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Real-Time Accident Detection and Alert System with GPS and GSM

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Abstract: *Nowadays, Road accidents are one of the leading causes of fatalities and injuries worldwide, with delays in emergency response significantly contributing to the severity of outcomes. To mitigate this issue, this project proposes a Real-Time Accident Detection and Alerting System using GPS and GSM technologies. The system is designed to detect accidents instantly using sensors such as Tilt sensor or vibration sensors, which monitor sudden changes in velocity or impact forces. Upon detecting an accident, the system automatically captures the precise location using a GPS module and sends an alert message containing the coordinates and time of the incident via GSM to predefined emergency contacts, including nearby hospitals and police stations. This system ensures a rapid response by eliminating the need for manual communication, which may not always be possible due to the condition of the victim. The hardware is compact and can be easily integrated into any vehicle. In addition to accident alerts, the system can also serve as a vehicle tracking device, enhancing security and monitoring. Overall, this solution aims to reduce emergency response time, improve the chances of survival for accident victims, and contribute to road safety initiatives.* .

Keywords: Accident Detection, GPS, GSM, Real-Time Alert, Vehicle Safety, Emergency Response

I. INTRODUCTION

Embedded systems are specialized computing systems designed to perform dedicated tasks with real-time computing constraints. They integrate hardware and software to control and monitor specific functions within a larger system. In recent years, embedded systems have become vital in developing intelligent safety solutions for transportation, especially in reducing road accidents and enabling quicker emergency responses.

A **Real-Time Accident Detection and Alert System** using GPS (Global Positioning System) and GSM (Global System for Mobile Communications) is a prime example of an embedded application that enhances road safety. This system detects vehicle accidents using sensors like accelerometers or vibration sensors and immediately sends the location coordinates via SMS using the GSM module. The GPS module provides real-time location tracking, ensuring that emergency responders can be directed to the exact accident location quickly.

This system is typically powered by a microcontroller (e.g., Arduino, STM32, or Raspberry Pi), which processes sensor data and controls the communication modules. The integration of GPS and GSM with accident detection logic creates a compact, cost- effective, and life-saving embedded solution that bridges the gap between accident occurrence and emergency response.

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Figure 1 Block diagram

II. EMBEDDED SYSTEM

An Embedded System is a specialized computer system that is designed to perform a specific task or function within a larger mechanical or electrical system. Unlike general-purpose computers, embedded systems are optimized for particular applications, often operating under real-time constraints. They combine hardware and software components to carry out dedicated functions efficiently and reliably.

Embedded systems are everywhere in household appliances, automobiles, medical devices, industrial machines, consumer electronics, and more. For example, a washing machine uses an embedded system to control its operations based on user inputs, while a car may contain dozens of embedded systems to manage everything from engine control to safety features like airbags.

Typically built around microcontrollers or microprocessors, these systems interact with their environment through sensors and actuators. The embedded software (firmware) embedded in ROM or Flash memory provides the logic that drives the system.With the advancement of technologies like the Internet of Things (IoT), embedded systems are becoming smarter and more connected, playing a vital role in building intelligent environments such as smart homes, smart cities, and autonomous vehicles.

III. REAL-TIME ACCIDENT DETECTION AND ALERT SYSTEM WITH GPS & GSM

An Embedded Real-Time Accident Detection and Alert System with GPS and GSM is an intelligent safety solution designed to detect road accidents and immediately alert emergency services and designated contacts. The system is typically built around a microcontroller (like Arduino or Raspberry Pi) and integrates various sensors such as accelerometers and gyroscopes to detect sudden changes in velocity or orientation that indicate a collision. Once an accident is detected, the GPS module captures the exact location coordinates of the vehicle. These coordinates, along with a predefined emergency message, are sent via the GSM module as an SMS or call to emergency responders or family members. Some systems may also include additional features like a buzzer or display unit for real-time alerts, and a panic button for manual assistance. This system ensures timely response, reduces fatalities by minimizing the delay in medical help, and offers peace of mind to vehicle owners and their families. It is especially beneficial for use in cars, motorcycles, or even public transport vehicles, and can be integrated into smart city infrastructure for enhanced road safety.

This system uses a combination of sensors, communication modules, and a microcontroller to monitor and respond to accident scenarios in real-time. The core components include a microcontroller (such as Arduino or Raspberry Pi), an accelerometer and gyroscope (e.g., **MPU6050**) for detecting sudden impact or abnormal orientation changes, a GPS

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module (e.g., **NEO-6M)** to determine the real-time geographic coordinates of the vehicle, and a GSM module (e.g., **SIM800L** or SIM900A) to send alert messages via SMS or initiate emergency calls.

