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ResQharmony - Design & Development of an Automated Emergency Alert IoT System for Car Accident Scenario

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Abstract: *ResQharmony is a proactive car-centric application which is being designed for generating alert messages automatically, during an accident scenario. The system is planned for enabling an automated medical assistance alert to nearby hospitals and to family members of the victim. This life saving application uses cutting-edge technologies such as MEMS (Micro-Electro-Mechanical Systems), sensors, Raspberry Pi, GPS (Global Positioning System), and GSM (Global System for Mobile communication), the system detects airbag deployment and provides automated responses, thereby minimizing human intervention and reducing response time and sharing of live location with emergency services and to the persons of interest like relatives, friends, Hospital, Police station while continuously monitoring the location using Global positioning system (GPS). This paper is focussed more towards the software application development component with future potential for integration with suitable electronics.*

Keywords: Global Positioning System (GPS), GSM (Global System for Mobile communication), MEMS(Micro-Electro-Mechanical Systems), Emergency Alert, Car Safety, Mobile Application, CAN(Controller area network).

I. INTRODUCTION

Over the last few years, road safety has grown to become of prime importance worldwide with vehicular accidents rising at an alarming rate. The rise in the number of traffic-related accidents is another stark reality which is due to rapid urbanization and increasing vehicles on the road. Delays in the administration of proper medical aid can exacerbate the aftermath of such accidents. In critical hours seek a fatal reduction of casualties. But the manual alert to emergency responders is also often slow and time is precious in an emergency.

This is an immediate need & so, we present you with "ResQharmony" - a preventive car-focused application that can auto-create SOS (Save Our Souls) messages if involved in an accident. This new system helps us in reducing the difference between accidents and medical aid provided by automating alert mechanisms. By using features like MEMS (Micro-Electro-Mechanical Systems), and advancements in Global Positioning System (GPS)[7], ResQharmony can ensure accurate detection of accidents along with sharing the live location to respective emergency services & contacts. The app keeps track of the location of vehicles at all times and, in-case any accident is confirmed with real time data then an immediate notification shall be sent to hospitals, relatives and police station.

Indispensability of Automated Emergency Alert System Independent Operation is key to driving ResQharmony. In this paper, the SAD portion of ResQharmony i.e. its software application development will be discussed together with some highlights on what it can basically perform now and in the future when we find suitable electronics to connect into it. To address project needs, locate existing solutions and process migration techniques to improve all-over application quality and efficiency a thorough literature survey is required. Inspired by literature survey and existing systems, this

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study is aimed at providing a powerful solution which has high potential to decrease mortality due road accidents and increase the speed of Medical-emergency response.

With this we integrate GPS ,Micro-Electro-Mechanical Systems and sensors into a fully functional system like ResQharmony provides an accurate reliable way to detect crash accidents for generating alerts. The paper describes the technical architecture of the system, its expected contribution to road safety and opportunities for collaboration with consumer electronics companies in future development. ResQharmony is targeting to address the present-day inadequacies in emergency response by using state of Art Technology which will eventually lead to saving lives and reducing damage as a result of vehicular accidents.

II. LITERATURE SURVEY

It is imperative to survey the literature thoroughly when designing, and implementing a robust-cum-effective emergency alert system like ResQharmony. In this way, the literary survey plays a dual role in that it introduces crucial foundations of the project which will then allow you to move into specific technical and developmental aspects.

The objective of the literature survey is the development of a strong theoretical and empirical backbone for ResQharmony. This data impact study helps us better understand past research on the related subjects, available technologies in their respective fields and what could be some of the best practices to build an emergency alerting system i.e. existing solutions that are being utilised as well potential problem statements anticipated during this emergent scenario alerting platform evolution phase. We follow this process to guarantee that our intervention adopts well-validated methods and is informed by latest advancements, leading in the end to a domain specific solution for improving pedestrian safety and cutting down on emergency response times.

For years, researchers have been working to create a successful automotive accident alert system. All these studies provide us with valuable information and technological progress that we will be using to construct ResQharmony, a proactive car-centric application which is our proposed solution for the issue.

