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ORIGINAL RESEARCH ARTICLE

IMPLEMENTATION OF VEHICLE ACCIDENT MONITORING DEVICE ALONG BENIN-WARRI ROAD

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ABSTRACT

Vehicle accident motoring system is a system that automatically senses an accident in real time and sends an SMS alert to predetermined numbers for rescue of accident victims. The system comprises of a designed accident detecting device to be installed in vehicles that read and interpret geographical coordinates of various locations along Benin-Warri road and GSM mobile phone. The device has a vibration sensor, GSM/GPS module with an embedded computer chip which was programmed with C language. The coordinates of the Locations were collated using GPS measuring instrument and serves as input to the device. The obtained data were subject to normality and correlation test for validation. The results show that the data are normally distributed and significant at 0.01 The device was programmed in such a way as to convert the Latitude, Longitude and Altitude of a spot to its equivalent assigned or known name. If an accident occurs at any spot along the road, the device immediately sends the names of the location via SMS alert to relevant numbers. It was tested for the route and various successful accident alert messages were registered.

1.0 Introduction

On daily, monthly and yearly bases, death resulting from accidents is alarming. Accident is an unexpected and unpleasant event (Hornby, 2013). According to the World Health Organization. road accidents kill more than 1.2 million people every year, representing 21% of all deaths, and cause 50 million injuries. People, aged 15 to 44 years, who are the economically active adults, account for more than a half of the total road traffic deaths and about 30% to 86% of all trauma admissions as a result of road traffic crashes in some low-income and middle-income countries (Peden et al., 2004). The problem of road traffic crashes and injuries is growing and this poses a serious developmental and public health problems. Generally, the poorer population groups in developing countries bear a disproportionate burden of avoidable consequences from road traffic injuries. In the case of rich countries, children from relatively lower socio-economic classes also suffer a higher burden of morbidity and deaths from road crashes than their counterparts from high-income groups (Akpoghomeh, 1998). The economic cost of road accidents and resulting injuries is estimated at $518 billion worldwide. Irrespective of the numerous measures put in place to curb the menace, little or no success had been achieved. As in other developing countries, road traffic accident in Nigeria is one of the most serious problems in need of pragmatic solution. Yet this problem has been difficult to address probably because of the country's level of development. Nigeria is said to have the highest road traffic accident rates in Africa and the second in the world (Nantulya and Reich, 2003). According to statistics published by Nigeria Watch in 2015 on the trends and patterns of fatal vehicle accidents in Nigeria (Ukoji, 2015), approximately 61,090 people lost their lives in 14,087 events nationwide from year 2006 to 2014. The publication also revealed that Lagos State recorded the highest number, with 1,543 car accident deaths, followed by Edo with 1,201 deaths and FCT (Abuja) with 1,026 deaths. On the other hand, the statistics released by the Federal Road Safety Commission Annual report 2015, shows that a total of 1,115,663 road traffic crashes were recorded from the year 1960 to 2015 that resulted to the death of 343,909 persons across the Country. From the data, year 2015 alone recorded a total of 9734 traffic crashes with 5440 deaths. Detailed review of the year 2015 in some states shows that. Kaduna State recorded the highest number of fatalities with 474, followed by FCT with 328 deaths, Kogi with 310 deaths while Edo and Delta States recorded 184 and 151 deaths respectively. Bayelsa (16 deaths), Taraba (14 deaths) and Borno (2 deaths) states recorded far fewer fatal road accidents. From the data, Edo and Delta States recorded a total of 2088 road crashes that led to 335 deaths in 2015 (FRSC, 2016).

2. Literature Review

2.1 Traffic Monitoring and Accident Detection at Intersections

The Traffic Monitoring and Accident Detection at Intersections is a modelled system based on local analysis of the behavior of a vehicle at intersection. It identifies a vehicle and track its behavior and to recognize situations or events that are likely to result from a chain of such behavior. In order to solve this problem an algorithm, referred to as spatio-temporal Markov random field (MRF), for traffic images at intersections was formulated using blocks. This algorithm models a tracking problem by determining the state of each pixel in an image and its transit, and how such states transit along both the x-y image axes as well as the time axes. Vehicles, of course, are of various shapes and they move in random fashion, thereby leading to full or partial occlusion at intersections. The following are models formulated in its realization (Shunsuke et al., 2000).

$$U_{12}(yk) = U(yk = Q_1) - U(yk = Q_2) \qquad (1)$$

where:

y is label distribution of a vehicle, k is block number, Q_1 is vehicle label 1 and Q_2 is vehicle label 2.