The microcontroller then reads the GPS coordinates and activates the GSM module. An alert message, containing the location (latitude and longitude) and possibly a predefined text like "Accident Detected! Need Help," is sent to emergency contacts such as ambulance services or family members. The integration of GPS and GSM ensures that even if the driver is unconscious or unable to use a phone, help can still be dispatched to the correct location automatically.

IV. EXISTING SYSTEM

In the current scenario, accident detection and emergency response are largely dependent on manual intervention or witnesses who report incidents to emergency services. This conventional approach often leads to delays in medical assistance, especially in remote or less-trafficked areas, increasing the risk of fatalities.

Some vehicles are equipped with basic tracking systems or emergency alert buttons (e.g., in modern cars with OnStar or eCall), but these systems are either expensive, regionspecific, or not widely implemented in low- to mid-range vehicles. Additionally, these systems may not automatically detect accidents based on sensor input and typically require user interaction or significant infrastructure.

Existing manual systems have several limitations:

- Delay in response time due to the need for human reporting.
- Lack of precise location tracking without GPS integration.
- Absence of automated accident detection, leading to unreported or late- reported accidents.
- Limited accessibility in rural or developing regions.

To overcome these challenges, an embedded real-time accident detection and alert system using GPS and GSM can provide a low-cost, automated, and widely deployable solution that reduces response time and improves survival chances in road accidents.

V. PROPOSED METHOD

The proposed system is an embedded, real-time accident detection and alert solution that automatically identifies vehicular accidents and immediately notifies emergency contacts or rescue services with accurate location details. It combines sensors, a microcontroller, a GPS module, and a GSM module to ensure fast and automated accident reporting.

Key Components:

- **Microcontroller** (e.g., Arduino, ESP32): Processes sensor data and controls the system.
- **Accelerometer/Vibration Sensor:** Detects sudden impacts or abnormal motion indicating a collision.
- **GPS Module**: Provides real-time geographic coordinates of the vehicle.
- **GSM Module**: Sends SMS alerts containing accident details and location to predefined contacts (e.g., family members, emergency services).
- **Power Supply**: Ensures uninterrupted operation, even after a collision.

VI. SOFTWARE EMPLOYED

The software employed in the Real-Time Accident Detection and Alert System with GPS and GSM is primarily based on embedded system programming using the Arduino IDE, which supports coding in **C/C++** specifically tailored for Arduino microcontrollers such as the Arduino Uno or Nano. The main function of the software is to integrate all the hardware components—tilt sensor, GPS module, GSM module, L298N motor driver, DC motor, and LCD display—into a cohesive system that can detect accidents and respond in real time. The tilt sensor continuously monitors the orientation of the system, and when a sudden change or tilt beyond a predefined threshold is detected (which may indicate a vehicle accident), the microcontroller triggers an alert routine.

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The software uses several libraries to manage hardware communication effectively. The SoftwareSerial library is used to establish serial communication between the microcontroller and the GSM module, which is responsible for sending SMS alerts. The TinyGPS++ or Adafruit_GPS library is used to read and parse location data from the GPS module, which provides the real-time coordinates of the accident location. These coordinates are formatted into a readable message and sent via the GSM module to pre-defined emergency contacts.

To display the system status (e.g., "Normal", "Accident Detected", "Sending Location"), the LiquidCrystal library is employed to control the 16x2 LCD display. Additionally, the software includes motor control logic using digital I/O pins connected to the L298N motor driver, which in turn drives the DC motor—this can simulate vehicle movement or stop the motor in case of an accident.

The overall software design involves continuous monitoring, interrupt handling, data acquisition, and serial communication, ensuring that the system can detect accidents promptly and send alerts without manual intervention. Optionally, tools like Proteus can be used for simulation and testing before hardware implementation, and Fritzing can be used to create the system's schematic diagram. This software-centric approach is crucial in making the system intelligent, responsive, and reliable in emergency situations.

VII. RESULTS AND DISCUSSIONS

When the power supply is turned on, the real-time accident detection and alert system initializes, and the GPS and GSM modules are activated. The accelerometer continuously monitors the vehicle's acceleration and vibration, sending data to the microcontroller. The GPS module provides location coordinates, which are stored and updated in real-time. If an accident occurs, the atilt sensor detects the sudden change in acceleration and sends a signal to the microcontroller. The microcontroller then retrieves the current location coordinates from the GPS module and sends an alert message, including the location, to designated contacts or emergency services via the GSM module. The GSM module sends an SMS with the alert message, enabling timely alerts and potentially saving lives. This system provides accurate location information and fast response times, making it an effective solution for real-time accident detection and alerting.