Neel*et* *al.*(2019), came up with its vehicle accident alert system where the Internet of Things (IoT) Node MCU(microcontroller unit) is used to detect accidents and then it instantly sent location alerts to emergency services as well as provided details in contacts using Blynk application. The system focused on the use of real-time alerts and location tracking to reduce fatalities through faster response. The researchers also showed how IoT can be used for automated emergency response and proved that Wi-Fi is a viable mean of fast information spreading.

Avinash *et al.*(2020), took up as a starting point and constructed upon it by incorporating GPS and GSM (Global System for Mobile communication)modules into the concept in order to make it self-sufficient for accident detection and alerting purposes. Consequently, their system featured multiple sensors that could identify the occurrence of accidents and send out distress signals without any human intervention. They introduced a time frame within which the alerts can be manually disabled or cancelled as a way of dealing with the problem of false detections. In conclusion, this study demonstrated how critical it is to minimize false positives and enhance system reliability, which are vital for effective emergency response

Sumathy *et* *al.*(2021), forged ahead even more with their Vehicle Accident Emergency Alert System that was a bingo of accelerometers, GPS, and GSM modules. They were mainly concentrating on the transfer of the exact coordinate of the incident to the first aid staff and even the relatives sending them the alert emitting device details. They underscored that this device is really cost-effective. Thus, this study has also proved that the inclusion of different technologies could drastically improve the delivery of emergency services.

Abdulkadir *et al.* (2022), examined the available systems and suggested the adoption of accelerometers alongside vibration sensors as a way of achieving positive outcomes. They built a system that can find extreme accidents out and alert emergency services through the usage of GPS and GSM modules. This paper also provided some insights into the use of different sensors for accurate detection and the need for real-time communication to speed up responses.

Gomathy *et al.* (2022), addressed the issue with their introduction of a system that included heartbeat sensors and accelerometers to evaluate accident severity and, through a smartphone application, to inform the emergency contacts. the way of the combination of health monitoring and accident detection, which helped the system to offer more the knowledge of the victim's problem.

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Veera *et al.*(2023) proposed an IoT-based accident detection and alert system using an Arduino Nano as the controlling unit. The system utilizes tri-lateral axis motions, an accelerometer, a gyroscope, and vibration sensors to detect collisions and rollovers. After confirming an accident, the system uses a GPS module to obtain the vehicle's exact coordinates and alerts nearby hospitals and emergency services. The study emphasizes the importance of accurate accident detection and prompt notification to emergency responders to save lives.

Naja'atu *et al.*(2023) presented a GSM, Buzzer, and GPS module-based accident detection system. The study highlights how increasing road traffic has led to more accidents and emphasizes the importance of prompt emergency response. By using an accelerometer and vibration sensor to detect serious accidents, the system sends alerts with the vehicle's location via GSM to emergency services. This approach is especially critical in remote areas where quick response can save lives.

Abdulkadir *et al.* (2022) explored an accident detection and alerting system that addresses the rise in road traffic and associated accidents. Their research emphasizes the crucial need for timely emergency response to minimize fatalities. By employing an accelerometer to detect rollovers and a vibration sensor for monitoring impact, the system promptly sends alerts with GPS coordinates via GSM to emergency services. This technology proves particularly vital in remote areas where immediate response can significantly enhance survival chances.

Veera *et al.*(2023) introduced an IoT-based accident detection and rescue system, addressing the rise in road accidents due to increased vehicle numbers and inadequate emergency response. The study highlights how accelerometers and vibration sensors can detect severe accidents, triggering alerts with GPS coordinates via GSM to emergency services. This approach is crucial for improving response times, especially in remote areas where timely intervention can be life-saving. The research emphasizes the importance of integrating technology to enhance emergency support and reduce the impact of accidents.

Jiahui *et al.*(2024) examined the role of generative edge intelligence (GEI) in enhancing vehicle accident detection systems within IoT networks. The study addresses key challenges in vehicle accident detection, such as data accuracy and communication latency. By integrating GEI, which augments data and learns underlying patterns, the proposed system aims to improve performance. The article reviews traditional methods, highlights their limitations, and presents a novel GEI-based architecture using an end-edge-cloud framework, offering insights into its applications, challenges, and future research directions.

Jayati Routh *et al.* (2019) proposed an automatic vehicle accident detection and messaging system using GPS and GSM modules. Their system addresses the increased traffic hazards and frequent accidents exacerbated by inadequate emergency response. When a vehicle is involved in an accident, a MEMS sensor detects the incident, and the signal is processed by an Arduino. The Arduino then sends an alert with the accident location via GSM to emergency services. This allows the police or rescue teams to quickly trace the accident site through GPS coordinates and take prompt action, aiming to improve response times and reduce loss of life and property.