U12 ($yk=Q_1$) is the energy for a block of yk having a vehicle labeled Q_1 among two possible vehicles labeled as Q_1 and Q_2.

The derivative of equation 1 is shown in equation 2.

$$\dot{U}_{12}(yk) = a\{N_y(yk = Q_1) - N_y(yk = Q_2)\} - \{N_y(yk = Q_1) + N_y(yk = Q_2) - 2\mu_{N_y}\} + b\{M_{xy}(yk = Q_1) - M_{xy}(yk = Q_2)\} - \{M_{xy}(yk = Q_1) + M_{xy}(yk = Q_2) - 2\mu_{M_{xy}}\} + c\{Dxy\ (yk = Q_1)^2 - Dxy\ (yk = Q_2)^2\} \qquad (2)$$

Since the energy function Ck is to confuse two blocks as the case of accident,

$$N_y(yk = Q_1) + N_y(yk = Q_2) = 2\mu_{N_y} \qquad (3)$$

$$M_{xy}(yk = Q_1) + M_{xy}(yk = Q_2) = 2\mu_{M_{xy}} \qquad (4)$$

where,

Ny is the number of neighbour blocks of a block Ck, Mxy is the goodness measure of the previous object while μ is a constant.

The resultant effect to the energy function of equation 1 is shown in equation 5.

$$U_{12}(yk) = \alpha\{N_y(yk = Q_1) - N_y(yk = Q_2)\} + \beta\{M_{xy}(yk = Q_1) - M_{xy}(yk = Q_2)\} + \gamma\{Dxy\ (yk = Q_1)^2 - Dxy\ (yk = Q_2)^2\} \quad (5)$$

where:

α, β and γ constants while Dxy is energy function estimate.

Looking at equation 5, it is symmentrical with respect to Q1 and Q2. Suppose U12(yk) is negative, the block Ck will likely have more Q1 than Q2. Again, if U12(yk) is positive, the block Ck will likely have more Q2 than Q1 that indicates accident (Shunsuke et al., 2000).

2.2 Smartphones to detect car accidents that provide situational awareness to emergency responders

The smartphones car accidents detecting and situational awareness to emergency responders is also called the Wreck Watch. It provides functionality similar to an accident/event data recorder by recording the path, speed, and forces of acceleration on a vehicle leading up to and during an accident. It can also notify emergency responders of accidents, aggregate images and video uploaded by bystanders at the scene of an accident and send prerecorded text and/or audio messages to emergency contacts. It is built using Google Android on the client and Java/MySQL with Jetty and the Spring Framework on the server. The Wreck Watch is separated into two main components (the Wreck Watch server and the Wreck Watch client). The Wreck Watch client provides mapping functionality through Google Maps on the device to ensure that emergency responders continuously receive information about an accident. The Wreck Watch Android client is written in Java based on Android 1.5 with Google APIs that consists of several Android application activities for mapping, testing, and image upload. The background services detect accidents by polling smartphone system sensors, such as the GPS receiver and accelerometers. As accident information becomes available, the Wreck Watch server posts location, route and severity information to a Google Map to aid emergency responders, as well as other drivers attempting to navigate the roads near the accident (Chris et al., 2011).

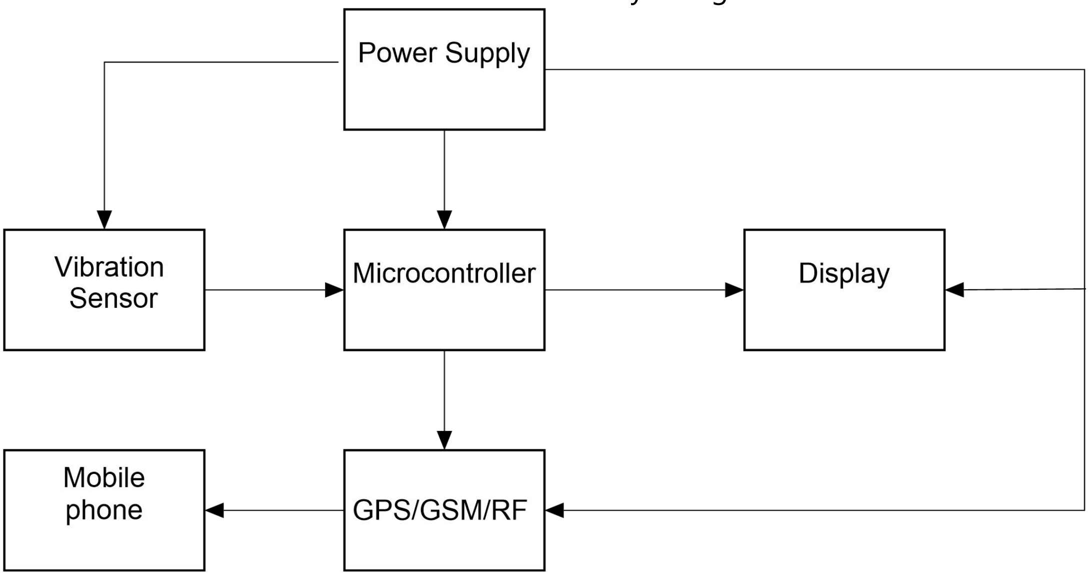
2.3 Development of automatic geofencing and accidental monitoring system based on GPS technology

