A Health Perspective Smartphone Application for the Safety of Road Accident Victims

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***Abstract*—This work presents an android-based application, the SOS (Save Our Souls), a personal safety app that aims to reduce the emergency response time in case of any road casualty. Currently, the increase in the number of road fatalities and injuries requires an advanced system that can intimate for immediate rescue to save precious lives. The use of smartphone's onboard sensors data for vehicular accident detection and intimation will help in reducing the rescue time. Providing additional geolocation data to the nearest available emergency responder will immensely improve the odds of survival while saving time and resources for emergency services. Using the pre-filled medical details of the user will also help doctors for necessary diagnoses, which in turn will increase the scope of saving lives. This work aims to use today's cell phones features with three-axis accelerometer data to improve road safety. The developed android application will suggest the nearest hospital with a Google root map. The phone call facility for rescue is enabled with automatic and manual calling facility for informing pre-filled emergency units like police, hospital, family members. This work implemented the android application and verified its working, reducing the rescue time for accident victims.**

***Keywords*—Android Mobile Application, Traffic Accidents, Geolocation, Emergency Alert, Accelerometer Sensor.**

I. Introduction

Accidents in traffic are unpreventable and are the main risk factors in our day-to-day lives [1]. Even though accidents are unavoidable, studies have shown that the time it takes for emergency services to arrive is a significant factor in the increased frequency of fatalities in catastrophic accidents. Reducing the time it takes to report an accident is one method to improve reaction time [2]. Smartphones are ubiquitous, and when combined with an internet connection, they are excellent tools for notifying the appropriate authorities of an accident as soon as possible [3], [4]. In-vehicle data collected from smartphone sensors are used for detecting driving behavior, which is essential for the safety of the driver as well as other shared-road users [5]. Vehicle signals like longitudinal and angular velocities, accelerator and brake pedal positions, accelerations, steering wheel angle and fuel consumption are captured from various sources for driving style recognition algorithms [6]–[8]. The on-board vehicle sensors IMU [7], GPS [9], RADAR or LiDAR [8] are the main source of vehicle signals. However, the smartphone sensors are the low-cost implementation approach to collect these vehicle signals in comparison to the onboard sensors, which are costly [10]–[12]. The solution to recognize driving characteristics task can be solved by analyzing diving signals data pattern directly [13]. The sensors like inertial measurements (accelerometer and gyroscope), vehicle orientation, speed, and braking events are used for vehicle dynamics approach [5], [12], [14]–[16] [17]–[19]. Vehicle dynamics-based driving behavior analysis provides better classification scores. It is preferred due to advanced low-cost sensor platform availability with many different sensors. The sensors, accelerometers, gyroscopes, GPS, magnetometer, and camera sensors, are primarily used in this driving tasks evaluation [20], [21]. Due to the availability of smartphones, all these in-vehicle sensor data are easily collected externally without depending on internal data collectors-based techniques using the in-vehicle CAN-bus. Also, CAN bus data is vehicle specific, and the smartphones can provide sensor data comparable in the quality with even more detailed information over the sensor data provided by the internal CAN-bus of the vehicle [20].

In the last few decades, the total number of vehicles on the road has increased significantly over the past few decades. As a result of this situation, there is a spike in road traffic fatalities, which is a severe issue in most countries. One of the leading causes of death is traffic collisions [22], [23]. Although most of the crashes only impact the drivers' cars' exteriors, others have led to severe and fatal injuries. It has been discovered that a driver's conduct is comparatively safer when it is regulated, input on individual driving incidents is offered, and records of possibly hazardous incidents are captured for enhanced integration. Several firms provide predictive maintenance and individual consumption solutions that track driving behavior with expensive cameras and technologies. Still, we believe in designing a low-cost, available system and make effective use of the sensors present on a smartphone [24], [25]. A comprehensive study of state-of-the-artwork reported by M. Kumar *et al.* in [26] developed a system to gather scratch information about road accidents from nearby vehicles using machine learning tools when an accident happens. The system uses mobile phones, GSM and GPS, VANET, and android applications with internet services to transmit the data to ambulances in road traffic accidents, increasing implementation and complexity. The work reported by Singh *et al.* in [27] wanted to solve is the ambulance's response to an accident spot and the lengthy procedure to admit patients in hospitals. The authors used an accelerometer (ADXL345) for velocity change measurement, an RFID card for passenger counting, and a GSM Module for SMS information to the emergency contacts to enhance the challenging job of making easy hospitalization of the accident victim. All these devices are external devices added to vehicles for monitoring abnormal events. The work by Kumar *et al.* in [28] presented a simulation model that detects accidents using sensors integrated with Arduino. When the accident is detected, a notification message is sent to friends and family through the detection android app. One of the major concerns in the systems is fault accident detection. The health status information of the victim is also essential, which needs to be available at the nearest hospital before the accident victim reaches the hospital. In most cases, the in-vehicle smartphone sensor data are not considered for accident detection and emergency notification.

