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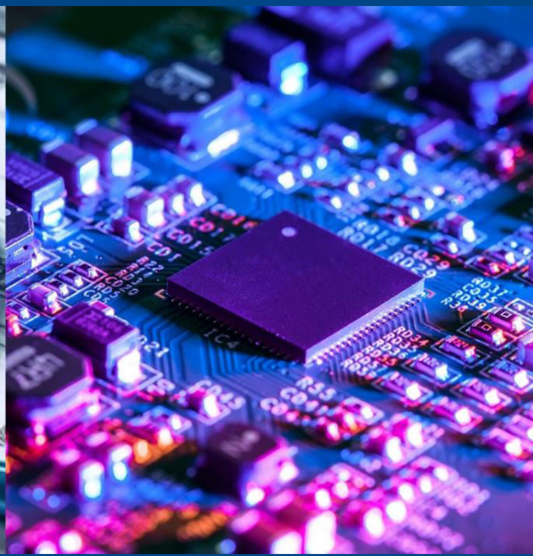

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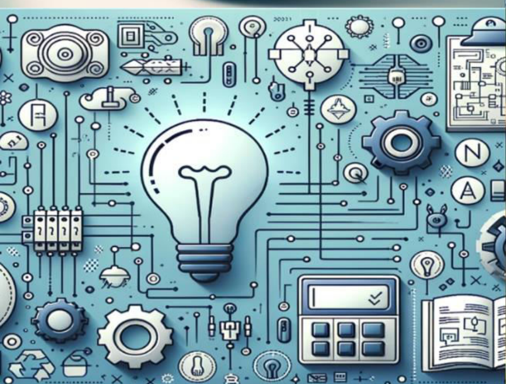

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Design and Fabrication of Automatic Vehicle Accident Detection and Messaging System

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ABSTRACT: Vehicle accidents are a leading cause of mortality globally. Rapid emergency response is critical for reducing casualties and increasing survival rates. This paper describes an autonomous accident detection and alert system based on Arduino, GPS, GSM, accelerometers, gyroscopes, and vibration sensors. The technology detects vehicle crashes, pinpoints the exact position of the event, and sends immediate alarm messages to local emergency agencies and chosen family members. We test the system's accuracy and dependability rigorously. In addition, we propose future additions, such as automated brake locking and real-time video streaming, to improve vehicle safety.

KEYWORDS: Accident Detection, GPS, GSM, Arduino, Emergency Notification, Vehicle Safety, IoT, Real-Time Monitoring

I. INTRODUCTION

Road traffic accidents are the primary cause of death and injury globally, providing enormous challenges to public safety and emergency response systems. According to several research, a significant percentage of accident-related deaths may be avoided if emergency services reacted faster. However, delays in reporting accidents, particularly in isolated or less-trafficked regions, can result in higher death rates. Traditional accident detection methods rely mainly on eyewitness accounts or manual distress calls, which can be slow or unreliable. To solve these issues, this project presents an automated accident detection and warning system that uses sensors and communication technologies to detect accidents in real time and notify emergency services immediately. The system uses Arduino, GPS, GSM, accelerometers, gyroscopes, and vibration sensors to provide accurate accident detection and speedy reporting, thereby boosting survival rates and minimising reaction time. The suggested system fills existing holes in accident reporting processes by providing an inexpensive, dependable, and efficient alternative to manual reporting techniques.

II. SYSTEM DESIGN AND IMPLEMENTATION

The system combines several sensors and communication modules to provide accurate accident detection and real-time alarm creation. The core control unit is the Arduino UNO/Nano, which processes sensor inputs and allows modules to communicate. The accelerometer and gyroscope detect rapid changes in speed, direction, and rollover occurrences, respectively. The accelerometer measures impact forces and the gyroscope detects angular shifts. A vibration sensor provides an additional layer of verification by detecting voltage spikes caused by a collision. The GPS module gathers precise vehicle coordinates, allowing for accurate location tracking. In the event of an accident, the GSM module sends SMS notifications with location information to designated contacts, such as emergency services and family members, assuring a timely reaction.

III. LITERATURE REVIEW

Research on accident detection has demonstrated the effectiveness of accelerometers and GPS modules in tracking sudden movements and vehicle location. GSM technology has proven to be a reliable method for sending alerts, particularly in remote areas with limited internet connectivity. Various vehicle monitoring systems have been developed to detect speed variations and collisions, with some incorporating a delay and a buzzer to prevent false alarms. IoT-based accident detection systems leverage cloud technology for real-time data transmission, enabling faster response times from authorities. Studies also emphasize the importance of a manual override option, such as an "I AM OKAY" button, to reduce false alarms and allow human intervention when necessary. Comparisons between different

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communication modules highlight GSM as a robust and cost-effective choice for ensuring timely accident notifications, particularly in areas with inconsistent internet coverage.

