Smartphone-Based Accident Detection and Alert System

Bharti Kumari, Sarthak Bhatnagar, Yuvraj Pratap Singh, Mitul Srivastava, Devansh Tiwari
Computer Science Engineering Core
VIT Bhopal University
Bhopal, India

***Abstract*—Road accidents remain one of the leading causes of fatalities, primarily due to delays in emergency response and lack of immediate medical assistance. Existing vehicle-based accident detection systems rely on dedicated hardware modules, which increase deployment cost and limit portability. This paper proposes a Smartphone-Based Accident Detection and Alert System (ADAS) that utilizes built-in sensors such as accelerometer, GPS, microphone, and camera to detect potential crash events. Upon detecting abnormal acceleration patterns and sudden speed variations, the system determines the location of the accident and automatically notifies emergency services and pre-registered contacts. The architecture consists of a client-side mobile application and a centralized server for data analysis and dispatch coordination. The proposed approach aims to reduce response time, improve reporting accuracy, and provide an affordable and portable solution for real-time accident detection.**

***Index Terms*—Accident Detection, Smartphone Sensors, Emergency Response, Automation**

I. Introduction

Every year in India around 1214 road accidents occur and about 377 casualties happen every day [8]. Maximum of the accidents result in deaths as ambulance is not called immediately and as people do not inform the ambulance to avoid police interrogation. The accident might occur at an isolated location where people are not present to report the accident. Recent technologies in vehicles have inbuilt hardware modules to spot and report accidents. Such systems are expensive and non-portable. Not all cars have such systems, only luxury cars have such facility. Hence we introduce Accident Detection and Alert System (ADAS) which will identify the accident with the help of sensors in the Smartphone. Since many Smartphone have the basic required sensors and good computing power, they could be employed to detect accidents and request response. As compared to hardware add-ons, Smartphone are portable - we could carry them in any vehicle we are driving or even travelling in. The way we would use their sensors will make this system inexpensive and lifesaving. The processes to detect accidents could be updated easily and has more scope for forthcoming enhancements. As we are using Smartphone for communication we could use multiple ways of communicating with server, i.e. if the internet connectivity is not available the SMS could be used to converse with the server for help. The principal objective of ADAS is to successfully detect accidents and communicate the same to ensure that the medical assistance can reach the accident location on time. The data from this system could be used to analyze and study the acceleration waveforms generated during the accidents.

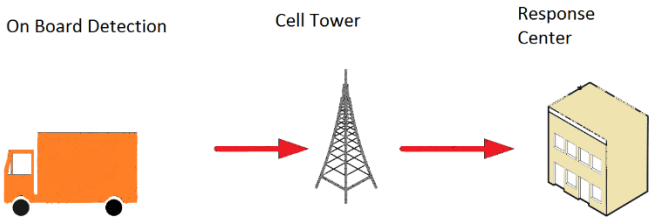

Fig. 1. Traditional Accident Detection Systems

II. Literature Review

Earlier research on accident detection systems includes the following approaches:

- **Automatic Accident Detection and Ambulance Rescue with Intelligent Traffic Light System:** Automatic Accident Detection and Ambulance Rescue with Intelligent Traffic Light System [6]. It is a full hardware based system including the likes of microcontroller, modem, drivers, GPS etc. It includes three basic units - Vehicle unit, Ambulance control unit, and Traffic unit. The author has developed a hardware system which in case of an accident notifies ambulance with appropriate data about the accident location. And ITLS system will help the ambulance to reach the hospital at earliest by manipulating the traffic signals. This can be efficiently carried out with the help of Smartphone with their in-built sensor and Google maps. Besides that, the GSM modem used in the system creates a delay while sending messages to the ambulance control unit (since it is a queue based technique) also the maintenance or upgrading process of this ITLS system is quite expensive.
- **Sensor-Based Vehicle Accident Detection:** An Efficient Vehicle Accident detection using Sensor Technology [3].It has been suggested that with the support of sensors like vibration sensor, MEMS (micro electrical mechanical system), GPS and GSM we can develop an efficient accident detection system. The requirements to successfully implement this system are the sensors, which can be easily accomplished with the help of Smartphone

and their in-built sensors. There may be delay because of external GSM used – which is a queue based technique. Also the maintenance of the sensor will be costly.