In this work, a smartphone application is developed using Android Studio. The novelty of this work is the development of an android application with a significant focus on providing the details of accident victims, including several factors such as the severity, location, vehicle speed, driving style, traffic jam, previous health record of the accident victim and alerting emergency services [10], [29] for the need of life safety. The smartphone is the best in-vehicle low-cost device to implement safety applications for saving precious human life. The smartphone contains many sensors to measure vehicular activity. This study uses smartphone sensor data to provide a novel application for primary healthcare of an accident victim using their available medical history collected before vehicular movement. The major contributions of this paper are as follows:

1) Development of android application, SOS for personal safety.
2) Sending an emergency message if the victim is in danger establishes immediate rescue assistance to road accident victims.
3) Providing additional geolocation data to the nearest available emergency response unit.
4) Suggesting the nearest hospital with geo-coordinates and Google root map.
5) Alerting the drivers about aggressive driving through notification as red color on driver's phone.
6) Establishing a medical history of the victim that will be relevant to the doctor, police, or emergency contact.

This paper contributes to customized driver assistance for rescue operations during any abnormal event. The rest of the article is organized as follows: Section II describes the detailed description of the problem formulation with the proposed methodology. Section III explains the experimental results and analysis. Section IV presents limitations of the work, and the conclusion of the work is mentioned in Section V.

II. Problem Formulation and Proposed Methodology

As we all know, accidents are unavoidable and frequently occur, resulting in many individuals dying or being in serious condition. Because when an accident occurs, people are not informed of their accident, causing a delay. When an accident occurs, the person will be too shocked to notify their emergency contacts, the police, or the nearest hospital. A smartphone application, SOS, is developed to detect and notify road accidents. The SOS apps are advanced emergency apps that can save you and/or your loved ones if you and/or they are in a life-threatening emergency and require immediate assistance. When we need personal assistance, we can turn on our phones and call or text for assistance. The hardware and software requirements for the whole working framework setup are :

- Smartphone
- Android studio
- Java
- Camera API
- Google location API
- Android Google Map API
- Firebase
- Sensors

The advances in sensor technologies and their application in embedded devices like smartphones help analyze the various driving activity. In the in-vehicle scenario, the smartphone with inbuilt developed applications plays a significant role in saving valuable lives from danger. The problem formulation for the work setup and studies of sensor technologies, their application, and SOS algorithm is discussed in the following sections.

A. Problem formulation

The in-vehicle scenario where the smartphone with the inbuilt developed android application will help the user for immediate rescue whenever some abnormal situation occurs while driving. The aim is to develop a connected service to gather whatever possible help from every unit to save an accident victim. This problem framework is trying to establish connectivity from all emergency units for providing faster rescue operations. This SOS application aims to generate the route map to reach the accident spot, search the nearest hospital, provide medical details of the victim to doctors for easy diagnosis, inform the police to handle emergencies, and inform relatives about the accident. Immediate help is only possible and will be effective if the victim installs the application before driving with all accurate information. Proper care must be taken while filling every detail in the SOS application, as the accident is uncertain and may put lives in danger. The whole working setup to build the SOS application is shown in Fig. 1. The SOS application will allow users to choose manual and automatic calling facilities to reduce false reporting.

