A Novel Automatic Vehicle Accident Detection and Notification System for Emergency Situation

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***Abstract*— The dawn of the 21st century has seen an upsurge in private transportation modes. This has consequently increased the number of vehicles running on the roads, thereby leading to more caution while commuting through vehicles. On Indian roads, survey reveals that every minute an accident occurs and 20% of victims who succumb to injury could have been saved if emergency attention had been received on time. To automate the major accident detection and notification, in this paper a low-cost prototype has been developed using Arduino Uno, Peizo vibration sensor and Wireless Communication technology. The emergency situation is notified via SMS and phone call to the emergency services, police personnel and pre-defined numbers in the GSM module. The accident site can also be tracked via the mobile device app developed where with the geographic location is marked on the Google Map using ReST API via GPS and GSM. The focus of the proposed work is to optimize the response time for the accident victim requiring the attention of the emergency services.**

***Keywords*—** *Vehicle; GSM; GPS; Emergency Service; SMS; Phone call; Geographic Location; Mobile Device; Application Software*

I. INTRODUCTION

The advent of vehicular communication has increased the use of transport facility on roads. Vehicular communications [1] along with recent advances in wireless communication seems to be the hot topic for researchers. Such technological advancements enable sharing of information through real time communication facilities between vehicles and communication infrastructure. This has led to focus on methodologies to improve the safety of passengers travelling in vehicles [1].

Information and Communication Technology (ICT) has a profound impact in the way information is accessed. The core of data communication lies in Wireless technology such as Global Positioning System (GPS) and Global System for Mobile communications (GSM-Mobile). GSM supports digital cellular system where eight simultaneous calls on the same radio frequency is possible. Hence these technologies invariably enhance vehicular communication [2]. GPS on the other hand, is a satellite-based navigation system collectively made-up of a network of satellites that are placed in the orbit. With data communication focusing on common user or machine goals between entities, communicating the obtained data to a mobile device via GPS and GSM is setting its footprint in today's technology [3, 4]. With the development of software complementing data communication via mobile applications, smart phones and tablets have become the buzzword of this generation.

A variety of sensors are available in the market and vibration sensors find notable applications in vehicular communication. Vibration sensors can be used for testing the impact force induced on it when placed in the microcontroller. Arduino [5] is a popular organization for microcontroller-based kits to build digital devices and interactive objects that sense and control other entities in this world. Arduino Uno boards are popular to get started with in handling sensors. A number of studies pertaining to the recent research works have focused on vehicle accident detection using sensors. Some of the existing work related to vehicle accident detection and notification are briefly discussed next. In the work of Varsha and Padmaja [6] the focus is on how the microcontroller sends the alert message through GSM modem to the rescue system and police control room. In contrast the work of Sarika et al [7] extended the option of resetting the sensor in the case of a minor accident. Amol et al [8] and Prabha et al [9] use AVR controller along with GPS and GSM. The work of Aboli et al [4] also addresses safety of passengers through airbags that automatically shoot out. Similarly SMS notification is sent to the ambulance and police station. Pankaj and Bhatia [10] used GPS and GSM to convey the route taken by a vehicle and the details could be accessed from any remote location. Abid and Ravi [11] proposed a tracking system for telemonitoring transportation such as taxies and buses between cities.

The proposed work focuses on detecting vehicle accidents and notifying the concerned through SMS alert, phone call and Google Map. The content of this paper is organized as follows: Section 2 gives an overview of the proposed system. Section 3 depicts the results and finally section 4 presents the concluding remarks.

II. PROPOSED SYSTEM

The proposed system comprises of: Arduino Uno, Wireless Communication devices, Peizo vibration sensor, Android and Google Map.