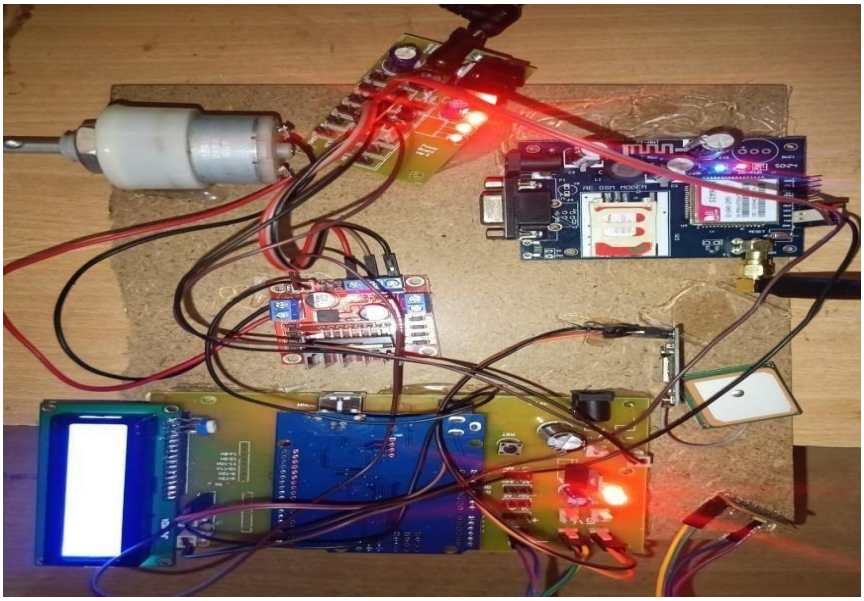

Figure 2 Before giving commands

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Figure 3LCD Display Accident Detection Command

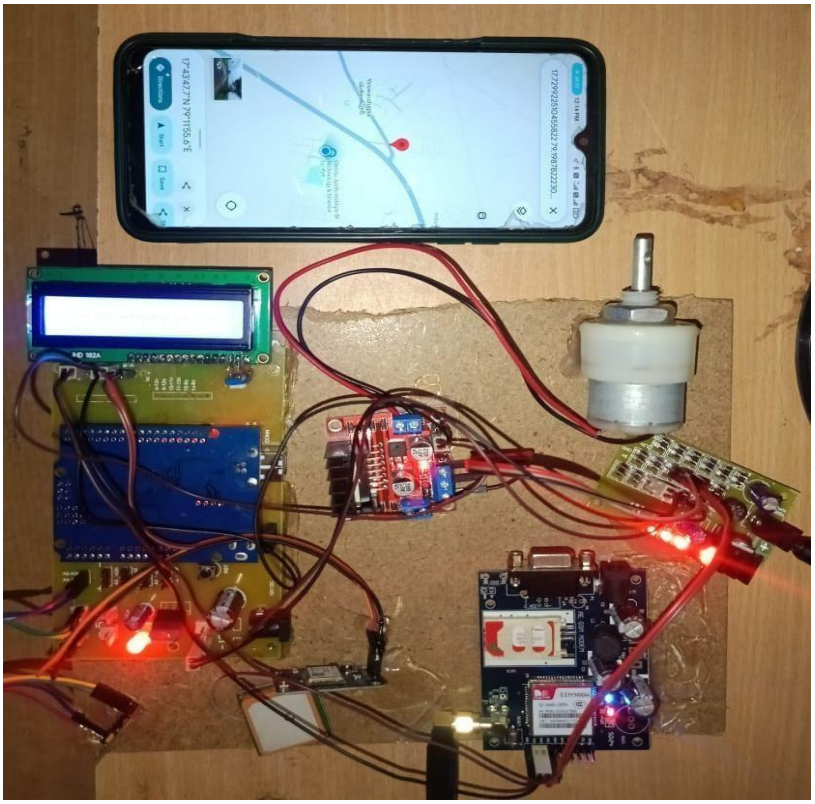

Figure 4 After giving commands

VIII. CONCLUSION

The real-time accident detection and alert system using GPS and GSM provides an efficient and reliable method for enhancing road safety by automatically identifying accidents and immediately notifying emergency contacts or services with accurate location details. This system addresses critical delays in emergency response, especially in cases where victims are unconscious or isolated, by eliminating the need for manual intervention. Through the integration of GPS technology for real-time tracking and GSM modules for instant communication, it ensures quick and accurate transmission of information. The project demonstrates the practical use of embedded systems and IoT in saving lives, making it highly valuable for individual users, fleet operators, and smart city initiatives. In conclusion, this system offers a scalable, cost-effective, and impactful solution for reducing fatalities and improving emergency response times on roads.

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