

# AUTOMATIC VEHICLE ACCIDENT DETECTION AND ALERT SYSTEM USING ARDUINO, GPS AND GSM

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## Abstract:

Road accidents often result in serious injuries and fatalities due to delayed emergency response. This paper presents an Automatic Vehicle Accident Detection and Alert System using Arduino, GPS, and GSM technology. The system employs an ADXL335 accelerometer to detect sudden impacts or abnormal vehicle motion. Upon detection of an accident, the Arduino microcontroller retrieves real-time location coordinates from the GPS module and transmits an alert SMS via the GSM module to predefined emergency contacts. An LCD display shows system status and location details, while a buzzer provides an immediate alert. The proposed system is cost-effective, reliable, and significantly reduces emergency response time, thereby increasing the chances of saving lives.

**Keywords** — Accident Detection, Arduino Nano, GPS Module, GSM Module, ADXL335, Emergency Alert System

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## I. INTRODUCTION

Road accidents are one of the leading causes of death globally, especially in developing countries where emergency response infrastructure is often limited. According to various studies, a significant number of fatalities occur not due to the severity of the accident itself, but due to the delay in providing timely medical assistance. The “golden hour” concept in trauma care emphasizes that victims have a much higher survival rate if they receive treatment within the first hour of the accident.

Traditional accident reporting systems rely heavily on human intervention, where a bystander or the victim must manually inform emergency services. However, in many cases, victims may be unconscious or unable to communicate, especially in severe collisions or in remote areas. This delay in communication increases the risk of fatalities.

To overcome these challenges, an Automatic Vehicle Accident Detection and Alert System is proposed. This system integrates embedded systems and wireless communication technologies to detect accidents in real time and automatically send alerts to predefined contacts. The system is built using an Arduino Nano

microcontroller, which acts as the central processing unit. It continuously monitors data from an ADXL335 accelerometer sensor to detect abnormal acceleration patterns indicative of an accident.

Once an accident is detected, the system retrieves the exact geographical coordinates using a GPS module (Neo-6M). These coordinates are then transmitted via a GSM module (SIM800L) as an SMS alert to emergency contacts such as family members, hospitals, or police authorities. The inclusion of an LCD display provides real-time system status, while a buzzer alerts nearby individuals.

The proposed system is compact, cost-effective, and highly efficient. It minimizes human dependency and ensures immediate communication, thereby significantly reducing emergency response time and increasing the chances of saving lives.

## **II. METHODS AND MATERIALS**

### ***A. System Overview***

The proposed Automatic Vehicle Accident Detection and Alert System is designed as an embedded system that integrates sensing, processing, positioning, and communication technologies into a single compact unit. The system operates continuously to monitor the dynamic behavior of a vehicle and identify abnormal conditions that may indicate an accident.

At the core of the system lies the Arduino Nano microcontroller, which acts as the central processing unit. It receives real-time analog signals from the ADXL335 accelerometer sensor, processes these signals, and determines whether the measured acceleration exceeds a predefined threshold value. This threshold is carefully calibrated to distinguish between normal driving conditions such as braking or road vibrations and actual accident scenarios involving sudden impact or collision.

The system operates in a sequential manner. Under normal conditions, the accelerometer continuously measures acceleration along three axes—X, Y, and Z—and transmits corresponding analog voltage values to the Arduino. These values are periodically sampled and analyzed. When a sudden spike in acceleration is detected, indicating a possible crash event, the Arduino immediately triggers the accident detection mechanism.

Upon detection of an accident, the Arduino initiates communication with the GPS module to obtain the precise geographical location of the vehicle. The GPS module communicates with satellites orbiting the Earth and calculates the latitude and longitude coordinates using trilateration techniques. These coordinates are then transmitted back to the Arduino.

Following this, the Arduino sends commands to the GSM module to transmit an SMS alert. This message contains a predefined accident alert text along with the real-time GPS coordinates of the accident location. The message is sent to pre-registered emergency contacts, ensuring that help can be dispatched without delay. Simultaneously, the LCD display module provides visual feedback by showing the system status and location information, while a buzzer generates an audible alert to attract attention from nearby individuals.

This integrated workflow ensures that the system not only detects accidents automatically but also communicates critical information efficiently, thereby minimizing response time and improving the chances of timely medical assistance.

### ***B. Hardware Components***

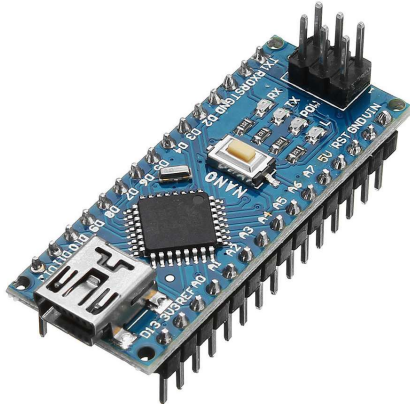
The system is composed of several essential hardware components, each playing a specific role in the detection, processing, and communication processes. The careful selection and integration of these components ensure reliable and efficient system performance.

