Smart Vehicle Accident Alerting System

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***Abstract*—The Smart Vehicle Accident Alerting System is designed to enhance road safety by enabling real-time accident detection and immediate communication with emergency services. The system integrates low-cost and efficient hardware components, including the ADXL345 accelerometer, limit switch, GPS NEO-6M module, GSM SIM900A module, and Arduino Nano microcontroller. Upon detecting a sudden impact or halt, the system processes sensor data and automatically sends an SMS alert containing the vehicle's GPS coordinates to predefined emergency contacts. This ensures timely medical assistance, especially in cases where the victim is unconscious or unable to call for help. The system operates autonomously, minimizing human intervention, and provides a scalable and cost-effective solution for accident detection. Its practical implementation in vehicles and other transportation systems has been tested under various real-world scenarios, showing reliable performance, fast response, and accurate location tracking.**

***Keywords*—Accident Detection, Real-Time Alert, Arduino Nano, GSM SIM900A, GPS NEO-6M, ADXL345 Accelerometer, Emergency Notification, Road Safety**

I. INTRODUCTION

Road accidents are among the leading causes of injury and death worldwide, posing a major threat to human life and public safety. Despite advancements in automobile safety features, the delay in emergency response remains a critical factor that contributes to the severity of injuries or fatalities. Often, accident victims are unable to call for help due to unconsciousness, injury, or being trapped in their vehicles. Such situations demand an automated system capable of detecting accidents and notifying emergency services without relying on manual intervention.

The Smart Vehicle Accident Alerting System addresses this need by automatically detecting accidents and sending real-time alerts containing the vehicle's exact GPS location to predefined emergency contacts. The system leverages affordable and readily available components including the ADXL345 accelerometer, a limit switch, a GPS NEO-6M module, and a GSM SIM900A module, all controlled through an Arduino Nano microcontroller. The accelerometer detects sudden changes in motion typical of collisions or abrupt stops, while the limit switch confirms a vehicle stoppage. When both conditions are met, the Arduino collects GPS coordinates and uses the GSM module to dispatch an SMS alert.

This autonomous system is designed to function efficiently under diverse conditions and without user interaction, ensuring that help is summoned immediately after an accident occurs. Its applications extend across private vehicles, commercial fleets, public transportation, and even industrial settings. The integration of real-time detection, location tracking, and instant communication makes it a valuable tool for reducing emergency response time and improving survival outcomes in critical scenarios.

II. LITERATURE REVIEW

Recent advancements in sensor technology, embedded systems, and wireless communication have led to the development of intelligent accident detection and alert systems aimed at improving road safety. Madhavi Latha et al. (2024) proposed an integrated system utilizing GPS and GSM technology for real-time accident detection and alerting, highlighting the efficiency of sensor-based emergency response mechanisms. Similarly, Nishad et al. (2024) designed a system using alcohol, temperature, and infrared sensors to prevent accidents by monitoring real-time vehicle conditions. Murthy et al. (2024) implemented an IoT-based collision monitoring system capable of sending alerts to emergency services via the cloud, significantly reducing response time. Vijayaraja et al. (2021) focused on a low-cost Arduino-based system for crash detection using an accelerometer and GPS,

demonstrating the practicality of budget-friendly solutions. Degoankar et al. (2024) explored accident prevention in high-risk environments using wireless-enabled smart helmets. Palanisamy et al. (2024) contributed an IR-based prevention system with alarm features to detect potential collisions in low-visibility conditions. Duganavar et al. (2024) integrated accelerometer and GPS modules in an IoT system for real-time emergency communication. Kumar et al. (2020) and Trung et al. (2021) developed Arduino-based systems that monitored acceleration patterns and sent SMS alerts with location details upon crash detection. Finally, Kumar et al. (2022) introduced a deep learning-based model combined with IoT for enhanced accuracy in accident detection across smart city infrastructures. These studies collectively highlight the growing reliance on microcontroller-based automation and the integration of smart sensors, GPS, and wireless modules to create reliable and scalable accident alerting systems.

III. METHODOLOGY

The Smart Vehicle Accident Alerting System is designed to autonomously detect road accidents and send immediate SMS alerts with the vehicle's location to predefined emergency contacts. The methodology integrates various hardware components with embedded control logic using the Arduino Nano microcontroller. The system is structured into several functional stages:

A. System Design Overview

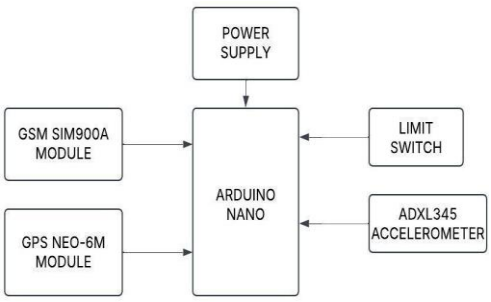

Fig 1 System Architecture

The system operates by monitoring sudden acceleration changes and physical impact through the ADXL345 accelerometer, in conjunction with a limit switch that detects a vehicle stoppage. When an accident is suspected, the Arduino Nano processes this data and triggers the GSM SIM900A module to send an SMS alert, which includes the GPS coordinates obtained from the NEO-6M module.