A. OBU Design

Arduino Uno a popular microcontroller to govern motor vehicles *is used in the proposed work for crash collision*

detection and notification. This microcontroller has 14 digital input/output pins in its board. The Arduino can be connected to a computer via USB cable or AC-to-DC adapter or even battery powered [12]. Apart from these facilities the Arduino Uno board has provision for wireless communication also. As the proposed system deals with vehicle tracking, the advantages of wireless technology through GPS and GSM can also be extended in the proposed work. For the proposed work, Arduino acts as receiver while the GSM module acts as the transmission unit while interfacing [13]. For serial communication, the serial pins Arduino-Rx (Receiver) and Arduino -Tx (Transmitter) are used. Similarly, the GSM's Tx pin connects to Arduino's Rx and the GSM's Rx pin connects to Arduino's Tx pin respectively. On the GSM board its Rx pin is connected to the 10th pin on the Arduino board. The ground pins of Arduino and GSM are connected to each other to enable communication with the GSM module. Another component used in the proposed work is the GPS receiver [13] which provides high sensitivity and tracking capabilities especially in urban conditions. Owing to its compactness and size, it is ideal for use in small-form factor device design. The GPS module transmits information in serial TTL (transistor-transistor logic) format when interfaced with Arduino-Rx. The Tx pin of GPS is connected to the 4th pin of Arduino. The power supply pins are connected from GPS to Arduino followed by the ground pins of GPS to the Arduino kit. Then the Arduino-Rx and Arduino -Tx pins are connected to the computer via the USB for transmitting the data. The Piezo vibration sensor [14] is a low-cost sensor which has the properties of high sensitivity at low frequency.

In the Peizo vibration sensor, the black wire is connected to the ground and the red wire to the analog pin0 of the Arduino Uno board's 5V power supply. This vibration sensor has in-built operational amplifier to amplify the sensed vibration sent to the Arduino Uno board. Fig.1. depicts a bird's eye view of the proposed system for crash collision detection and notification.

B. Mobile App and its functionalities

The Android mobile application software uses Android 4.2 driven smart phone. The Android development environment is complemented with several components such as Java Development Kit 1.7 (JDK), Eclipse Mars, Android Software Development Kit (SDK) and Android Virtual Devices (AVD) [15]. Further, the Android platform runs on Linux kernel comprising of the Operating System, middleware, User Interface and application software [15]. In the proposed work the Google Earth application facilitates have been extended for the emergency services to view the location and navigate to the crash site.

The proposed crash collision system communicates the latitude and the longitude coordinates of the vehicle location to the website hosted in the cloud via ReST API. The ReST API, then communicates the coordinates to the android application in the mobile device. The android application developed, maps the latitude and longitude coordinates tracked by the GPS device in the Arduino kit to indicate the site of the crash location.

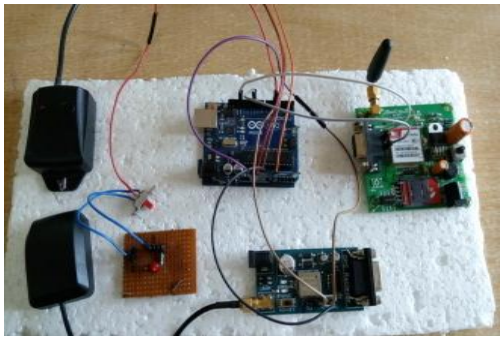

Fig. 1. OBU of the proposed system

Then the navigational facility is provided by the Google API depicting the route to the crash spot. Thus, with the aid of the mobile application, the location of the crash site can be easily tracked by the emergency and police personnel including the kith and kin of the accident victim. This facilitates any delay in reaching the site based on eye-witness references.