#### **1. Arduino Nano**

The Arduino Nano is a compact, breadboard-friendly microcontroller board based on the ATmega328P microcontroller. It serves as the central control unit of the system, responsible for coordinating all operations. The microcontroller processes analog input signals received from the accelerometer, performs logical comparisons to detect abnormal conditions, and controls communication with external modules such as GPS and GSM.

The Arduino Nano operates at a clock speed of 16 MHz and provides multiple input/output pins, including analog input pins used for reading sensor data and

digital pins for interfacing with communication modules. Its small size, low power consumption, and ease of programming make it an ideal choice for embedded applications such as accident detection systems.



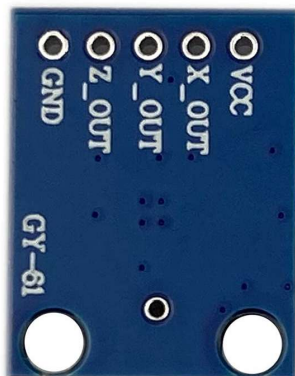
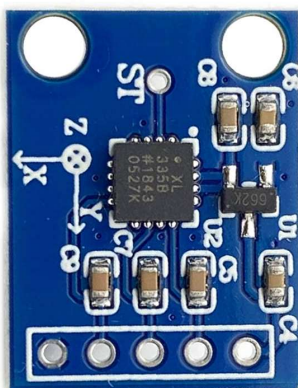
## 2. ADXL335

### Accelerometer

The ADXL335 is a three-axis analog accelerometer sensor that measures acceleration forces along the X, Y, and Z axes. It is capable of detecting both static acceleration, such as gravity, and dynamic acceleration caused by motion, vibration, or impact.

The sensor outputs analog voltage values corresponding to acceleration along each axis. These voltages are directly proportional to the magnitude of acceleration experienced by the sensor. Under normal driving conditions, the output values remain within a stable range. However, during a sudden collision or accident, the acceleration values change abruptly, producing a sharp spike in the sensor output.

The Arduino continuously monitors these outputs and compares them against a predefined threshold. If the acceleration exceeds this threshold, the system interprets it as an accident event. The sensitivity of the sensor can be adjusted to reduce false positives caused by minor vibrations or road irregularities.

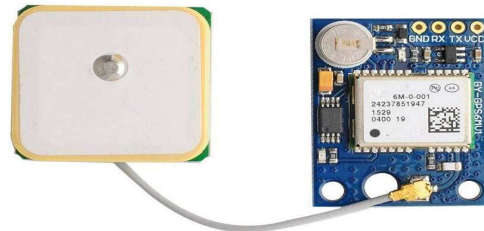


## 3. GPS Neo-6M Module

The GPS Neo-6M module is used to determine the real-time geographical location of the vehicle. It communicates with multiple satellites in the Global Positioning System to obtain accurate position data.

The working principle of the GPS module is based on trilateration. It calculates its position by measuring the time taken for signals from multiple satellites to reach the receiver. Using these time measurements, the module computes the distance from each satellite and determines the exact location in terms of latitude and longitude.

The GPS module communicates with the Arduino through serial communication and provides data in the form of NMEA sentences. The Arduino extracts relevant information, such as latitude and longitude, from these sentences and uses it to construct the alert message.



4.

## SIM800L GSM Module

The SIM800L GSM module is responsible for wireless communication. It enables the system to send SMS alerts to predefined contacts using a SIM card and cellular network.

The module operates using AT commands, which are sent by the Arduino via serial communication. When an accident is detected, the Arduino sends a sequence of AT commands to the GSM module to initiate message transmission. The message includes the accident notification along with GPS coordinates.

The GSM module operates on low voltage and requires a stable power supply, which is provided through a step-down converter. Its ability to function over standard mobile networks makes it suitable for use in both urban and rural areas.



### 5. LCD Display (16x2)

The 16x2 LCD display module is used to provide real-time visual feedback to the user. It can display two lines of text, each containing up to 16 characters.

The LCD is interfaced with the Arduino in 4-bit mode to reduce the number of required data pins. It displays system status messages such as “System Ready,” “Accident Detected,” and the corresponding GPS coordinates. This feature enhances usability and allows for easy monitoring of system operations.