- **Android-Based Accident Detection Applications:** Utilizing the Emergence of Android Smartphone for Public Welfare by providing Advance Accident Detection and Remedy by 108 Ambulance [4] here they have developed an android application that is used to identify the accident using variation in acceleration parameters. After detecting the accident application spontaneously generates the topographical information by GPS and send pre-recorded voice message to emergency response service. The crucial theory behind the working of this application is that the mobile phone should not be kept with the driver who is driving the car. It must be attached inside the vehicle. The biggest shortcoming or the loophole in this system is that the phone may tilt or fall inside the vehicle accidently without having a real time accident thus generating false positives.
- **OBD-II Integrated Smartphone Systems:** • Providing Accident Detection in Vehicular Network through OBD-II Devices and Android based Smartphones [1], here the researcher develops an accident detection and report system that chain Smartphone with vehicle through a second generation On-Board-Diagnostics (OBD-II) that works as an interface to accomplish smart vehicle modeling, providing the user emergency facilities. The researchers have established an android application that deploys an SMS to pre-stored address with related information about the accident location. Also a call is made to the emergency service. The only prerequisite to reach the goal of this system is OBD-II standard. The OBD-II standard is made compulsory from 2001 in U.S and it is also a European, and Japanese variant of this standard, thus this solution is limited to these countries only. Besides that the maintenance as well as upgrading procedure of the system is pretty expensive.
- **Tilt-Based Detection Systems:** Accident Detection Depending on the Vehicle Position and Vehicle Theft Tracking, Reporting Systems [5], here the researcher introduces a new system with different algorithm that sense the accidents with the help of accelerometer sensor's tilt direction and other various hardware like GSM modem and GPS. The researches have also developed an android application which will display the accident location in case it happens. The vital components on which the system is solely dependent are the 3-axis accelerometer sensor and GSM modem, which can be replaced with a single device i.e. 'Smartphone' as it comes with the entire mentioned sensor above pre-built in it. In addition to this system uses GSM modem, which can create a delay while sending the emergency message to the user as it is a queue based technique. Beside that the maintenance of the hardware system is quite expensive.
- **IoT-Based Accident Notification Systems:** Car Accident Notification System based on Internet of Things [10]; here the researchers introduce an emergency call notification system using Internet of Things and Cloud computing. The researches have implemented the proposed system using XBee Wi-Fi module, XBee Shield, GPS module, Seeeduino and crash sensors. The basic idea is to detect the accident with the help of crash sensor and trace the exact co-ordinates of the accident spot via cloud using XBee Wi-Fi to the nearest hospital. The main aim was to propose a system allowing global interconnect with the Internet of Thing and Cloud. Despite the limitation the system is a step forward in the field of Internet of Things and with the help of Cloud the information can be transmitted to a long distance. Furthermore the system can be improvised by programming the system to immediately notify the family members of the victim.
- **Vehicular Communication Architectures (e-NOTIFY):** Assistance through Communication Technologies and Vehicle [11], proposed a prototype architecture called as e-NOTIFY which will help in increasing the chance of survival for passengers involved in car accidents. The proposed system offers automated detection, reports and assistance to the victims exploiting the capabilities of vehicular communication technologies. The goal of the system is to provide an architecture that allows 1. Automatic sending of data files containing information about the incident to the control unit. 2. Assessment of the damage done to the vehicle and its occupants, based on the data received from the incident. According to the reported information and the preliminary accident estimation, the system will alert the required rescue organization to optimize accident assistance.

From the reviewed literature, it is evident that hardware-centric solutions provide structured detection but increase cost and maintenance complexity. Smartphone-based systems offer portability and affordability, yet improving detection reliability remains a critical challenge.