C. Algorithms for accident detection and notification

The detection of the vehicle accident by the vibration sensor, notification of an emergency situation and specifying the crash site using a mobile app are depicted as two separate algorithms. Algorithm1 and algorithm2 of the proposed system are implemented using Arduino coding [16-18] to send SMS and phone calls using GSM along with the geographic location of the accident site.

```
Algorithm 1: Sense_Accident

Input      : Vibration range

Output     :  Digital value

Step1      :Sense vibration using
sensor

Step2      :Determine the force of
vibration after converting it to a
digital value

Step3      :Call
Accident_Notification
End Sense_Accident
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Algorithm 2: Accident_Notification

Input      : Sensor Value
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Output      : SMS, Phone call

Step1       : Send SMS notification to
the predefined mobile numbers using
the GSM module

Step2       : Call the predefined
mobile numbers using the GPS module
after 1 minute delay

Step 3      : The recipient of the SMS
message opens the app in the mobile
device

Step 4      : The app maps the
coordinates of the crash location
along with the address

Step 5      : Proceed to the crash
site
End Accident_Notification
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III. RESULTS

The proposed system for vehicle accident detection and notification in an emergency situation demands the use of Arduino, vibration sensor, wireless communication facility and Android. The analog to digital conversion of the voltage 0-5V to a numerical range 0-1023 is done by the Arduino kit, when a vibration is detected. The vibration values converted to digital form is displayed in the serial monitor. The sensor values are programmatically checked if it is less than 100 [16]. If so then an automatic SMS notification using the GSM module and GPS facility [17, 18] is sent to the emergency service department and other predefined numbers of the victim's family. After a delay of 1 minute, a phone call is automatically made to the predefined numbers stored in the SIM of the GSM module. The coordinates tracked by the GPS module in the OBU is mapped to the Android application via ReST API. The mobile application installed in the user's phone automatically maps the coordinates of the accident site on the Google Map. This information also specifies the address of the location of the crash site. It enables the emergency services to reach the crash site without trying to search for the crash location. The step by step process of notifying the accident and location are depicted as screen shots in Fig.2.

A. Discussions

The peizo vibration sensor in the Arduino kit was subjected to 25 different vibration values to simulate accidents. These vibration values which physically deformed the sensor was converted from analog to digital values and represented in Fig..3. The x-axis represents the vibration converted to digital values against the samples. The minimum vibration value was 78 and the maximum 108 in digital representation. Then the samples representing the major accidents i.e. vibration values below 100 were only considered for notification via SMS and phone call.

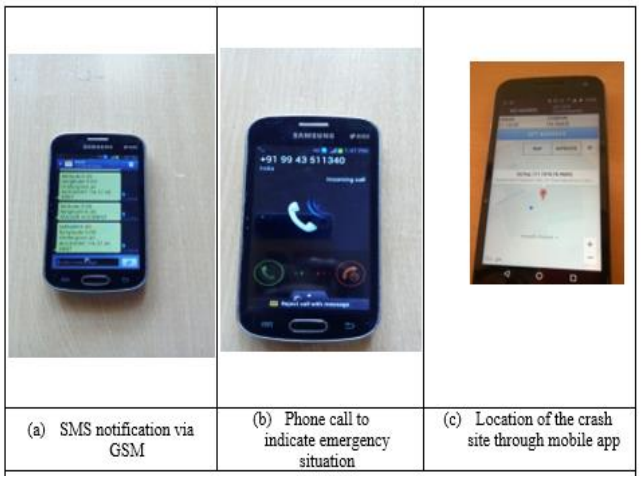

Fig. 2. Pictures representing accident notification

The proposed work does not consider minor accidents i.e. vibration values above 100, as the driver or fellow passenger(s) can notify their kith and kin for help. Fig.4. represents the time taken in seconds to notify the emergency personnel and accident victim's relatives of a major accident. The graph reveals that samples S4 took the minimum notification time of 98 seconds and S14 took the maximum time of 138 seconds to notify respectively. The time taken to notify the emergency situation was between 98 seconds to 182 seconds for the sample cases that were simulated. The experimentation also reveals the fact that the time taken to notify through the proposed crash collision system, was invariably driven by the signal strength and also the network provider. Upon receipt of the notification, the stakeholders could view the route to the crash location via the mobile app.