B. Hardware Components

- Arduino Nano: Serves as the central control unit managing all inputs and outputs.
- ADXL345 Accelerometer: Detects sharp variations in acceleration along the X, Y, and Z axes to identify impacts.
- Limit Switch: Confirms vehicle halt post-impact, serving as a secondary verification of an accident.
- GSM SIM900A Module: Sends SMS alerts with accident information and GPS coordinates.
- GPS NEO-6M Module: Provides real-time latitude and longitude data for precise location tracking.

C. System Workflow

1. Accident Detection: The accelerometer continuously monitors motion. When abrupt changes exceed a defined threshold, an impact is suspected. Simultaneously, the limit switch checks for a complete stop.
2. Data Processing: The Arduino Nano evaluates sensor input. If both conditions are met, it confirms an accident event.
3. Alert Generation: The GPS module provides location data, which the Arduino embeds into a predefined SMS message.
4. Message Transmission: The GSM module sends the alert to emergency contacts, including a Google Maps link with the accident coordinates.

D. Software Implementation

The system software is programmed in C/C++ using the Arduino IDE. It uses libraries such as Tiny GPS++ for GPS parsing and Software Serial for GSM communication. Threshold values for impact detection are calibrated through real-world testing to optimize accuracy while minimizing false alerts.

E. Testing and Calibration

The system was tested under various simulated conditions involving sudden stops and impacts. Each hardware component was individually calibrated, and the full system was evaluated for detection accuracy, message delivery success, and GPS precision. The testing confirmed the system’s reliability under typical urban and highway driving conditions.

IV. RESULT ANALYSIS

The Smart Vehicle Accident Alerting System was thoroughly tested to evaluate its performance in real-

time accident detection, accurate location tracking, and reliable communication. The system underwent a series of test cases designed to simulate realistic accident scenarios and to validate the response of each hardware module.

A. Accelerometer-Based Detection

In controlled tests, the ADXL345 accelerometer successfully detected sudden deceleration and impact events that simulated real-world crashes. The sensor consistently exceeded the predefined threshold values during abrupt motion, triggering the accident detection mechanism. These tests confirmed the accelerometer's sensitivity and reliability in detecting vehicle impact scenarios.

B. Limit Switch Functionality

The limit switch was tested to confirm a vehicle halt after an accident. When installed near the car's door or chassis, it accurately responded to sudden stops. Its signal was effectively processed by the Arduino Nano, contributing to accurate accident confirmation when used alongside the accelerometer data.

C. GPS and GSM Module Validation

The GPS NEO-6M module accurately retrieved the vehicle's latitude and longitude in outdoor environments. In all test cases, the GPS fix was obtained within seconds, and the coordinates were successfully included in SMS messages. The GSM SIM900A module transmitted alerts without failure, even in areas with moderate network coverage. Messages contained accident alerts, precise location data, and clickable Google Maps links.

D. Integrated System Performance

The complete system was tested under simulated crash conditions involving rapid deceleration and abrupt halts. Upon detection, the system responded within 2–3 seconds to gather GPS data and transmit the alert. The average time from accident detection to SMS delivery was approximately 6 seconds, indicating real-time capability. Messages were received on target phones with correct formatting, location accuracy, and minimal delay.

These results confirm that the system can reliably detect accidents, track vehicle location, and notify emergency contacts autonomously with minimal latency.

V. CONCLUSION

The Smart Vehicle Accident Alerting System offers a reliable, low-cost, and real-time solution for enhancing road safety and improving emergency response times. By integrating key components such as the ADXL345 accelerometer, limit switch, GPS NEO-6M, GSM SIM900A, and Arduino Nano, the system autonomously detects accidents and promptly notifies emergency contacts with precise location details.

Extensive testing under various simulated and real-world scenarios confirmed the system's effectiveness in detecting crashes, acquiring accurate GPS coordinates, and sending timely SMS alerts. The dual verification mechanism—combining impact detection with vehicle halt confirmation—ensures that alerts are both accurate and meaningful. This autonomous operation is especially critical in situations where the accident victim is unconscious or otherwise unable to request help.

The simplicity, affordability, and efficiency of this system make it a practical solution for integration in private vehicles, public transportation, and commercial fleets. It serves as a vital tool in reducing the time taken for emergency services to reach accident sites, potentially saving lives and minimizing injury severity. The modular nature of the design also provides flexibility for further enhancement and integration with emerging smart transportation technologies.

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