Road Guard Emergency Response System using Embedded C

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***Abstract*—Road Guard Emergency Response is a comprehensive solution addressing delayed emergency responses to accidents globally. Utilizing Android phone sensors, the system swiftly detects accidents and initiates a two-step notification process. Initially sending an alert to theuser, it provides a 10-second response window; failing user acknowledgment, it automatically notifies pre-stored contacts. The multi-panel application interface includes user,admin, hospital, and police station panels, fostering seamless communication and coordination. Notably, the systemoptimizes emergency response without requiring a rear camera, emphasizing efficiency and accessibility.**

Keywords: Android Accident Detection, Emergency Response, User Notification, Multi-Panel Interface, Global Road Safety, Two-Step Notification, Sensor Technology, Accessibility Coordination, Efficient EmergencyCommunication.

I. INTRODUCTION

In the face of escalating demands for automobiles, the surge in road accidents has become a global crisis, claiming the lives of 1.35 million individuals annually, as reported by theWorld Health Organization (WHO). This pressing issue underscores the urgent need to enhance road safety facilities and rescue operations. Often, the critical factor in roadaccident fatalities lies in the delayed response of rescue teams and authorities. The proposed accident detection system aims to mitigate this challenge by incorporating sensors, a sound meter, GPS, and GSM modules. Upon detecting an accident, the system activates an alarm, tracks the precise location coordinates, and promptly alerts nearbyhospitals and police authorities via GSM. Notably, the system prioritizes user acknowledgment by sending an alert; failing a response within 10 seconds, it automatically notifies pre-stored contacts. With a comprehensive panel structure comprising user, admin, hospital, and police station interfaces, the system streamlines communication. Furthermore, it stands out for its absence of a rear camera, emphasizing efficiency and accessibility in the urgent context of road accidents. This innovative system strives to revolutionize the response to road accidents, ensuring timely and coordinated actions to save lives and alleviate the globalburden of road traffic injuries. [1][4]

II. LITERATURE SURVEY

Accident detection and management technologies have evolved significantly in recent years, driven by the need for more effective pre and post-accident procedures. Initially, laser sensors such as LIDAR and RADAR were deployed, but their effectiveness was limited beyond short distances (Vaishali et al., [10]). Subsequent advancements, such as Vehicle-to-Vehicle communication (VANET) and Co-operative Mobility Services of the Future (CoMoSeF), have emerged as promising alternatives, leveraging sensor networks for improved communication and accident prevention (Vaishali et al., [10]).

The Internet of Vehicles (IOV) has further expanded capabilities in accident detection and management, enabling various types of vehicular communications including Vehicle-to-Vehicle, Vehicle-to-Roadside, and Vehicle-to-Infrastructure (Vaishali et al., [10]). These developments have paved the way for more comprehensive and efficient accident prevention strategies.

On the post-accident detection front, systems incorporating GPS, accelerometer sensors, and advanced algorithms have been developed to swiftly identify accidents and alert emergency services (Hari Sankar et al., [11]). Recent research also emphasizes the integration of additional features such as heartbeat sensors for driver/victim health monitoring (Nicky Kattukkaran et al., [9]).

Technologies such as VANETs, IEEE 802.11p (WAVE) protocol, and IoT sensors play pivotal roles in

establishing communication networks and facilitatingrapid response to accidents (Vaishali et al., [10]). These advancements contribute to reducing accident severity, improving emergency response times, andultimately enhancing road safety (Chatrapathi et al., [7]).

III. EXISTING SYSTEM

Current accident detection systems often rely on simple sensors or GPS data, which might not provide accurate and timely information. False positives or delayed alerts can lead to inefficient emergency responses. The need for a more sophisticated and reliable system is evident.