Alok *et al.*(2023) investigated the feasibility of an IoT-based accident detection and alert system using GPS and GSM modules. Their system addresses the delayed emergency response following vehicular accidents, where prompt action is crucial. When a vehicle is involved in an accident, an accelerometer and GPS sensor detect the incident, uploading a signal to the cloud. The signal, indicating accident severity and GPS position, triggers an autonomous alert and notification system. Subscribers, including relatives, friends, police, and ambulance services, receive immediate warning messages. Emergency services utilize GPS coordinates to swiftly locate the accident site, aiming to reduce response times and minimize losses.

Rajat *et al.*(2023) developed an IoT-based smart accident detection and emergency notification system integrating GPS and GSM modules. Their system addresses the critical need for timely emergency response services, often lacking in accident scenarios, resulting in valuable lives lost. When a vehicle is involved in an accident, an accelerometer sensor detects the incident, and the signal is processed by an Arduino UNO R3 microcontroller. The Arduino then sends real-time information, including accident location, time, and date, via GSM to emergency services, utilizing GPS coordinates. Emergency responders, such as hospitals, ambulance services, and police stations, receive this crucial information, enabling prompt action and potentially saving numerous lives.

Jayati *et al.*(2019) proposed an automatic vehicle accident detection and messaging system utilizing GPS and GSM modules. Their system tackles the escalating traffic hazards and frequent accidents compounded by inadequate

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emergency response. When a vehicle is involved in an accident, a MEMS sensor detects the incident, and the signal is analyzed by Arduino. The Arduino then sends an alert message, including location coordinates, via GSM to emergency services, such as police control rooms or rescue teams. This enables prompt tracing of the accident site through GPS coordinates, facilitating swift action and aiming to reduce loss of life and property.

***Aayush** et al.*(2021) developed Accilert, an accident detection and alert system. Their system tackles the escalating traffic hazards and frequent accidents compounded by inadequate emergency response. When a vehicle is involved in an accident, an accelerometer and vibration sensor detect the incident, processing data to recognize severe accidents. The system then sends an alert message, including GPS-provided latitude and longitude, via GSM to emergency services, such as police control rooms or rescue teams. This enables prompt tracing of the accident site, facilitating swift action and aiming to reduce loss of life and property, particularly in isolated areas where timely reporting is crucial.

Lakshmi *et al.* (2024) proposed a wireless black box for cars using sensors and GPS modules. Their system addresses the need for a vehicle-embedded crash detection and notification device. When a vehicle is involved in an accident, various sensors (temperature, vibration, alcohol, and MEMS) detect and record parameters. The system, integrated with GSM and GPS modules, sends alerts to registered mobile numbers, including emergency services and family members. The device stores and displays critical data, such as location, temperature, and vibration, facilitating prompt response.

Duaa *et al.* (2024) developed a vehicle accident detection and notification system. Their system addresses the escalating road accidents and inadequate emergency response times. When an accident occurs, road surveillance camera data and machine learning techniques detect the incident, utilizing a convolutional neural network-support vector machine (CNN-SVM) hybrid model. The system then sends notification messages via Gmail to specialists, achieving accuracy rates of 99.74% and 98.88% on two datasets. Real-world testing demonstrated 100% accuracy within 30 seconds, enabling prompt action and aiming to reduce loss of life and property.

Seelam *et al.* (2024) introduced an IoT-based accident identification and alert system designed to enhance road safety. The system addresses the critical issue of delayed medical treatment, a leading cause of fatalities in accidents. By using a vibration or MEMS sensor to detect abnormal vibration frequencies, the system, which interfaces with a Raspberry Pi, monitors for accidents. When a threshold is exceeded, it retrieves GPS data and sends an immediate alert with the accident details to emergency contacts. This system aims to ensure rapid assistance and accurate location tracking to improve emergency response times.