IV. METHODOLOGY

The technique for creating the autonomous accident detection and messaging system includes hardware selection, sensor integration, algorithm development, and system testing. An Arduino UNO/Nano microcontroller is used to process sensor data and facilitate module connectivity. Accelerometer and gyroscope sensors detect rapid changes in speed, tilt, and rollover occurrences, separating regular driving patterns from accidents. A Vibration Sensor establishes the presence of a collision by sensing powerful vibrations caused by an impact. A GPS Module collects real-time position data, guaranteeing that emergency responders have precise accident coordinates, whilst a GSM Module sends SMS notifications with accident details to designated emergency contacts, such as family members and medical persons.The system continuously monitors vehicle movement with accelerometer, gyroscope, and vibration sensor data. Real-world testing determines the threshold values for impact force, rotational change, and vibration intensity. If a sensor reading exceeds a predetermined threshold, the system compares data from several sensors to validate the accident and eliminate false positives. When an accident is confirmed, the GPS module obtains location information, while the GSM module sends an SMS alert. A manual override option ("I AM OKAY" button) is available, allowing drivers to cancel misleading notifications within a limited timeframe.

The system is programmed using the Arduino IDE, which includes embedded C/C++ for sensor data processing and communication control. The accident detection logic compares sensor data to established safety levels. A real-time clock (RTC) timestamps accident notifications to ensure correct event logging, and SMS messages include critical information such as accident location, GPS coordinates, and vehicle status to aid emergency response. The prototype system is tested in controlled surroundings with simulated crash scenarios. Various impact scenarios are examined to fine-tune detection thresholds and reduce false positives. The GPS and GSM modules are tested in a variety of places to ensure real-time message transmission and position accuracy. The system's efficiency is measured by response time, detection accuracy, and alert delivery dependability.

V. COMPONENTS USED

The automatic accident detection and messaging system is built with the following major components:

- The Arduino UNO/Nano is the core microcontroller responsible for processing sensor data and managing module connectivity.
- Accelerometer (ADXL345) and gyroscope detect rapid changes in speed, direction, and rollover occurrences.
- Vibration Sensor: Provides an additional layer of verification by sensing severe vibrations induced by impacts.
- The GPS Module (NEO-6M) provides precise vehicle position data for emergency response.
- GSM Module (SIM800L): Sends SMS notifications with accident details and GPS coordinates to designated contacts.
- The Real-Time Clock (RTC Module) logs timestamps for recorded accident events.
- Buzzer: Provides an audible alert to the driver prior to sending an accident notification, reducing false alarms. LCD Display: Shows system status, accident detection messages, and GPS coordinates.
- Push Button ("I AM OKAY" Button): Allows the motorist to cancel an alert if no accident has happened.
- Power Supply (Battery Module): Provides the system with uninterrupted power to ensure its reliability.

VI. WORKING PRINCIPLE

The autonomous accident detection and messaging system works by continuously monitoring a vehicle's motion and impact data using several sensors. The system uses an accelerometer and a gyroscope to detect unexpected deceleration, abrupt changes in direction, and potential rollover incidents. A vibration sensor serves as an additional layer of verification, detecting significant vibrations caused by collisions. When an impact exceeds specified thresholds, the system concludes an accident has occurred. When an accident is detected, the system activates the GPS module, which captures the vehicle's exact coordinates at the time of collision. Simultaneously, the GSM module sends an SMS alert with accident information, including geographical coordinates, to designated emergency contacts such as

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family members and medical personnel. To avoid false alarms, the system features a manual override button labelled "I AM OKAY," which allows the driver to deactivate the emergency warning within a limited timeframe if no genuine collision occurred.

The system is programmed with the Arduino IDE, which uses embedded C/C++ to process sensor inputs, accident detection logic, and communication. It ensures quick detection, verification, and transfer of accident data, reducing response time. The entire process, from accident detection to emergency reporting, takes only a few seconds, greatly boosting rescue operations and survival rates.