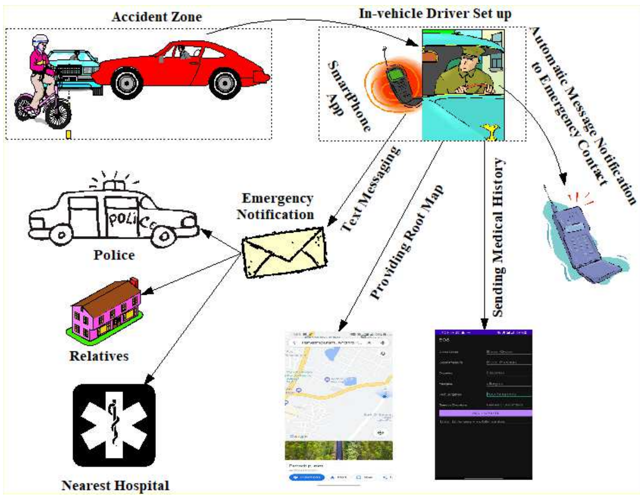


Fig. 1: Working Setup for the SOS Application.

B. Sensors

1) Accelerometer: An accelerometer is an electrical sensor that measures the velocity stresses imposed on an item to calculate its position in space and track its movement. The rate of movement of an entity's motion, a dimensionless quantity, is called acceleration. Stable and transient acceleration forces are the two types of acceleration forces. Forces consistently applied to an item are steady forces (such as friction or gravity). Transient forces are "moving" forces applied to an object at different speeds (such as vibration or the force exerted on a cue ball in a game of pool.

2) Gyroscope: A gyroscope sensor is a device that uses the earth's gravitational pull to determine its orientation. It's a sensor found within an IMU (Inertial Measurement Unit). A gyroscope measures rotation on a specific axis. A rotor, which is nothing more than a freely revolving disc, is at the center of the device. The rotor is attached to a spinning axis that runs through the center of a giant wheel. In navigation, stabilizers, and other applications, it is a device that maintains a reference direction or provides stability. A gyroscope, sometimes known as a Gyro detector, is a device that monitors the perforated speed of the object. A gyroscope Sensor is responsible for all mobile games we can play on our devices, tablets, and other gadgets that use motion sensing. Similarly, watching 360-degree videos or photographs on a smartphone is essential because of the presence of a gyroscope, the photo or video moves when we move our phone.

C. Application of sensors embedded in smartphone

The three axes of an accelerometer $(x, y, and\ z)$ are denoted by the characters a_x, a_y, and a_z. The three axes of a gyroscope are denoted by the characters g_x, g_y, and g_z. The axes of a vehicle are designated by the characters $x', y', and\ z'$. These measurements are represented with g (9.8 m/s2), while gyroscope values are expressed in terms of rotation rate (radians/seconds). The components of the acceleration vector are denoted by the characters a_x, a'_x, and so on. A smartphone's axes are defined as $x,\ y,\ z$ is directing to the right, to the top from the front, directing out orthogonal to the screen. The axes of a vehicle are described as x' directing to the right and y' directing to the front, with z' directing up toward the roof. The 3-axis diagram of the accelerometer is shown in Fig. 2. It makes use of a 3-axis accelerometer that can detect movement in any direction. This movement could be the result of the slightest lane change or a pothole.

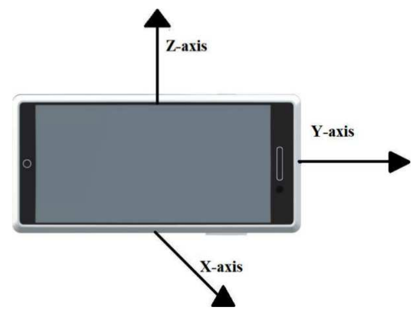


Fig. 2: Three-axis diagram of the accelerometer.