This idea proposal has been introduced at the start of the modern age of mobile phones.AI and web-based HUMAN-LIKE INTERACTIVE UNIVERSITY CHATBOT (UNIBOT)With the introduction of GPS sensors in the mobile, security applications based on GPS were proposed. Then they proposed special hardware devices which can be linked with mobile phones. Though, it had the disadvantage of actually buying extra hardware with more money. With the massive development of mobile phones in the last decade and new sensors added with the development, the extra hardware can be avoided. The present application of this paper is present in a very few countries and providing the information with the relatives and friends with the emergency services the efficiency of the application can be increased massively.[1][2][4]

IV. PROPOSED SYSTEM

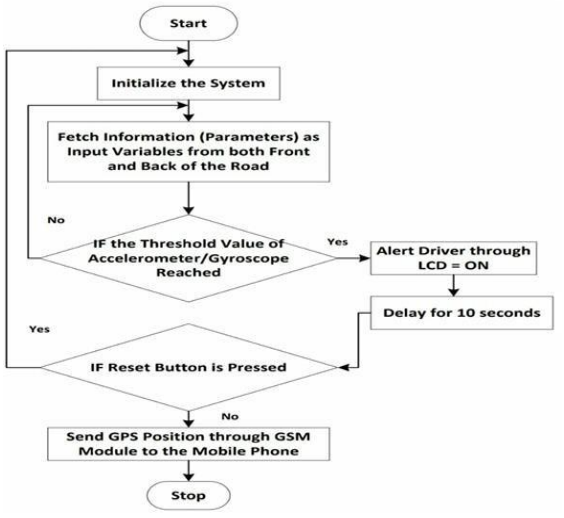

Fig. 1: Flowchart

The flowchart of the system displays how the Android Accident Detection & Alert System performs [1]. This Application aids in having a better coordination and keeps all the concerned bodies and authorities informed and alerts them quickly which also saves time in rescuing an accident patient. When a person meets an accident, he is usually not ina condition to interact with an application on his phone and ask for help. In such situation Accident is detected automatically in user app based on sound reading and sensorreading, user app continuously senses for such accidents. App then quickly assigns and sends notification to the nearby Ambulance, nearby hospital and also the police informing incase of an accident detected. Ambulance then keep updatingof the status of patient whether dropped to the hospital. Hospital can also update status if admitted to the hospital from their app. This helps in keeping the assigned hospital prepared and informed. Also, the User details are shared withhospital and police which helps hospital to see the medical records of the patient and police gets to see required details of the user in an accident.[1][5]

V.DESIGN

Our design for an accident detection and alert system draws upon advancements in sensor technology, communication protocols, and algorithmic analysis to create a robust and efficient solution. We aim to integrate various components seamlessly to ensure accurate accident detection and timely alerting of emergency services.

Sensor Integration:

In line with previous research [Chen et al., 2018], [11]our system will incorporate sensors such as accelerometers, gyroscopes, and GPS modules. These sensors will be strategically placed within the vehicle to detect sudden changes in velocity, orientation, and location, indicative of apotential accident. The data from these sensors will be processed in real-time using a microcontroller, facilitating rapid decision-making and response.

Communication Modules:

Building upon the principles outlined in previous studies [Sharma & Papadimitratos, 2019], our system will utilize GSM/3G/4G/5G and Wi-Fi/Bluetooth modules forcommunication.[12] These modules will enable thetransmission of accident alerts, including

precise GPS coordinates, to designated emergency contacts and central monitoring systems. This multi-modal communication approach ensures redundancy and reliability, crucial for emergency situations where every second counts.

Algorithmic Analysis:
Inspired by research on accident detection algorithms [Li et al., 2020],[13] our system will employ sophisticated algorithms to analyze sensor data and determine the likelihood of an accident. These algorithms will utilize threshold-based methods and machine learning techniques todifferentiate between normal driving events and potential accidents. By continuously monitoring sensor data and adapting to changing driving conditions, our system aims to minimize false positives and accurately detect accidents.