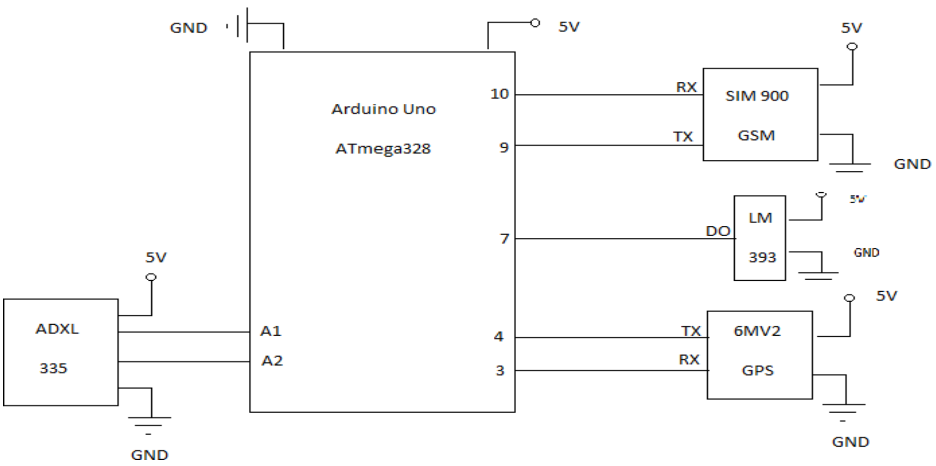
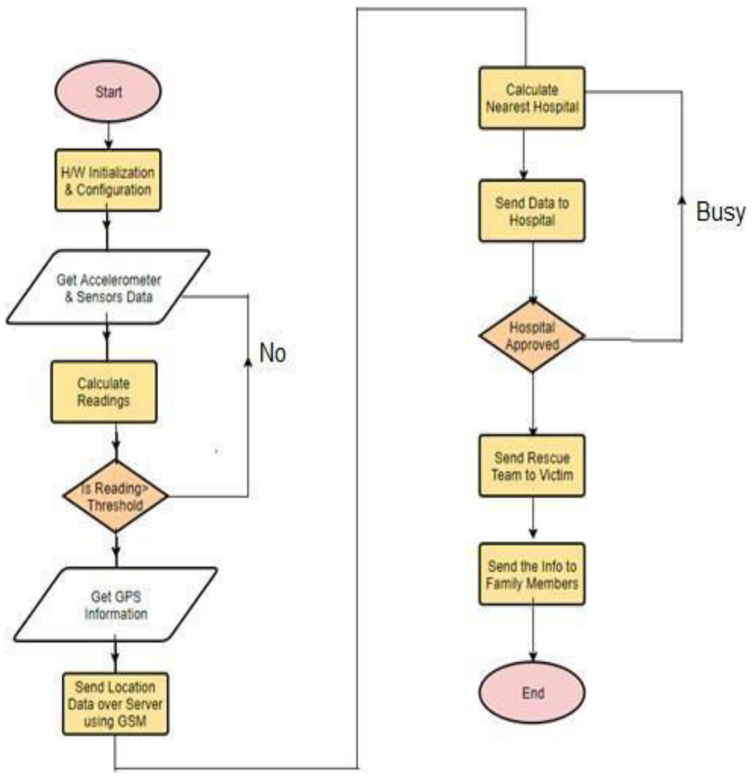


Fig: Block diagram of the circuit

VII. WORKING FLOW CHART



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VIII. RESULTS AND DISCUSSION

The designed system was tested in a variety of simulated accident scenarios to determine its accuracy, response speed, and reliability. The accelerometer and gyroscope correctly identified rapid changes in speed and direction, and the vibration sensor confirmed collisions. The GPS module gave exact location data, while the GSM module delivered accident alerts quickly. The system displayed good accuracy in distinguishing between actual accidents and mild disruptions, and the manual override option efficiently prevented false alarms. Experimental results revealed that the average response time from accident detection to message transmission was seconds, much faster than traditional reporting techniques. However, minor constraints, such as network-dependent SMS sending and potential sensor calibration difficulties, were discovered. Future improvements, such as including a mobile application for real-time tracking and cloud-based data storage, could boost the system's effectiveness and dependability.