The development of automatic geofencing and accidental monitoring system is based on GPS technology embedded in vehicle to detect road accident for immediate medical help as well as for security purpose in theft prevention using single shock sensor. In case of accidental mode, the system informs automatically via text message to medical rescue team indicating the position of vehicle location. When the driver is out of the vehicle, the system automatically goes into security mode. At this mode, a theft attempt on the vehicle, this system sends an alert message to the owner. Mobile text message is containing location from GPS (Latitude, Longitude) will be sent if the device detects an accident. The major shortcoming in this work include detecting only a vehicle that exceeded its maximum speed limit, but incapable of detecting accident occurrence and reporting same with precise location (Danish and Jaspal, 2013).

3. Materials and Methods

3.1 Accident Detecting Device Design

Figure 1 is the block diagram of the designed accident detecting device. It was implemented with the following major units/components namely; the vibration sensor model SPM8667VC, the GPS/GSM dual module SIM808, LCD display LM018 (16x2) and the programmable microcontroller PIC18f2550. The PIC18f2550 microcontroller was chosen from the Microchip Technology 2006. It could communicate with GPS/GSM module, drives the display, reads in real time picture date from camera, responds to motion detection signal from the PIR, and drives the buzzer when necessary. It is a 28-pins, 8-bit, Integrated Circuit that has in-built Universal Asynchronous Receiver Transmitter (UART) Module, Pulse Width Modulation (PWM), In-Circuit Serial Programmer (ICSP) and runs at a high clock speed of 48MHz. It also has an Internal Program memory capacity of 32kilobytes, a 16384 single word instructions, data memory capacity of 2048 bytes and 256bytes of SRAM. In addition, it has an EEPROM that can make it perform many functions almost at the same time. Its power consumption is 5Vmax. Figure 2 is the IC representation of the PIC18f2550 microcontroller. The accident detecting device is powered with a 12Vdc which is the conventional battery rating of cars and vehicles.



Fgure 1: Block diagram of proposed accident detecting device.

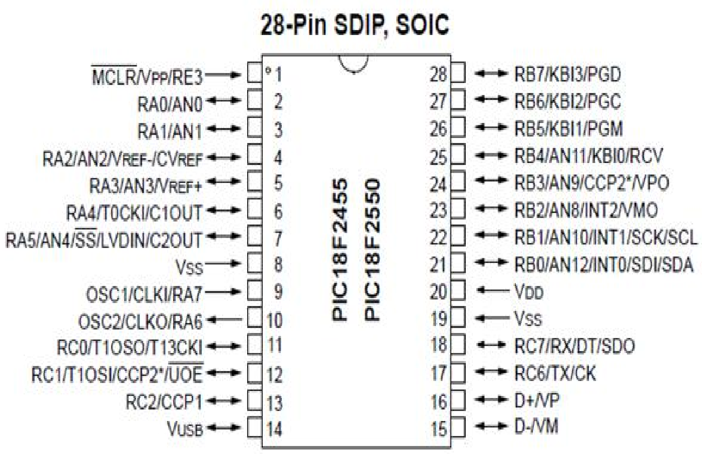


Figure 2: PIC18f2550 microcontroller IC representation. (Microchip 2006)

3.2 Accident Detecting Device Input Data Implementation

The accident reporting device inputs data are raw Longitudes and Latitudes obtained at interval of 150m along Benin-Warri road. The Longitudes and Latitudes data were obtained in degrees and minutes using a GPS measuring device called Garmin GPSmap78sc. The raw data were converted to their equivalent decimal values, a format for programming the microcontroller using the Latlong converter software. Furthermore, the data were validated by computing for the distance between each location along the Benin -Warri road. This was realized by programming the Excel for △d using the Haversine formula in equation 6 (Noel and Montavont, 2006).