Marimuthu *et al.* (2018) presented an accident detection and reporting system using IoT to enhance the safety of motorbike riders. Given the rising number of motorcycle accidents, the system focuses on early accident detection and timely communication with emergency services. When a rider's helmet impacts the ground during an accident, an embedded vibration sensor detects the event and sends the data to a Raspberry Pi module. If the vibration exceeds a preset threshold, the system retrieves GPS coordinates and quickly transmits an alert with the accident's details to the rider's registered emergency contacts. The system has been designed to provide immediate assistance, ensuring that the exact location of the accident is promptly reported.

Srividhya *et al.*(2022) proposed a smart accident detection system using Raspberry Pi and IoT to address the critical issue of delayed emergency response. The system aims to overcome the challenge of slow information transmission by integrating various sensors, a GPS transceiver, and a camera into a Raspberry Pi. A centralized server is set up to store essential medical information for quick access during accidents. The system is equipped with an auto-alert module that uses image processing to detect accidents and automatically sends the location details via message to the relevant authorities, ensuring a faster and more efficient response.

Aditya *et al.* (2020) introduced RoadNurse, a cloud-based infrastructure designed to enhance accident detection and emergency response. The system addresses the critical delay in notifying authorities after a roadside accident, which often leads to fatalities. RoadNurse employs vibration sensors to detect accidents by measuring impact severity, and a GPS module to pinpoint the exact location. This information is sent to a cloud server that identifies the nearest hospital capable of handling the emergency based on proximity and treatment capability. The system then automatically notifies both the hospital and the victim's loved ones via GSM, initiating a phone call to the hospital to expedite the rescue process. RoadNurse aims to significantly reduce the time between an accident and the arrival of emergency services, potentially saving lives.

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Yaswanth *et al.* (2021) introduced a smart assistant for accident prevention and rescue, addressing the alarming rise in fatalities due to road accidents. The system aims to prevent accidents using an alcohol sensor and enhance emergency response by integrating GSM, GPS, and vibration sensors. These sensors detect accidents and promptly send location details to rescue teams, enabling quicker intervention. Additionally, the system employs an ultrasonic sensor to help drivers navigate safely in low-visibility conditions, such as fog. This comprehensive approach seeks to reduce accident-related deaths by both preventing accidents and ensuring timely rescue efforts.

Based on the above review of literature, ResQHarmony introduces a novel approach to emergency alert systems by incorporating airbag deployment analysis as a critical factor in accident detection. By using MEMS sensors to monitor airbag deployment, the system ensures that alerts are only triggered in serious accidents, reducing false alarms. This method, combined with real-time GPS tracking and automated GSM alerts, provides a more accurate and reliable emergency response, enhancing the overall effectiveness of the system in saving lives.

III. PROBLEM STATEMENT

Accidents on the road can turn into life-threatening emergencies within moments, yet the response time to these crises often falls short. The heartbreaking reality is that lives can be lost because it takes too long for ambulances, police, and hospitals to learn about an accident and rush to the scene. The delays are often due to gaps in communication and the absence of immediate alerts when an accident happens. Addressing these delays and ensuring rapid, coordinated emergency responses is vital to reducing the pain and suffering caused by such tragedies.

Road accident scenario:

Road accidents Claimed around 19 lives every Hour in the year 2022. According to the Ministry of Road Transport and Highways, total accidents in 2022 were 4,61,312 recorded by States and Union Territories.

In Majority Cases the victim cannot find immediate help due to the place of accident or the victim may be out of their consciousness due to the injury.

Design:

Our application mainly targets car users, so it should be able to have a highly user-friendly User Interface to help all types of users.

User Interface:

Our UI can be easily used by our end users, as it consists of vibrant colours and large sized texts and buttons with high responsiveness.

Implementation:

- Once the app is opened it asks permission for enabling location, the entire app works only when location is enabled.
- On enabling location the user then be directed to the registration page if he is a new user.
- On Registration page the application asks for the user's name, mobile number, vehicle identification number, mobile number, perseon to contact in case of accident, and their mobile number.
- After this when the user logs they can view the home page where they can edit their details as and when needed, it also shows the message that had been sent to the nearby hospital in the past.