The accelerometer is the most critical sensor since it controls deceleration, sinkhole detection, and crash recognition. However, the orientation of its axis in relation to the vehicle in which it is located must be determined. As a result, an algorithm was developed to virtually realign the phone's sensors with the vehicle's basis of comparison. A sensor detects the acceleration associated with the weight experienced by any mass; if the sensor is perfectly aligned, it will measure $a_z = 1g$. The sensor reorientation architecture is built on Euler angles, which are simple to understand but numerically wasteful, producing concerns with outliers and stabilizers. The sensor's location can be defined as a pre-rotation around z', a tilt around y', and a post-rotation around z', with pre-rotation, tilt, and post-rotation indicated as pre-rotation, tilt, and post-rotation, correspondingly. Only the tilt action changes the angle of z with respect to z' since $|a_{z'}| = 1$ while the vehicle is on flat ground.

$$\theta_{tilt} = cos^{-1}(\frac{a_z}{a_{z'}}) = cos^{-1}(a_z) \tag{1}$$

Furthermore, because $|a_{z'}| = 1$, the result would be on or before followed by a tilt. Both a_x and a_y have non-zero values. As a result, in order to estimate tilt and pre-rotation, it's necessary to pinpoint instances when the car is stationary or moving steadily. Using the median values of a_x, a_y, and a_z throughout a 10-second frame, on the other hand, proved to be a simpler and effective technique. Even on a bumpy road, the findings are quite reliable as long as no big maneuvers are performed during the duration. Finally, the post-rotation around z' has no effect on the forces imposed by gravity because the angle of rotation is dictated by another force. The smartphone and vehicle coordinate system is shown in Fig. 3.

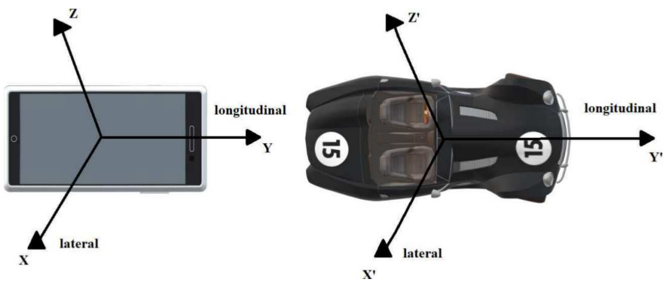


Fig. 3: Smartphone and vehicle coordinate system.

The acceleration and retardation of a vehicle produce forces in the positive and negative y' position in a straight line, respectively. Deceleration (braking) is employed in the estimating technique because it produces more force than acceleration. As a result, the process for estimating is based on acceleration. The GPS trace is used to keep an eye on the vehicle for a sudden slowdown in a straight path. A post-rotation formulation that is dependent on tilt and pre-rotation is derived as a result of the maximization technique. As a result, before determining post-rotation, tilt, and pre-rotation, it's essential to compute post-rotation, tilt, and pre-rotation. The satellite signal is examined for braking occurring during the transient surge, and the averages of a_x, a_y, and a_z are recorded. This compensates for the time discrepancy between the GPS speed estimate and the real speed. Using a single sensor like only an accelerometer, we won't get accurate results, so combing the accelerometer and gyroscope sensor will improve the accuracy result of the movement and position of the vehicle in x,y, z directions.

D. Algorithm involved in the development of SOS

The detail process as in Algorithm 1 explains the SOS smartphone application that aims to improve personal safety by automatically reducing the rescue response time. The algorithm's robustness is experimentally verified, and the detailed discussions are presented in the next section.

