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Accident Detection and Emergency Reporting System Using ESP32, ADXL335, GPS, and GSM

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ABSTRACT: Road accidents are a significant global issue, often leading to severe injuries and fatalities due to delayed emergency response times. This paper presents an accident detection and reporting system designed to reduce response times and improve the chances of survival for accident victims. The system leverages an ESP32 microcontroller integrated with an ADXL335 accelerometer to detect sudden impacts, a GPS module (NEO-7M) for location tracking, and a SIM800L GSM module for instant notification. Upon detecting a collision, the system verifies the event using limit switches, retrieves the GPS coordinates, and sends an SMS alert to emergency services and predefined contacts, including the nearest hospital and police station. The proposed solution is cost-effective, easy to implement, and aims to improve road safety by ensuring timely assistance for accident victims. Additionally, the data collected could support authorities in identifying accident-prone areas and enhancing traffic infrastructure.

This system ensures faster emergency response, potentially reducing fatalities by increasing the chances of delivering first aid within the critical golden hour. The solution is designed to be user friendly and practical, ensuring even non-technical users can operate it seamlessly. Furthermore, the low-cost components and compact structure make it suitable for widespread implementation, especially in developing regions where road safety infrastructure may be limited.

Beyond individual safety, the proposed system has the potential to provide authorities with valuable data, helping to identify high-risk areas and improve urban planning and traffic management. Future improvements may include incorporating machine learning to differentiate between real accidents and false alarms and integrating alternative communication methods like satellite networks or LoRa to overcome connectivity challenges in rural and remote regions. The proposed system offers a reliable, affordable, and scalable approach to accident detection and emergency response, aiming to enhance public safety and mitigate the devastating impact of road accidents on individuals and society.

Keywords: Accident Detection, ESP32, ADXL335 Accelerometer, GPS, SIM800L, GSM, Emergency Notification.

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1. INTRODUCTION:

Accidents are a major public issue worldwide. The huge [3] number of injuries and death as a result of road traffic accident uncovers the story of global crisis of road safety. This massive traffic load [2] has uplifted the road accident graph, which has consequently raised injuries and death rates worldwide. The deaths or disabilities of youngsters [5] caused by accidents have a solemn effect on families and more widely on society. People are going under risk because of [6] their over speed, due to unavailability of advanced techniques, the rate of accidents can't be decreased. To reduce the accident rate in the country this paper introduces a solution. Automatic accident detection and alert systems are introduced. The main objective is to [7]control the accidents by sending a message to the registered mobile, hospital and police station using wireless communications techniques.

The primary reason why people die in accidents is because first aid materials are not easily accessible, which results from a delay in reporting the ambulance or hospital about the accident. Response time thus becomes crucial to providing emergency medical care to accident victims in the quickest possible time in the event of a vehicle accident, and it will probably impact the number of fatalities. In addition, [1] each minute that passes by with an injured crash victim receiving emergency medical attention may significantly decrease their chances of life. For example, data indicates that a one-minute decrease in accident response time leads to a 6% increase in the number of lives saved.

When an accident occurs in a city or any place, the message is sent to the registered mobile through GSM module in less time. Arduino is the heart of the system which helps in transferring the message to different devices in the system. Vibration sensor will be activated when the accident occurs and the information is transferred to the registered number through the GSM module. The GPS system will help in finding the location of the accident spot. The proposed system will check whether an accident has occurred and notify nearest medical centers and registered mobile numbers about the place of accident using GSM and GPS modules. The location can be sent through a tracking system to cover the geographical coordinates over the area. The accident can be detected by a vibration sensor which is used as a major module in the system.

2. PROPOSED METHODOLOGY:

Location tracking accident detection, and notification system. This section outlines the three primary phases of the proposed system's architecture and functionality:

1. Accident Detection
2. Tracking Location
3. Sending Notifications

1) Accident Detection

Limit switches and an accelerometer sensor are utilized by the system to detect accidents. The X, Y, and Z axes of the vehicle's tilt are monitored by the accelerometer. Acceleration data are taken by the accelerometer [6] to estimate the impact intensity of accidents. Along with its (X-axis to GPIO 36, Y-axis to GPIO 39, Z-axis to GPIO 34) links, the accelerometer is connected to the ESP32. The vehicle is initially at zero degrees, but the system detects an accident if the tilt in addition to threshold values (310° for the X-axis and 340° for the Y-axis). The sensor advises the ESP32 microcontroller in the case of an accident. Four ultrasonic sensors are set up at the vehicle's left, right, rear, and front to detect objects in the nearby area.