User Interface:
In line with user-centric design principles [Kim et al., 2021], our system will feature intuitive user interfaces accessible through both mobile applications and web portals.These interfaces will enable users to receive real-time notifications, view vehicle status, and communicate with emergency services seamlessly. [14]By prioritizing usabilityand accessibility, we aim to ensure that users can interact with the system effectively during stressful situations.

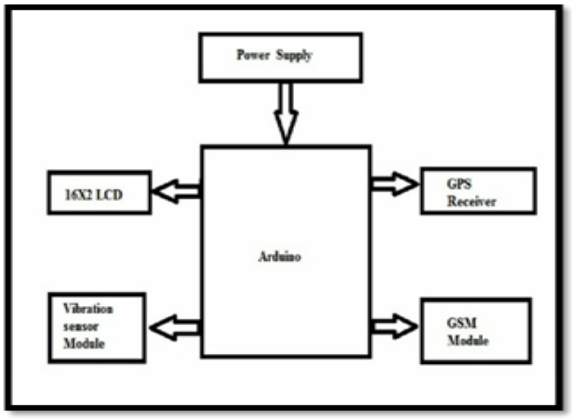

Fig 2: Ardunio System Fig 2 show the basic design of the system [1].

VI.HARDWARE COMPONENTS

The hardware architecture of the accident detection andalert system consists of several key components, each serving a specific function in the detection and notification process. [1][17]

Arduino UNO Microcontroller:
The Arduino UNO serves as the central control unit ofthe system, responsible for collecting data from various sensors and modules, processing this information, and triggering appropriate actions in case of an accident. Utilizing its versatility and programmability, the Arduino UNO facilitates seamless integration of multiple hardware components.

Vibration Sensor:
A vibration sensor is employed to detect sudden changes in vehicle motion, indicative of a potential accident. This sensor captures vibrations and relays thisinformation to the Arduino UNO, initiating the accidentdetection process.

GSM Module (SIM900):
The GSM module, specifically the SIM900 model, enables communication between the system and designated mobile phones. Utilizing tri-band technology, the GSM module facilitates the transmission of alert messages to preconfigured contacts, including emergency services and designated contacts.

GPS Module (SIM28ML):
A GPS module, such as the SIM28ML, is integrated into the system to ascertain the precise location of the vehicle in real-time. By capturing coordinates and transmitting location data in NMEA format, the GPS module provides crucial information for accurately alerting emergency services and notifying designated contacts.

LCD Module:
An LCD module with a 16x2 alphanumeric display is incorporated into the system to provide visual feedbackto users. This module serves as an interface for displaying relevant information, such as system status, alerts, and location data, enhancing user interaction andsituational awareness.

VII.SYSTEM DESCRIPTION

The system comprises of 5 major modules with their sub-modules as follows: [17]

1. User:

- Register: User can register using personal details.
- Login: User can login in his personal account email id and password.

- Profile: User can edit their profile as well as add Emergency Contacts.
- Home: User will be able to see the Sensor readings i.e., Sound Meter and Accelerometer readings. User can also stop/start the detection system.
- Background: The system in the background will be continuously monitoring the Sound decibel value and accelerometer for any Accident type impacts. If it finds the AppNotifies the User to verify if it's a false alarm,if no action is done in 5 secs the Ambulance is assigned & notifies Hospital, Ambulance and Police about the accident with the location & User details.
- History: History of Accident detections & details.
- Notifications: User will be notified if system detects an Accident.

2. Admin:

- Login: Admin can login his account using id and password.
- Manage Hospital: Admin is the only person who can manage Hospital data and provide credentials tothem.
- Manage Ambulance: Admin can manage Ambulance data and provide credentials to them. Ambulances are also mentioned if they work independently or are owned by Hospitals.
- View Users: View all the Users registered in this system.
- View Accidents: View all the Accidents and detailsabout it, can be filtered date wise.