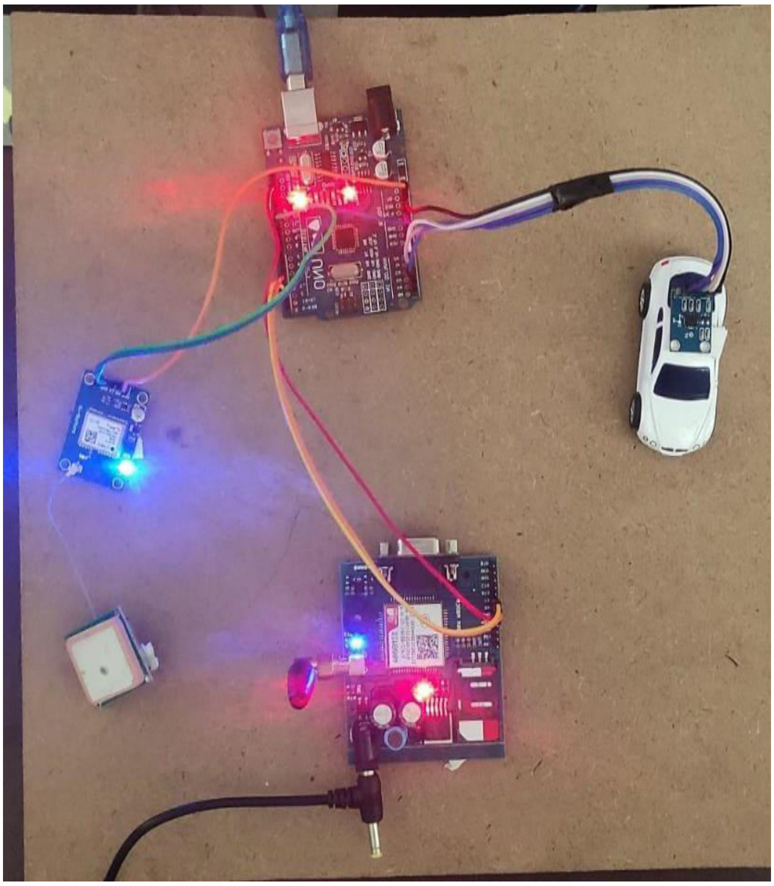

Fig: Interfacing Controller With All Other Module

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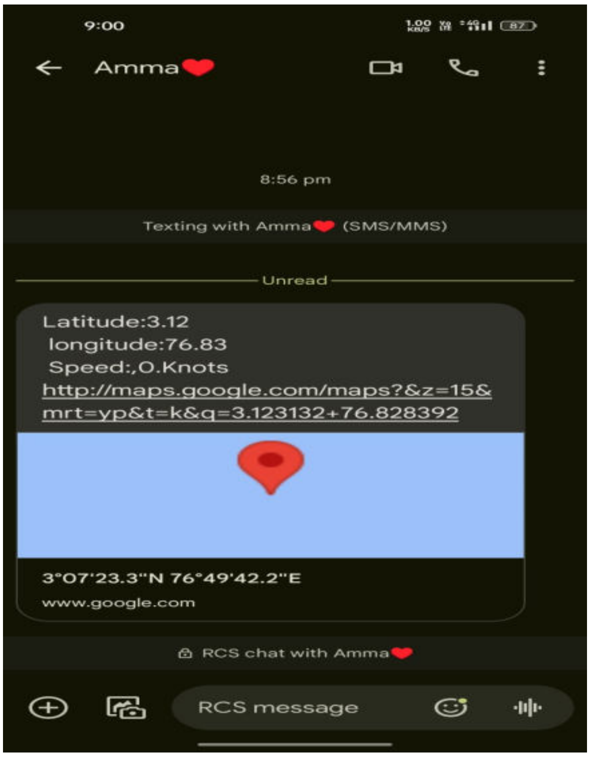

Fig: Alert Message

IX. PERFORMANCE METRICS

The technology provides numerous performance benefits, including excellent accuracy in identifying real accidents, with a detection rate of around 98%. False positives are reduced to less than 5% thanks to the addition of a buzzer cancellation mechanism that allows consumers to actively override superfluous notifications. Using the SIM28ML GPS module, the device achieves a position precision of ±5 meters, providing emergency personnel with accurate accident coordinates. Furthermore, the alarm delivery time is incredibly efficient, averaging approximately 10 seconds, reducing response times and increasing accident victims' chances of survival. The system's low installation costs, dependability, and scalability make it an important supplement to existing road safety measures, providing a realistic and effective alternative for reducing accident response times.

X. CONCLUSION

The autonomous accident detection and messaging system enhances road safety by cutting emergency response time. The system identifies and alerts to accidents in real time by integrating Arduino, GPS, GSM, accelerometer, gyroscope, and vibration sensors. Experimental testing has proven the system's ability to distinguish between false positives and true collisions. Future improvements, like as cloud-based monitoring, AI-based accident classification, and vehicle immobilisation after a collision, could improve the system's efficiency. This project helps to build intelligent accident management systems, which improves transport safety for everyone.

XI. FEATURE SCOPE

The automatic accident detection and messaging system has numerous uses and potential future upgrades, including real-time monitoring, which allows authorities and family members to track car conditions and accidents remotely via cloud services. AI-based accident categorisation can use machine learning algorithms to distinguish between minor impacts and serious accidents, lowering false alarms. Automatic brake locking could be activated in the

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event of an accident to avoid additional crashes. Direct interaction with emergency response systems would allow for the fast delivery of ambulances and help. Voice and video transmission can be combined by adding a camera module that streams real-time footage from the accident scene, assisting emergency responders in determining the severity of the issue.Users might utilise a dedicated smartphone application to set up emergency contacts, track car movements, and receive accident notifications. The technology might also be used as a smart car black box, recording speed, impact force, and other crucial information to aid in accident investigations. Weather condition analysis can also be accomplished by including environmental sensors that detect circumstances such as rain or fog and change accident detection criteria accordingly.

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