$$\text{haversin}\left(\frac{d}{R}\right) = \text{haversin}(\phi_1 - \phi_2) + \cos(\phi_1)\cos(\phi_2)\text{haversin}(\Delta\lambda) \qquad (6)$$

where :

haversin is the haversine function,

$haversin(\theta) = \sin^2(\theta/2)$

d is the distance between the two points (along a great circle of the sphere)

R is the radius of the sphere (earth) = about 6371km

ϕ_1 is the latitude of point 1

ϕ_2 is the latitude of point 2

$\Delta\lambda$ is the longitude separation

From equation 6, d can be solved for by applying the inverse haversine or by using the arcsin (inverse of sine) function, where:

$d = R\text{haversin}^{-1}(h) = 2R\arcsin(\sqrt{h})$ and $h = \text{haversin}\left(\frac{d}{R}\right)$

3.3 Accident Detecting Device Operation

The accident detecting device starts its operation with a vibrating sensor that is set at optimum vibrating resonant frequency of 50 kHz estimated for accident vibrations cases. When an accident occurs, the vibrating sensor converts the mechanical vibration to analog signal. This signal is in turn converted to digital signal with the aid of A/D converter. The signal is sent to the microcontroller chip which processes same and request at the same time for the spot where the accident occur from the GPS module/receiver registering every spot coordinates of Longitude, Latitude and Altitude with the aid of the GPS satellite. The microcontroller then converts the raw data coordinates to its equivalent known nomenclature of the spots along Warri-Benin road. The location nomenclature is again processed and sends to registered numbers of rescue agencies, relatives and friends of the victim via GSM network. The major role of the microcontroller is to extract speed information from the GPS satellites via the GPS module and then display them on the LCD while constantly checking the vibration levels and comparing them with already predefined values so that once the measured vibration values fall off the safe range or rises above the safe zone, a message alert is sent to the emergency response personnel via the GSM modem. This is actualized by continuously analyzing digital signals from inputs from the vibrating sensor and GPS controller circuits. The microcontroller output sends a high logic "1" signal to the SMS controller circuit when a high is received at its input from the vibrating sensor. The signal from the microcontroller also drives the LED indicators showing vibrating level and GPS network status. It also receives signals from the GPS, process same and send the appropriate codes to a mobile phone as SMS alert of accident occurrence to predetermined receivers. To have an easy access to the satellite, the GPS receiver is placed on cars /vehicles dash boards. The raw data employed in programming the PIC18f2550 microcontroller were obtained with the aid of GPS measuring device and the authentication of the data were verified with the aid of a Google maps coordinates of these selected spots along the route. C programming language was the software used for the device based on its compatibility and user friendly.

4. Results and Discussion

The collated GPS data of Longitudes and Latitudes obtained from Benin-Warri road were subjected to normality as well as correlation tests using the SPSS program and the results are shown in Figures 3, 4 and Table 1 respectively.

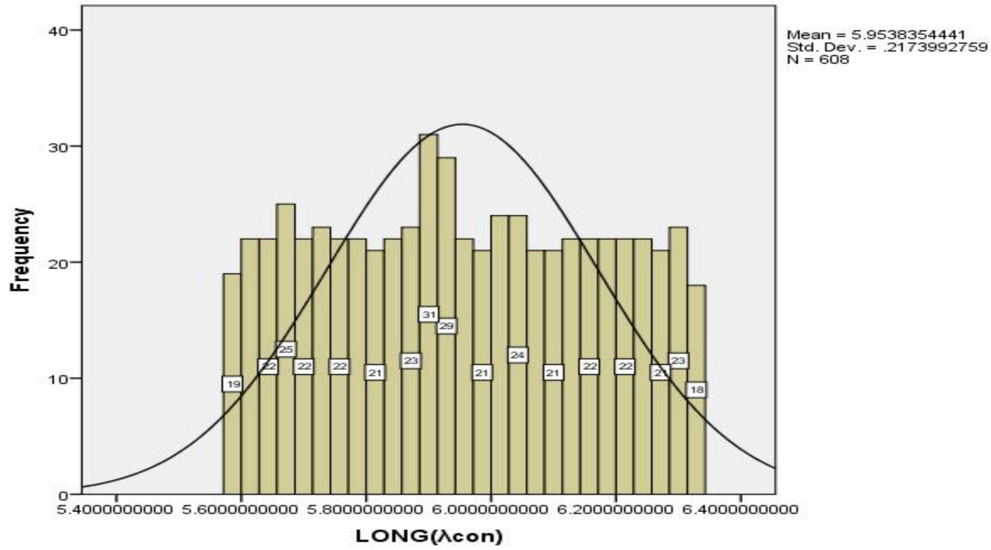


Figure 3: Longitude Normality Distribution Curve.