3. Ambulance:

- Login: Ambulance driver can login his account using id and password.
- Home: The driver can see the current accident location along with the User details, the driver can directly navigate through Google Maps. The Driver can update the status whether he has picked/droppedthe User.
- Notifications: The driver will get a notification if itis assigned a Pickup.

4. Hospital:

- Login: Hospital User can login his account using idand password.
- Home: The User can see the current accident location assigned to his Hospital if any. Hospital canalso update the status whether the user has been admitted in the Hospital.
- View Accidents: List of all the Accidents and details about it assigned to his Hospital.
- Manage Ambulance: Hospital can also manage their owned Ambulances.
- Notifications: The Hospital will get a notification ifit is assigned a Pickup.

5. Police:

- Login: Police can login his account using id and password.
- Home: Police is able to see to Today's accident specifically or filter date wise to see previous ones.
- Notifications: Police will get a notification if it isassigned a Pickup.

VIII.IMPLEMENTATION PROCESS

Our system comprises two phases: accident detection and notification phase. For the accident detection phase, a smartphone application has been fully implemented. For thenotification phase, a web-based system has beenimplemented for use by hospitals.

A. Detection Phase Implementation:

An Android application has been developed in the C++ programming language. The application is developed for anAndroid operating system with minimum API level 17 and target API level 26. A user first registers for system use. Once registered, to use the system, the user enters their ID and password to log in to the system. Recording and transmission of data starts when the user clicks to start tracking. The application continually reads the data from the smartphone's sensors and sends the data to the cloud. If an accident is identified, the application generates an alarm for 10 s. [1] The smartphone application consists of the following activities:

- Start and Stop Accident Detection Activity.
- Users can initiate and terminate the accident detection process as needed, ensuring flexibility and user control.

2. Tracking of Accidents.

- The application continually reads data from the smartphone's sensors, providing real-time tracking of user movements and environmental conditions.

3. Cancellation of Alarm.

- In the event of a false alarm or non-emergency

situation, users have the option to cancel the alarm within the 10-second window, preventing unnecessary alerts.

4. Management of Account.

- Users can efficiently manage their accounts, including updating personal information or modifying login credentials as necessary.

B. Notification Phase Implementation:

In the event of an identified accident, a web-based application developed using ASP .NET MVC 4 comes into play, acting as the bridge between the cloud and the nearest hospital. This interface serves as a crucial tool for hospitals to promptly assess the emergency status. The ASP .NET MVC 4 application receives real-time accident data, showcasing details such as accident location, driver information, and vehicle details.

Behind the scenes, a Microsoft SQL database securely stores all pertinent information related to each accident, ensuring a comprehensive record. The website's user interfaces are crafted using HTML, CSS, and Bootstrap, providing an intuitive and responsive design for efficient interaction.

Notably, the Google Maps API integration adds a visual element to the application, dynamically displaying the precise location of the accident on a map. This feature enhances the hospital's situational awareness, enabling quick and informed decision-making during emergency responses.[1]

IX.SAMPLE RESULTS

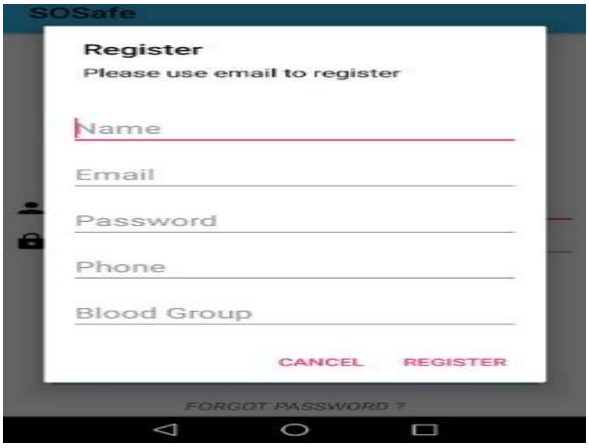

Fig. 3: User's details

Fig 3 login page where users can use email and password that they used to register, to log in to the system. After user's logs in to the system, they will be able to use all system features. [16]