III. Proposed System Architecture

The proposed Accident Detection and Alert System (ADAS) is designed using the built-in sensing and communication capabilities of modern smartphones. The architecture consists of two primary components: the ADAS client application installed on the smartphone and a centralized ADAS server responsible for analysis and emergency coordination. The system leverages physical context information obtained from embedded sensors to identify potential accident events and initiate automated response mechanisms.

The ADAS client application acts as both a sensing module and a communication interface. It continuously monitors sensor data and evaluates physical context information to determine whether an accident has occurred. The system relies on multiple embedded smartphone sensors to improve detection accuracy and reduce false alarms.

Smartphone Accelerometer Sensor: The accelerometer continuously measures acceleration along three axes. The magnitude of acceleration (G-force) is computed as:

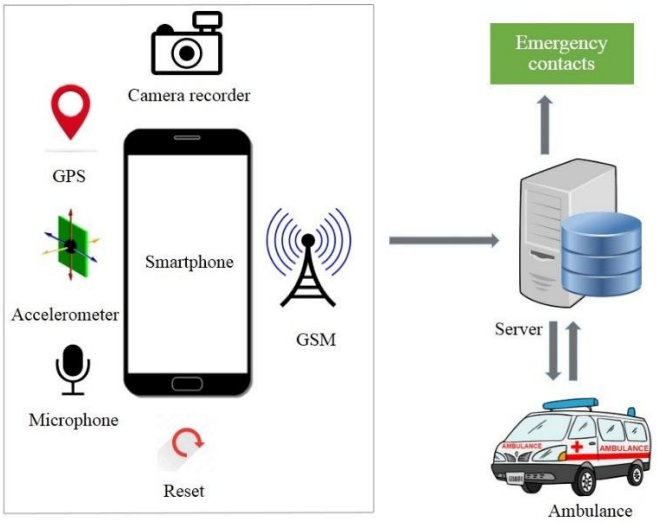

Fig. 2. Proposed ADAS System Architecture

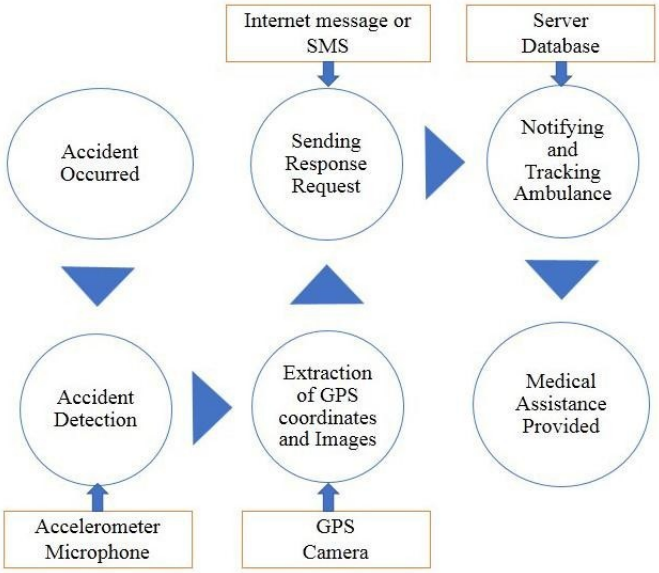

Fig. 3. ADAS System Flowchart

$$G = \sqrt{a_x^2 + a_y^2 + a_z^2} \tag{1}$$

A sudden increase in G-force combined with abrupt changes in vehicle speed indicates a high probability of collision. Monitoring acceleration patterns helps differentiate normal braking from crash events.

Smartphone GPS Module: The GPS receiver extracts real-time latitude and longitude coordinates. Once an accident is detected, the system determines the precise geographic location of the vehicle. This information is transmitted to the server to facilitate rapid emergency response and ambulance dispatch.

Smartphone Microphone: The microphone detects high-decibel acoustic signals such as the sound of impact or airbag deployment. Acoustic confirmation increases the reliability of detection and minimizes false positives caused by sudden but harmless movements of the device.