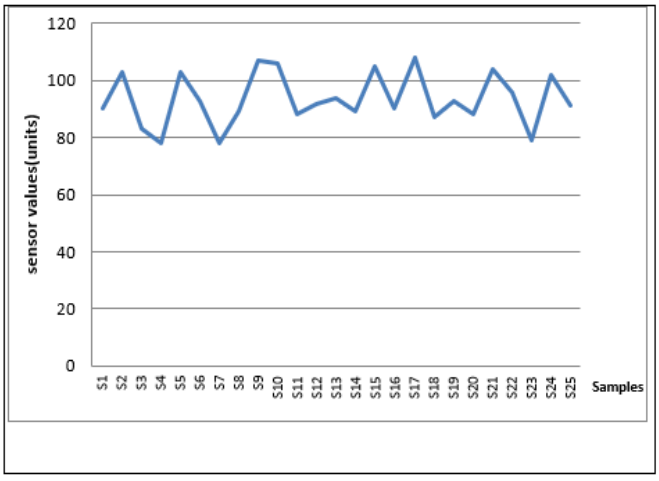

Fig. 3. Vibration values in digital format for sample cases

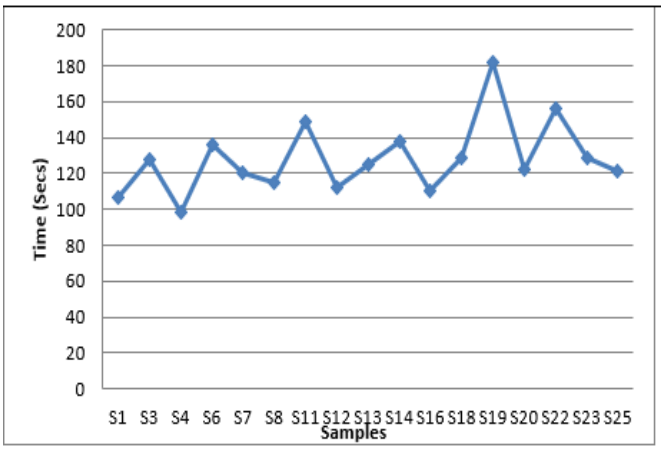

Fig. 4. Time taken to notify via SMS and phone call of major accident

B. Comparison

The conventional accident notification [19] is manual in nature where information is passed to the emergency personnel through telephone or mobile calls, either by a good Samaritan or fellow passengers. Such manual notifications usually cause delay in the arrival of emergency personnel and police as the exact location may not be known or described appropriately. Such delays have also witnessed loss in human life and disable a person permanently. Such a situation could have been avoided by automatic notification with minimum delay. A comparison between the manual conventional methods and the proposed automatic system is summarized in Table I.

S.No	Categorization of major events	Conventional Methodology	Proposed System
1.	Accident Detection	By fellow passengers or passers by	• Detected automatically by the vibration sensor
2.	Accident Notification	Phone call by fellow passengers or eye-witness(es)	• Automatic notification via SMS to all the predefined phone numbers with a minimum delay of 30 seconds • Automatic phone call provision after a delay of 1 minute to all the predefined phone numbers
3.	Accident Details	Phone call by fellow passengers or eye-witness(es)	• Indicating the crash location through the mobile app

Table 1. Comparison with conventional methodology

C. Applications

The proposed system can notify accidents in the highways and also other less inhabited areas which lack access to immediate medical attention or police patrol. This work is further enhanced by the advances in Information and Communication Technologies to detect major vehicular accidents in a more portable and cost effective manner than conventional manual methods. The following are the real time scenarios where the proposed system finds its application:

Emergency Service Department: Receive SMS notification about the accident which includes the vehicle number. It is followed by a phone call to reiterate the severity of the case. After these alerts the map specifying the location and route can be viewed upon opening the corresponding mobile app to verify the reality of the accident. With the help of these details the ambulance with the emergency personnel can be quickly deployed to the accident location and thereby reduce the valuable time in saving the life of a victim who needs emergency treatment.

Police Department: Accident cases are admitted in hospitals only after the police file a case. Hence the proposed system also notifies the police about the accident through SMS and phone call. This notification coupled with details of the crash location enable Police personnel to arrive at the location without any delay. Such automatic notifications prevent any false or misleading information which may be a waste of their time.

Kith and Kin: Many a time's the victim's kith and kin may not be aware of the accident that had occurred. Whenever contact is lost or if a person does not arrive at the destination it may result in panic and worry as the cause may not be known. On the contrast, if they are notified about the incident they can also be present at the crash location to support the victim.

IV. CONCLUSION

This paper describes a prototype for detecting major vehicle accidents and notifying via SMS, phone call to the emergency services department and other predefined mobile numbers stored in the GSM module. The recipient of the SMS can open the app in the mobile device to know the crash location, thereby reducing the response time for emergency treatment. The proposed system is simple in design, consumes low power and economically feasible as an OBU to detect and notify accidents that call for emergency attention. This prototype can be extended to create an on-board vehicle diagnostic system to assist emergency teams in responding swiftly to accidents especially in highways and less inhabited areas.

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