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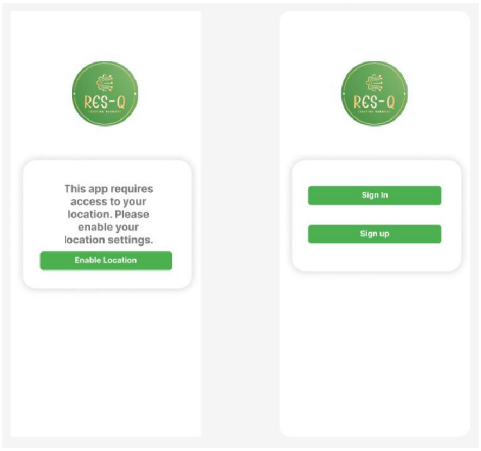

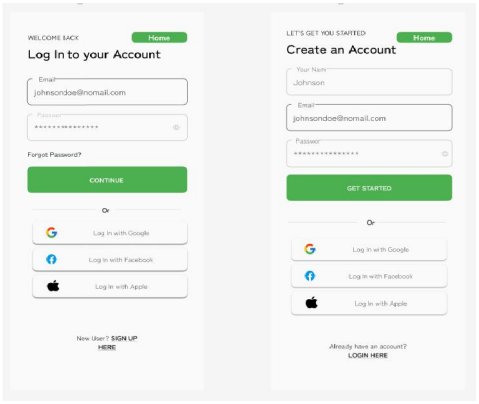

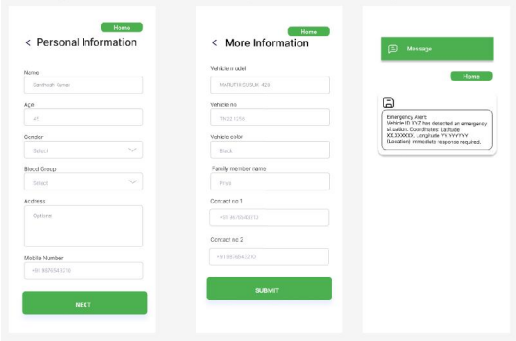

Application Development:

The mobile application developed with **React Native**, a popular framework that enables cross-platform development. This approach allows us to maintain a single codebase while targeting multiple mobile operating systems, including iOS and Android, ensuring broad compatibility and reducing development time.

Development Process:

Requirement Analysis:

- **Functional Requirements**: Define the core functionalities, such as accident detection, alert generation, and real-time location tracking.
- **Non-Functional Requirements**: Address performance, scalability, and user experience aspects.

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User Design Phase:

- **UI/UX Design**: Create wireframes and high-fidelity prototypes using tools like Figma.
- **Responsive Design**: Ensure the user interface adapts to different screen sizes and orientations across platforms.
- **Accessibility Features**: Incorporate accessibility options to make the app usable for all users.

Construction Phase:

- **Code Development**: Implement the app using React Native's components and APIs. Utilize libraries such as react-navigation for routing and redux for state management.
- **Integration**: Connect the application with external services, such as Firebase for backend services and GPS for real-time location tracking.
- **Testing**: Conduct unit testing, integration testing, and end-to-end testing using tools like Jest and Detox.

Feedback Implementation Phase:

- **Beta Testing**: Release the application to a group of beta testers to gather feedback on usability and performance.
- **Bug Fixing and Optimization**: Address issues identified during testing and optimize the app for better performance and stability.
- **Iterative Updates**: Refine features and address feedback to enhance the user experience.

React Native:

- **Cross-Platform Compatibility**: React Native allows us to write code once and deploy it on both iOS and Android, utilizing native components for high performance.
- **Native Modules**: For platform-specific functionalities, React Native's native modules and bridging capabilities ensure seamless integration with native code.
- **Database: Firebase** is employed as our backend service due to its robust features:
- **Real-Time Database**: Firebase Realtime Database and Firestore provide real-time synchronization and updates, essential for live location tracking and alert notifications.
- **Authentication**: Firebase Authentication supports various methods (email/password, phone authentication, social providers) to securely manage user access.
- **Analytics**: Firebase Analytics delivers insights into user behavior, app usage patterns, and performance metrics.
- **Performance Monitoring**: Tools such as Firebase Performance Monitoring help track and optimize the app's performance across different devices and network conditions.

Integration and Communication:

- **API Integration**: RESTful APIs can be used to communicate between the mobile application and external services.
- **Push Notifications**: Firebase Cloud Messaging (FCM) enables sending push notifications to users in real-time, crucial for alerting them in emergencies.