Algorithm 1 : Algorithm for the SOS application

```
Start installing the application.
Open the application.
Login into the application.
If new user, then do register.
    Enter all the required details for registration,
    After successful registration, Login into the app.
Now, diverted to the main screen of the application, that consists of :
    Medical details
    Emergency call
    Geolocation
    Record video
    Latitude value
    Longitude value
    Time of request
    Update location
    Enter a phone number to send SMS
Enter all the details of medical data (which can be updated anytime) like:
    Blood group
    Blood pressure
    Diabetes
    Allergies
    Past surgeries
    Genetic disorders
    Enter emergency mobile number
Emergency call section facilitates:
    Call option for police.
    Call option for an ambulance.
    Manual call- On-click opens the phone dialer.
    Call option for emergency contact entered previously.
Onclick of geolocation redirects to google maps page.
Onclick video record option opens phone's camera.
If acceleration a_y, a_z > a_x and a_y, a_z > 4g, then
    it is considered a dangerous event.
If gyroscope g_y, g_z > g_x and g_y, g_z > 4g, then
    it is considered a dangerous event.
If acceleration and gyroscope is considered as a dangerous event, then
    send SMS to the emergency contact.
end.
```

III. Experimental Results and Analysis

A. Triaxial Measurement Significance

Table I shows the triaxial measurements, where the left and right direction is taken in the direction of the X-axis, which represents the typical driving of turning and lane change. The front and rear approach is taken in the direction of the Y-axis, which means the typical driving of acceleration or breaking change. Up and down is taken in the Z-axis direction, representing the typical driving style of vibration and anomalies. An experimental calculation of centripetal acceleration is compared with the phone's measured data is shown in Fig. 4. In the graph, negative values are shown in the acceleration of the y-axis, which may signify a sudden change in acceleration or a jerk experienced when downshifting gears.

TABLE I: Significance of Triaxial Measurements

Axis	Direction of vehicle	Driving Type
X	Turning Left/Right	Turning/Lane change
Y	Front side/Rear Side	Acceleration/Breaking
Z	Up direction/Down direction	Vibration/Anamolies

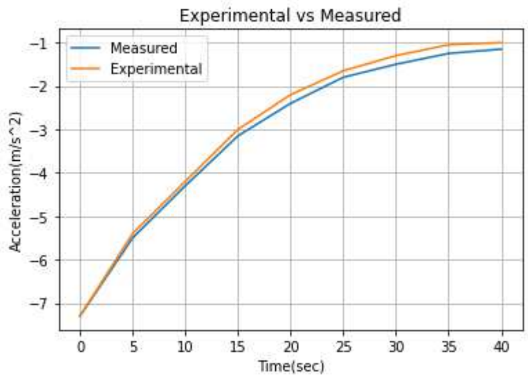
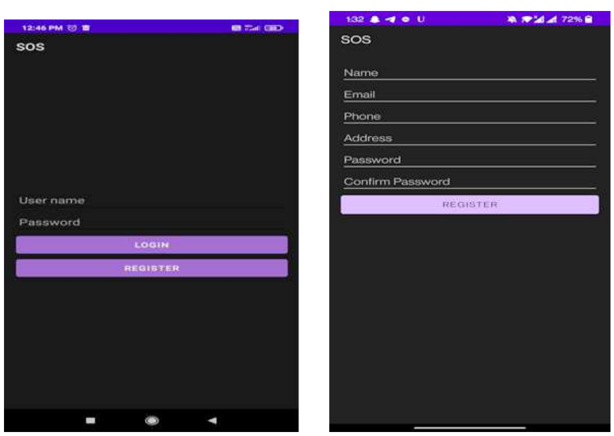


Fig. 4: Smartphone and vehicle coordinate system.

B. SOS Application Performances

The smartphone application SOS is created to detect and immediate rescue notification of road accidents. When an accident occurs, the person will be too shocked to notify their emergency contacts, the police, or the nearest hospital. We designed the program to alert those who are driving too fast or are unaware of their speed restriction. As a result, the driver may be notified or scared by a red color on his phone, indicating that he is driving aggressively.



(a) Login Screen. (b) Registration Screen.

Fig. 5: Login and User Registration Screen.