2) Location Tracking

The GPS module (NEO-7M) determines the vehicle's exact location when an accident occurs. NEO-7M is connected to ESP32 via serial Communication Tx (GPS) to RX (ESP32 GPIO 23), RX (GPS) to TX (ESP32 GPIO 25). [6] If any of the limit switches are triggered, the ESP32 microcontroller reads the activated switch and fetches GPS coordinates. The ESP32 then sends an SMS alert with the accident's location to predefined contacts using the SIM800L GSM module. The Sim 800L GSM module is connected to ESP32 TX (Sim 800L) to RL (ESP32 GPIO 17), RX(Sim

800L) to TX (ESP32 GPIO 16).The microcontroller continuously processes signals from the GPS module to ensure the correct accident location is identified before sending alerts.

3) Notification Sending

Once an accident is detected, the system sends an SMS alert with a Google Maps link containing the accident's latitude and longitude details. This message is sent to emergency responders, including the nearest hospital and police station. The notification [6] allows the ambulance to take the shortest route to the accident scene, reducing response time and potentially saving lives.

2.1 HARDWARE SETUP AND BLOCK DIAGRAM:

The system consists of key hardware components, including:

1. Voltage Regulator (LM2596): Two LM2596 modules are used to regulate voltage in which a) one provides 3.3v for ESP32, ADXL 335 and GPS, b) another voltage provides 5v for the sim 800L GSM module.

2. ESP32 Microcontroller:

ESP32 is the central unit which controls the sensors, communication and logic. It interfaces with GPS,GSM, accelerometer and limit switches.

3. GPS Module (NEO-7M):

Neo 7m (GPS module) provides the real time location data in the case of an accident. It is connected to ESP32 via serial communication, Tx (GPS) to Rx (ESP32 GPIO 23), Rx (GPS) to Tx (ESP32 GPIO 25).

4. GSM Module (SIM800L):

Sim 800L (GSM module) sends an sms alert when an accident is detected. It is connected to ESP32 , Tx (sim 800L) to Rx (ESP32 GPIO 17), Rx (sim 800L) to Tx (ESP32 GPIO 16).

5. ADXL 335 Accelerometer:

The accelerometer (ADXL 335) detetcts collision impact intensity based on acceleration values. It is connected to ESP32 (X-axis GPIO 36, Y-axis GPIO 39, Z-axis GPIO 34).It provides data on sudden acceleration changes indicating a crash.

6. Limit Switches (Impact Sensors):

There are four mechanical switches which detects the side of the vehicle was impacted and accidents from different impact directions:

Front Switch (GPIO 23)

Rear Switch (GPIO 26)

Left Switch (GPIO 27)

Right Switch (GPIO 14)

Each switch has 10kΩ pull-down resistor to keep signals low when inactive. These 10K(ohm) pull up resistors ensure a high state until the switch is pressed or accident occurs.