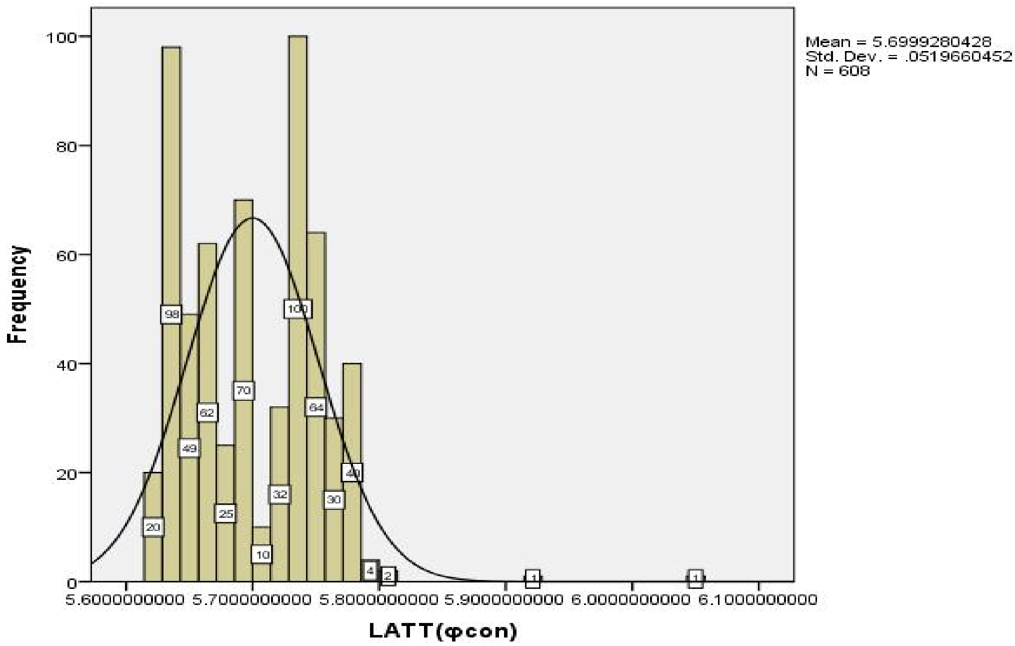


Figure 4: Latitude Normality Distribution Curve.

Table 1: Correlation test for both Longitude and Latitude.
Correlations

		LONG(λcon)	LATT(φcon)
LONG(λcon)	Pearson Correlation	1	-.957**
	Sig. (2-tailed)		.000
	N	608	608
LATT(φcon)	Pearson Correlation	-.957**	1
	Sig. (2-tailed)	.000	
	N	608	608

**. Correlation is significant at the 0.01 level (2-tailed).

Analysis of Figures 4 and 5 shows that the data are normally distributed with deviations of 0.2173892759 and 0.0519660452 respectively for the Longitudes and Latitudes while the relationship between Longitudes and Latitudes is significant at 0.01 level being less than standard 0.05 using two tail correlation test as shown in Table 1. The vibration shock sensor, microcontroller and GPS/GSM module were tested individually as well as with an integrated system. The assembled device was tested along Benin-Warri Highway while in a vehicle on motion. Testing results shows that the device performed satisfactorily as alert messages at various locations of accidents occurrence as manually simulated were automatically sent by the device at real time. Output results generated in form of SMS messages by the device were sent to programmed GSM numbers as designated safety personnel. Example of such messages is "ACCIDENT DETECTED! LOCATION: OLOGBO TOWN".

5. Conclusion

This paper presented an accident monitoring device that was designed based on GPS technology. The major objective of this system is to reduce informative time of contacting rescue agencies and relative of accident victims when an accident occurs. Manual callings which has many limitations that usually lead to time delay, before attending to accident victim(s) is drastically reduces. The data used in programming the microcontroller were validated and are significant at 0.01 less than 0.05 tolerance value.

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