In certain circumstances, doctors are uninformed of the victim's medical history, such as blood pressure or diabetes, or even blood group or previous surgeries. So, a medical details page has been established that has all of the victim's information relevant to the doctor, police, or emergency contact. Also, an emergency contact page has been put, and if the victim is in danger, the app will send a message alerting them to the situation. We have introduced the ability to retain different people as emergency contacts here. It also has a GPS location feature that sends a message with the coordinates of the accident location when a victim is involved in an accident or is in danger. This application must be installed on the phone with a network connection to assist victims in danger or who

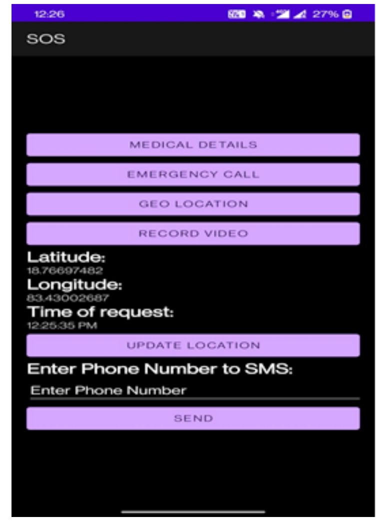
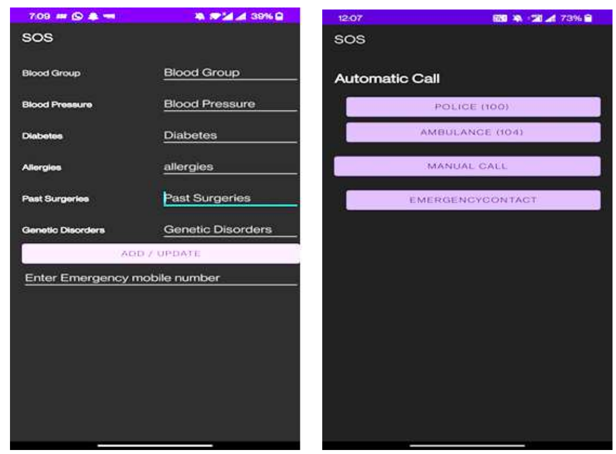


Fig. 6: Main Screen of the SOS Application.



(a) Medical Details. (b) Emergency Details.

Fig. 7: Medical and Emergency Details Screen.

have been involved in an accident. Different screen pages of the developed SOS android application used for detection and intimation of road accidents are shown in the Figures 5 to 8.

IV. Limitations

The developed smartphone application is only for android phones. It needs a GPS device to be used in the vehicle to get the proper location of the accident spot. Messages are used only for emergency messages, requiring a signal to send or receive emergency messages or calls. There is no battery-saving mode that consumes more power.

V. Conclusions

In this work, an android-based application, the SOS, is presented to improve personal safety during driving. The idea is to reduce the emergency response time in case of any road casualty. People who have downloaded and installed our Smartphone application find it quite handy. This app contains all of the user's medical information, emergency

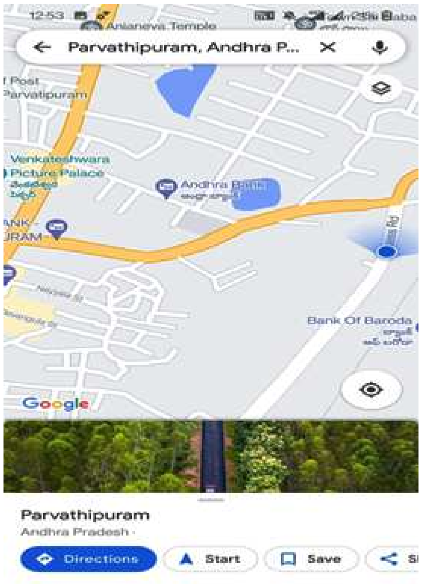


Fig. 8: Google Map Based Location Tracing Activity Screen.

contacts, sensors such as an accelerometer and gyroscope, and geolocation and messaging capabilities. Previously, if a user were involved in an accident or were in danger, they would not contact the police or an ambulance or emergency contact as the person may be unconscious or in critical condition. This application maintains all of the user's information in one place. So, suppose the user is involved in an accident or is in danger. In that case, he may easily send a message to an emergency contact person that contains his position coordinates, which will be very beneficial to the police, ambulance, or emergency contact. The developed android application suggests the nearest hospital with a Google root map and enables automatic and manual calling facilities for informing emergency units like police, hospital, family members.

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