### 6. LM2596 Step-Down Converter

The LM2596 step-down (buck) converter is used to regulate the voltage supplied to various components, particularly the GSM module, which requires a stable and lower voltage for proper operation.

The converter efficiently reduces the input voltage from the battery to the required level while minimizing power loss. This ensures stable system performance and prevents damage to sensitive components.



### 7. Power Supply (Li-ion Batteries)

The system is powered using rechargeable lithium-ion batteries, which provide a portable and reliable power source. The use of batteries allows the system to operate independently without requiring an external power supply.

Battery holders are used to securely mount the batteries, and proper voltage regulation ensures consistent power delivery to all components.

### C. System Methodology

The methodology of the system is based on continuous monitoring and threshold-based detection. The accelerometer continuously measures acceleration values along three axes and sends analog signals to the Arduino. These signals are converted into digital values using the analog-to-digital converter (ADC) of the microcontroller.

Under normal conditions, the acceleration values remain within a stable range. However, during an accident, a sudden impact causes a sharp increase in acceleration. The Arduino compares the measured values with a predefined threshold. If the threshold is exceeded, the system identifies it as an accident.

Following detection, the Arduino initiates a sequence of operations. It first communicates with the GPS module to obtain location data. Once the latitude and longitude are retrieved, the Arduino formats an alert message containing these details. It then sends this message to the GSM module using AT commands, which transmits the SMS to emergency contacts.

Simultaneously, the LCD display updates the system status and shows the coordinates, while the buzzer generates an alert sound. This ensures both remote notification and local awareness.

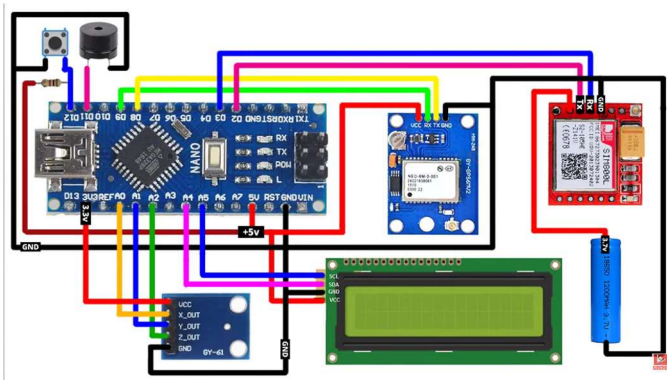
### D. Circuit Implementation

The circuit design integrates all components in a structured manner to ensure efficient communication and operation. The accelerometer is connected to the analog input pins of the Arduino, allowing continuous

monitoring of acceleration values. The GPS module is interfaced using serial communication, enabling the transfer of location data.

The GSM module is also connected via UART communication, allowing the Arduino to send AT commands for SMS transmission. The LCD display is interfaced in 4-bit mode using digital pins, reducing pin usage while maintaining functionality. The buzzer is connected to a digital output pin for alert generation.

Proper grounding and power supply connections are maintained throughout the circuit to ensure stability and reliability. The LM2596 converter is used to regulate voltage, especially for the GSM module, which is sensitive to power fluctuations.



### III. RESULTS AND DISCUSSION

The system was tested under controlled conditions to evaluate its performance in detecting accidents and sending alerts. The accelerometer successfully detected sudden changes in acceleration when a simulated impact was introduced. The Arduino processed this data and correctly identified the event as an accident.

Upon detection, the GPS module provided accurate location coordinates, which were included in the alert message. The GSM module successfully transmitted the SMS to the predefined contacts within a few seconds. The received message contained the accident notification along with latitude and longitude values, which could be used to locate the accident site.

The LCD display provided real-time feedback by showing system status and location details. The buzzer generated an audible alert, indicating that the system had been activated.

The performance of the system demonstrates its ability to detect accidents quickly and provide accurate location information. The response time of the system is minimal, ensuring that alerts are sent without significant delay.

However, the system has certain limitations. The accuracy of the GPS module may be affected in areas with poor satellite visibility, such as tunnels or dense urban environments. Similarly, the GSM module requires network coverage to send messages. Despite these limitations, the system provides a reliable and cost-effective solution for accident detection and alerting.

Overall, the results indicate that the proposed system is effective in reducing response time and improving the chances of timely medical assistance.

### IV. CONCLUSIONS

The Automatic Vehicle Accident Detection and Alert System developed in this work provides an efficient solution to the problem of delayed emergency response in road accidents. By integrating accelerometer-based detection with GPS location tracking and GSM communication, the system ensures real-time monitoring and automatic alert generation.

The system successfully detects accidents based on abnormal acceleration patterns and immediately sends location details to emergency contacts. This eliminates the need for manual reporting and reduces the time required for rescue operations.

### ACKNOWLEDGMENT

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