2.2 Block Diagram:

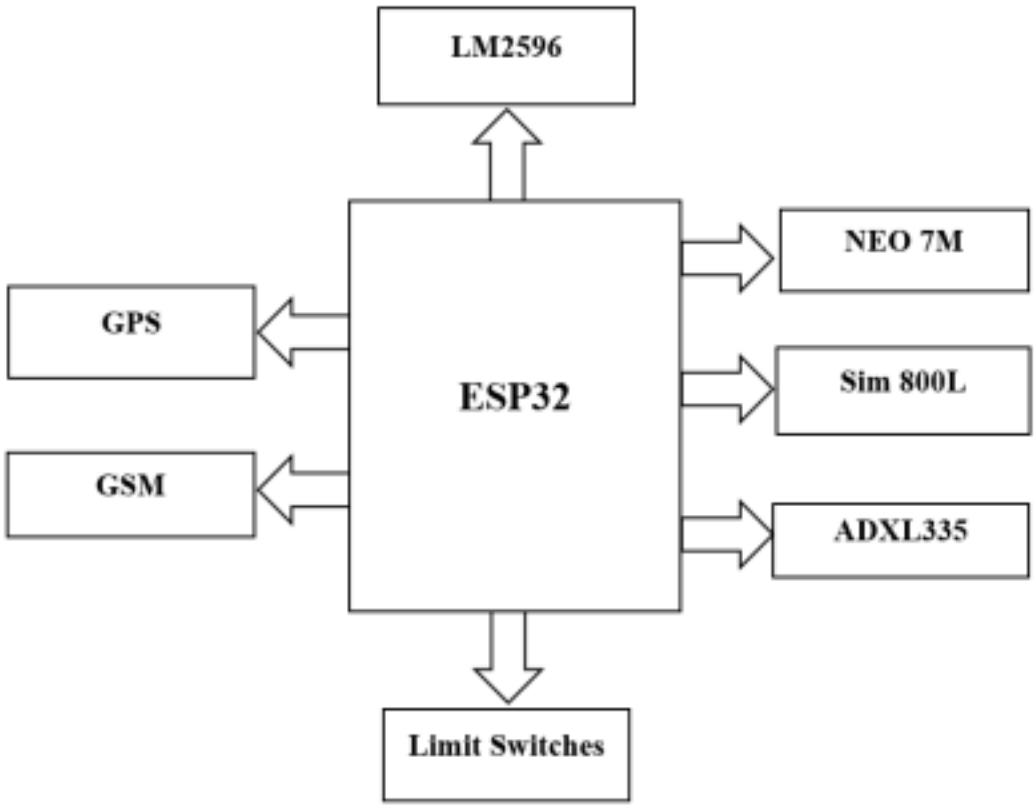

Fig.1 System Architecture of Accident Detection and Reporting System

2.3 WORKFLOW OF THE SYSTEM:

This section demonstrates the working flow of the proposed intelligent accident detection, location tracking and notification system. Fig.2 shows the flowchart of the proposed system below:

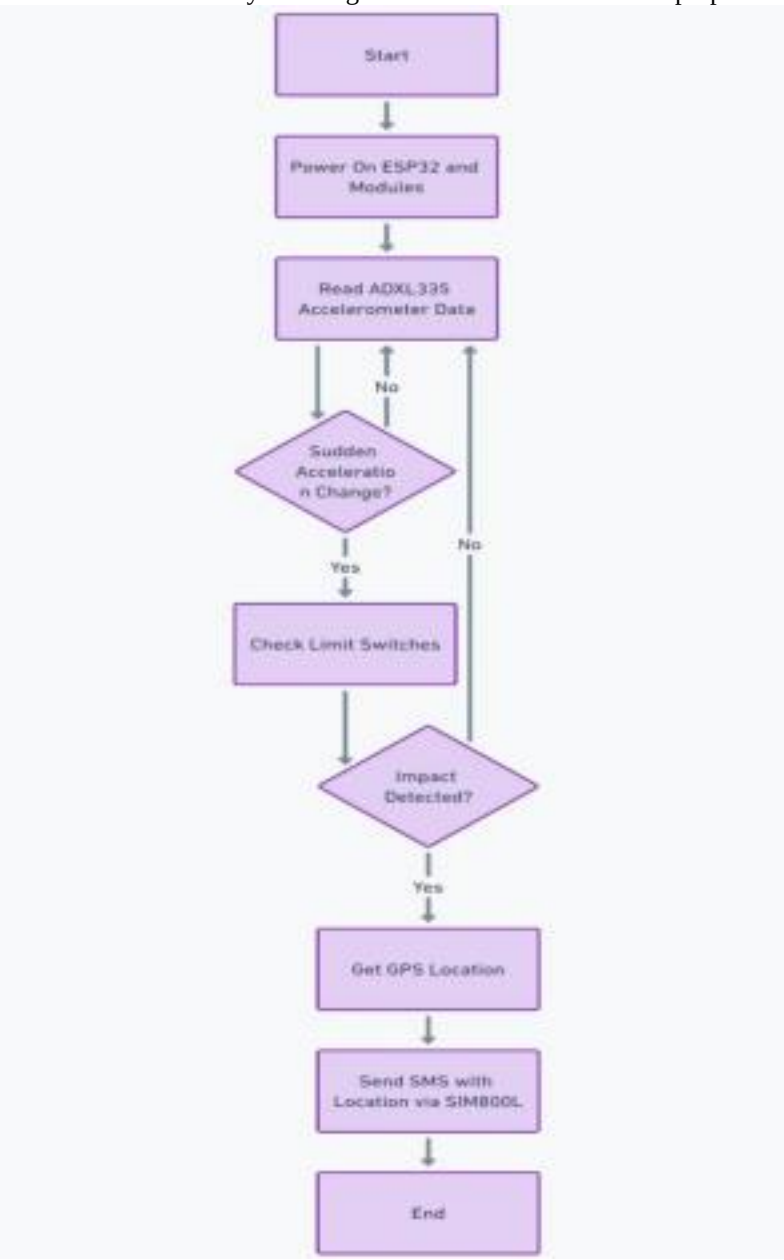

Fig.2 Flowchart of accident detection, location tracking and Notification system

1) Start: The system begins its operation.

2) Power On ESP32 and Modules: The ESP32 microcontroller and connected modules (ADXL335 accelerometer,

GPS, SIM800L GSM) power on and initialize. 3) Read ADXL335 Accelerometer Data: The ESP32 continuously reads data from the ADXL335 accelerometer to monitor for sudden changes in acceleration.

4) Sudden Acceleration Change? (Decision)

· The system checks if there's a rapid change in acceleration (e.g., a crash or fall). · No**:** If no sudden change is detected, the system loops back to read data again. · Yes**:** If a sudden change is detected, it moves to the next step.

5) Check Limit Switches: This step involves checking additional sensors, like limit switches (or other impact detection methods), to confirm the event is an actual impact, not just a false alarm. 6) Impact Detected? (Decision)

· The system verifies if the event qualifies as an impact.