IV. METHODOLOGY

Working:

Hardware Components(Airbag deployment)

1. **MEMS Sensor**: Detects airbag deployment and sends a signal to Raspberry Pi.
2. **Raspberry Pi**: A compact, low-power computing module that processes sensor data and coordinates alert notifications.

- **GPS Module**: Provides the vehicle's location coordinates (latitude, longitude).

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-**GSM Module**: Sends SMS alerts to emergency services and designated contacts.
3. **Power Supply**: Operates within 5-12V range, ensuring compatibility with most vehicle electrical systems.

System Workflow

1. Airbag deployment triggers MEMS sensors.
2. MEMS sensor sends a signal to Raspberry Pi.
3. Raspberry Pi processes signals and retrieves location coordinates from the GPS module.
4. GSM module sends SMS alerts to emergency services and designated contacts with location information.
5. Alerts include vital information: accident location, vehicle ID, and deployment time.

Key Features

- Automated emergency notification system
- Real-time location tracking
- Real-time alerts to emergency services and designated contacts
- Compact, low-power for vehicle integration
- Robust and reliable operation (5-12V)

Benefits

- Enhanced road safety
- Reduction in emergency service response time
- Increased peace of mind for drivers and passengers
- Seamless integration with existing vehicle systems

ResQHarmony's innovative hardware integration ensures efficient and reliable emergency alert notifications, providing critical support in the event of a vehicular accident.

V. SYSTEM DESIGN AND ARCHITECTURE

Software Architecture:

Data Collection and Processing:

- **Arduino UNO:** Acts as the microprocessor, collecting data from sensors.
- **CAN Tools:** Facilitate real-time data transmission from the Arduino to a central system.

Data Transmission:

- **Wi-Fi/Bluetooth Connectivity:** Used to transfer data to a central server or cloud-based system.
- **Real-Time Data Handling:** Ensures that data is processed and transmitted with minimal latency.

lowChart

The Flow Chart of the system is shown in figure 1. It shows the system is initialized on powerON. When the system is detected to be abnormal, it is confirmed that the accident has occurred. Thevibration/acceleration of the vehicle is detected to confirm the cause of the accident. As soon as the accident is detected the buzzer (alarm) is ON. The switch is scanned first; if it is a minor accident then the switch is on ON so that messaging is terminated. If it is a major accident, the switch remains OFF and the message is sent automatically to the rescue team after the location is detected by the GPS.

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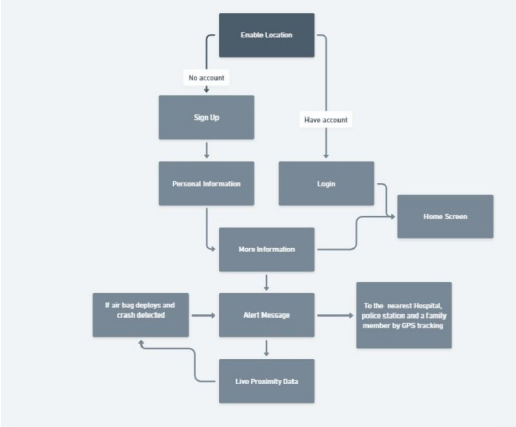
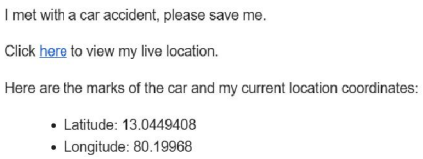


Result:

This mobile application will help in reducing the car accident rate and thus act as a life-saving app. We are currently in the designing phase of the application using Android Studio in react native, we have also worked upon different message-sending systems like email, twilio.

We plan to initialize the mobile app's testing phase using some random data and move to the hardware part. This ensures the correctness of our system.



VI. SUMMARY

ResQHarmony is an innovative emergency alert system leveraging Internet of Things (IoT) technology to enhance road safety. The system utilizes MEMS sensors to detect airbag deployment, Raspberry Pi for processing and integration, GPS modules for location tracking, and GSM modules for alert message generation.

Upon airbag deployment, ResQHarmony detects the incident using MEMS sensors and confirms the accident through victim acknowledgment on their mobile device. If unconfirmed after 20 seconds, the system sends emergency alerts with live location to nearby hospitals via GSM. This prompt response ensures assistance without third-party intervention, revolutionizing accident response and saving lives.

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