numbers stored in the system with accident information

REFERENCES

Agbonkhese, O., Yisa, G.L., Agbonkhese, E.G., Akanbi, D.O., Aka, E.O., Mondigha, E.B. (2013), Road Traffic Accidents in Nigeria: Causes and Preventive Measures. *Civil and Environmental Research*, ISSN 2224-5790 (Paper) ISSN 2225-0514 (Online), Vol.3, No.13

*Dave, E. (2011)."*The Internet of Things: How the Next Evolution of the Internet Is Changing Everything" *(PDF). CISCO white paper*

Department of Defense (2008). *Global positioning system Standard positioning service Performance standard.* USA: Pentagon.

Elprocus (2019). *Vibration Sensor Working and Applications.* Retrieved 10/11/2019 from https://www.elprocus.com/vibration-sensor-working-and-applications.

Huurdeman, A. A. (2003). The Worldwide History of Telecommunications, USA: John Wiley & Sons.

IHME, Global Burden of Disease (2024) – with minor processing by Our World in Data. “Death rate from road injuries” [dataset]. IHME, Global Burden of Disease, “Global Burden of Disease - Deaths and DALYs” [original data]. Retrieved May 19, 2025 from https://ourworldindata.org/grapher/death-rates-road-incidents

irf.global (2017) International Road Federation Report on the state of accidents in the world. [Online]. Available: https://www.irf.global/ [Accessed: 08-May-2018]

Perera, C., Liu, C. H., Jayawardena, S. (2015).The Emerging Internet of Things Marketplace From an Industrial Perspective: A Survey. IEEE Transactions on Emerging Topics in Computing 3(4): 585–598.

Real Engineering (2017).Why The US Military Made GPS Free-To-Use. Retrieved August 16, 2018 from https://web.archive.org/web/20181231195431/https://www.youtube.com/watch?v=ozAPGnr-934.

*Rouse, M. (2019).*Iinternet of things (IoT).Retrieved 14 August 2019 from https://internetofthingsagenda.techtarget.com/definition/Internet-of-Things-IoT.

Trackyourtruck.com, (2017) A Brief History of GPS Vehicle Tracking". [Online]. Available: http://www.trackyourtruck.com/blog/brief-history-gps-vehicle-tracking/. [Accessed: 16-March- 2018]

Wigmore, I. (2014). Internet of Things (IoT). Retrieved 09/11/2019 from https://internetofthingsagenda.techtarget.com/definition/Internet-of-Things-IoT.

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