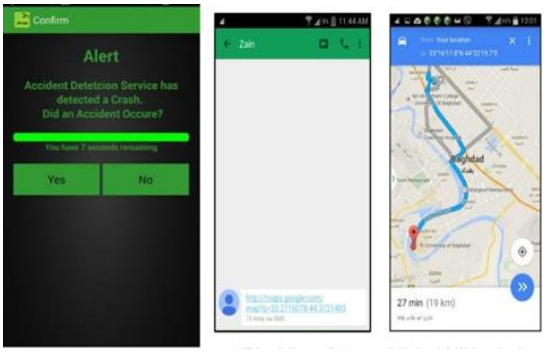

Fig 4: alert notificationFig 5: emergency alert to ambulance

Fig4 shows, the system will present an alert dialog to confirm the action before sending an emergency request to responder, this will help in situations when panic button is pressed accidently [15].

Fig 5 shows, this application shares the real time location ofaccidents to the emergency responder's. [15]

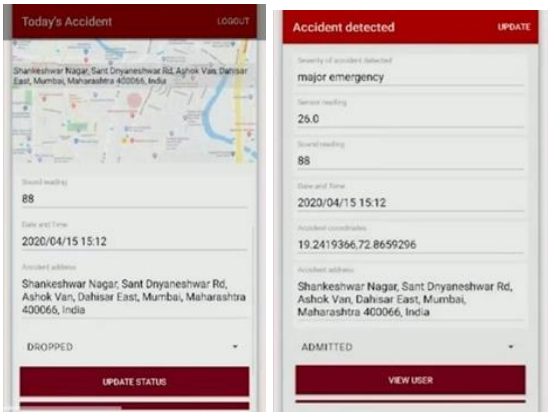

Fig 6: Ambulance status Fig 7: Hospital status

Fig 6 and 7 show the ambulance and the hospital in which the user has joined

X. FUTURE SCOPE

Wearable Device Integration:

Integrating the application with wearable devices presents anexciting opportunity to enhance emergency response systems. By seamlessly transmitting health data and location information, this integration can significantly improve the efficiency of emergency response efforts. Wearable devices, such as smartwatch or health bands, offer continuous monitoring of vital signs and can serve as valuable tools forassessing the severity of injuries sustained in accidents.Additionally, the real-time transmission of location datafrom wearable devices can aid emergency responders in accurately locating and providing

assistance to accident victims. This integration adds an extra layer of safety for users and contributes to more efficient and effective emergency response operations.

Predictive Analytics for Accident Prevention:

Implementing predictive analytics algorithms within accident detection systems can revolutionize accident prevention efforts. By analyzing historical accident data, traffic patterns, and environmental factors, these algorithms can identify accident-prone areas and predict potential hazards on the road. Proactively alerting users to these risksand suggesting preventive measures empowers them to makeinformed decisions and take precautionary actions while driving. Furthermore, such predictive capabilities enable the system to provide real-time updates and route recommendations, helping drivers avoid hazardous situations and minimize the likelihood of accidents. By harnessing the power of predictive analytics, accident prevention systems can significantly enhance road safety and contribute to a reduction in traffic accidents and related fatalities.

XI. CONCLUSION

In conclusion, the Road Guard Emergency Response Systemwith Notification provides a robust and timely response to road accidents, addressing the critical issue of delayed emergency assistance. By leveraging smartphone sensors and a well-designed C++ application, the system swiftly detects accidents, triggering instant notifications. The 10- second user acknowledgment window enhances user engagement, while the absence of a rear camera streamlines accessibility. The integration of cloud-based services ensures efficient data transmission, enabling immediate alerts to pre-stored contacts. This user-centric and technologically advanced system stands out for its potential to revolutionize emergency response, contributing significantly to the reduction of road accident fatalities and improving overall road safety.

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