Smartphone Camera: The camera allows users or nearby observers to capture images and videos of the accident scene. These multimedia files can be transmitted to the server, enabling emergency responders to assess damage severity before arrival.

The ADAS client application also provides access to emergency contact information stored within the smartphone. In the event of a confirmed accident, alerts are automatically sent to pre-registered contacts along with location details. A configurable time window allows the user to cancel the alert if triggered accidentally.

The ADAS server performs centralized data analysis and coordination. It receives sensor data and location details from the client application and verifies the accident event. Upon confirmation, the server notifies emergency responders such as ambulance services and may also inform family members or designated contacts. The server additionally manages map services, data hosting, and multimedia storage. By separating sensing functions (client side) and coordination functions (server side), the proposed architecture achieves portability, scalability, and improved response efficiency.

Figure 3 illustrates the operational workflow of the system. The process begins with continuous monitoring of sensor data. When abnormal acceleration patterns and contextual indicators exceed predefined thresholds, the system initiates accident verification. A short time window is provided to allow user cancellation in case of false detection. If no cancellation is received, location details are transmitted to the server, which coordinates emergency notification and dispatch.

IV. Conclusion

Accident detection in real-time environments is a complex and critical task due to the dynamic nature of vehicle motion and sensor variability. The proposed Smartphone-Based Accident Detection and Alert System aims to improve emergency response efficiency by utilizing built-in mobile sensors instead of expensive dedicated hardware systems.

- Although in-vehicle accident detection systems provide rapid emergency notification, their implementation is limited by high cost and lack of portability. In contrast, smartphones offer comparable sensing capabilities at significantly lower cost while ensuring mobility and widespread accessibility.
- Many existing smartphone-based accident detection systems suffer from false positive readings. The proposed system integrates multiple sensing parameters including acceleration, speed variation, and acoustic signals to improve detection accuracy. The inclusion of a reset or cancellation window further reduces unnecessary emergency dispatch.

- The ADAS interface includes activation and deactivation controls that allow the user to manage medical response within a defined time interval. If the alert is not cancelled within this window, emergency services are contacted automatically.
- The system enables users and observers to capture images or videos of the accident scene and transmit them to the server. This functionality assists emergency responders in assessing the severity of the situation prior to arrival.
- The system automatically notifies pre-registered family members or emergency contacts and provides accurate geographic location details to ensure timely assistance.

V. Expected Output

In comparison with the work done in automatic detection and response the proposed system will be able to overcome various shortfalls and enhance the automated accident detection and response. The table … depicts the results that is expected on the successful implementation of this project.

Ref.	Limitation	Solution
[1]	• Works only with OBD II • Only available in USA and European countries	• ADAS could be easily available and installed in any Smartphone.
[3]	• Bulky hardware components • GSM module have slow speed	• ADAS use Smartphones inbuilt sensor
[4]	• Phone must be docked inside the vehicle • Unnecessary use of network	• ADAS could be used on body as well as kept on the dashboard
[5]	• Non portable • Tilting of vehicle is considered hence can give false positive when on body	• Can travel with the user. • Combination of accelerometer and microphone used
[6]	• Unnecessary traffic lights are controlled • Bulky Hardware	• One click installation • Highly Portable and Available

Fig. 4. Expected Outcomes of the Proposed System

VI. Future Scope

The entire project is dependent on the application that is installed on the smartphone. This project can be integrated to the virtual systems of the vehicle that can enhance the performance of this system. This project can also be carried forward and used to predict and issue a warning to the driver in case of any irregularity or issues noted in the driving or the vehicle itself. Thus, preventing accidents from happening. Though there are many ways to improve the notification system, it is completely dependent on the hardware that is installed on the vehicle and therefore we conclude that the limitations of the implementation of the project are:

- The damage of the hardware that is installed on the vehicle or the hardware carried by the user.
- The connectivity of the hardware with the control tower has to be maintained.

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