· No: If no impact is detected, the system loops back to read data again.

· Yes: If an impact is confirmed, it proceeds to the next step.

7) Get GPS Location: The ESP32 fetches the current GPS coordinates from the GPS module. 8) Send SMS with Location via SIM800L: The ESP32 uses the SIM800L GSM module to send an SMS containing the GPS location to a predefined emergency contact.

9) End: The process completes after sending the alert.

3. RESULTS

The overall result of this project is an application that provides help to people who require help but can't ask for it. With the help of the application, [6] their request for help is sent at the time of the accident with their location which helps emergency services provide support as early and effective as possible. All this is done with only the sensors available at low cost.

Fig.3 shows SMS notifications from an accident detection system. Each message contains the vehicle number, GPS coordinates, impact intensity (measured in g-force), and the detected damaged side with one message indicating "Front" damage. This setup likely integrates sensors like an accelerometer and GPS for real-time accident reporting.

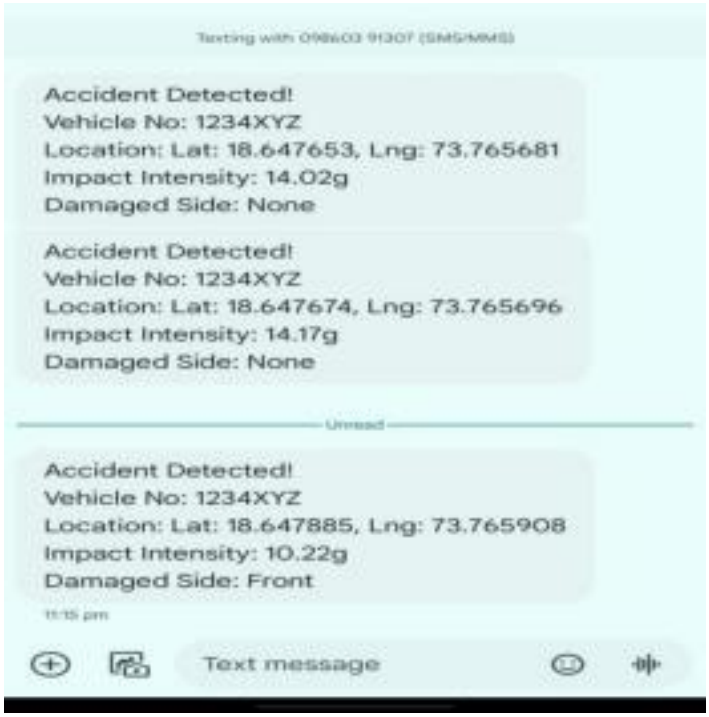

Fig. 3 Accident details in Notification message

Fig.4 shows a map with a pinpoint at GPS coordinates **18.647674, 73.765908**, likely marking the accident location reported in the previous SMS. Nearby landmarks like restaurants, clinics, and hotels are visible, providing context for the vehicle's position.

Fig.4 Location of an accident

4. CONCLUSION

The proposed programmed accident detection system can be a rescuer of life for the people who met with accidents. The proposed system is exceptionally easy to understand and even a non specialized Person can use it without any problem. Our research paper has highlighted the issue of road safety. However, these efforts are restricted in providing a holistic solution. Once the accident is detected, the information is communicated to emergency services to provide timely aid. Such systems provide many advantages such as identifying precise accident locations and facilitating over all rescue operations. The equipment unit includes accident detection sensors that are by an processor board and is fitted in the vehicle. Then again, the programming part is an Android application introduced in drivers Smartphones which is used to get the point by point map. In general, the benefits of this system are low cost, secure and simple to use.

The system's design focuses a high value on usability, ensuring that even non-technical people can operate it with ease. With a [6] straightforward configuration that includes an ESP32 microcontroller, GPS module, ADXL335 accelerometer, and SIM800L GSM module, it provides a useful, affordable solution that ensures accessibility and reliability. The device might encourage larger traffic safety measures in alongside personal safety. Authorities can potentially be able to detect accident-prone areas, improve infrastructure, and improve traffic management with the help of real-time accident data. In addition, implementing such technology into vehicles might modify emergency response systems, reducing fatalities and enhancing public safety usually in particular areas with high accident rates.

This study however does recognize multiple weaknesses. In rural or busy metropolitan regions, low network coverage or interference from GPS signals may impact the system's performance. To conquer these obstacles, subsequent editions might use various methods of communication like satellite connectivity or LoRa. Reliability could be further increased by using machine learning to distinguish between real accidents and fake triggers.

In order to sum up, the proposed accident detection and reporting system provides a reliable, cost effective, and simple to use address to an important issue with road safety. Though this research is an important step in the proper direction, more work and improvement could make this system an entire, globally scalable life-saving device.

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