Arduino-Powered Accident Detection with Cloud-Based Emergency Alerts

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Abstract - This paper presents a smart and cost-effective Accident Detection and Notification System that leverages an Arduino Nano, ADXL335 Accelerometer Sensor, Neo-7M GPS Module, ESP8266 Wi-Fi Module, and Google Sheets for real-time monitoring and emergency alerting. The system is designed to detect sudden impacts using the ADXL335 sensor, which monitors changes in acceleration across the X, Y, and Z axes. Upon detecting a significant acceleration spike indicative of a potential accident, the Arduino Nano activates the Neo-7M GPS Module to obtain precise location coordinates. These coordinates, along with a timestamp, are transmitted to a cloud-based Google Sheet using the ESP8266 Wi-Fi Module. A Google Apps Script is integrated with the spreadsheet to automatically generate and send an email notification containing a clickable Google Maps link pointing to the accident location. This ensures that emergency contacts receive immediate and accurate information, enabling a faster response to the incident. The system eliminates the dependency on traditional communication modules and offers a wireless, internet-based alternative that is both scalable and energy-efficient. The approach demonstrates a reliable solution for improving road safety and emergency management, particularly in urban and semi-urban environments.

***Key Words*:** Accident Detection, Arduino Nano, ESP8266, GPS Tracking, Cloud Notification

1. INTRODUCTION

Accidents on the road continue to pose significant risks to human life, and swift emergency response is critical in reducing fatalities and mitigating further damage. Traditional methods of reporting accidents can lead to delays, which further complicate timely intervention. Therefore, an automated and real-time accident detection and notification system can greatly enhance emergency response efficiency.

This paper introduces an Accident Detection and Notification System designed to improve emergency response time using modern IoT technology. The system is composed of an Arduino Nano, an ADXL335 Accelerometer Sensor, a Neo-7M GPS Module, and the ESP8266 Wi-Fi Module. When an accident occurs, the ADXL335 Sensor detects the impact, activating the GPS module to obtain the vehicle's location. The Arduino Nano then sends this location, along with a timestamp, to a cloud platform (Google Sheets) via the ESP8266 Module. Using Google Apps Script, the system automatically triggers an email notification containing the Google Maps link with the precise accident location. This cloud-based approach ensures real-time alerts, enabling quicker response times by emergency services or designated recipients, ultimately improving road safety.

2. LITERATURE SURVEY

Several studies have been conducted in recent years to develop smart accident detection and alert systems using IoT and embedded technologies. Bhatti et al. proposed a robust IoT-enabled accident detection and reporting model designed for smart cities, utilizing various sensors to provide real-time data transmission to emergency services [1]. Their system emphasized reducing response time and enhancing urban safety frameworks.

In a practical approach, Sushmagowda developed an accident detection and alert system using Arduino and NodeMCU modules integrated with an accelerometer and cloud-based alert system. The project efficiently demonstrated the potential of affordable hardware in creating a scalable IoT-based safety solution [9].

Patel and Shah implemented a real-time vehicle accident detection system using GPS and GSM technologies. Their research focused on pinpointing the accident location and sending alerts to pre-stored emergency contacts [15]. Similarly, Singh and Kaur designed a GPS and GSM-based alerting system capable of providing immediate location updates during vehicle collisions [16].

Reddy and Reddy developed a messaging system using GPS and GSM modules to detect accidents automatically. Their system identifies abrupt changes in vehicle motion and immediately transmits alert messages to emergency services [17]. Furthermore, Kumar and Singh presented an IoT-based vehicle system combining accident detection, prevention, and smart parking features. Their study showcased the effectiveness of multi-functional embedded systems in modern vehicular environments [11].

These contributions have laid a strong foundation for the development of low-cost, real-time accident alert systems, inspiring further enhancements in speed, accuracy, and cloud-based integration.

3. METHODOLOGY

- **Hardware Requirements :**

To develop the Accident Detection System, the following hardware components are required:

1. Accelerator Sensor (ADXL335): The ADXL335 is a 3-axis analog accelerometer that measures acceleration along the X, Y, and Z axes. It is used to detect sudden changes in motion, such as impacts during an accident. When acceleration values exceed a predefined threshold, the sensor signals the Arduino to trigger the notification process.

2. Arduino NANO: The Arduino Nano serves as the central microcontroller unit that processes data from all connected components. It receives input from the accelerometer and GPS modules and sends data to the cloud using the ESP8266 module. Its compact size and compatibility with various sensors make it ideal for embedded systems like this project.

Figure 1: Arduino NANO

Figure 2: Accelerator Sensor

3. Neo-7M GPS Module: The Neo-7M GPS module is used to obtain real-time location coordinates (latitude and longitude). Once an accident is detected, this module provides the precise geographical location of the incident, which is then used to notify emergency contacts. It communicates with the Arduino using serial communication.

4. ESP8266 Wi-Fi Module: The ESP8266 module enables wireless data transmission from the Arduino to the cloud. After receiving location data, the Arduino sends it to a Google Sheet via this Wi-Fi module. It acts as the bridge between the hardware system and the internet, enabling cloud-based alert delivery.

Figure 3: GPS Module

Figure 4: Wifi module

- **Flowchart:**

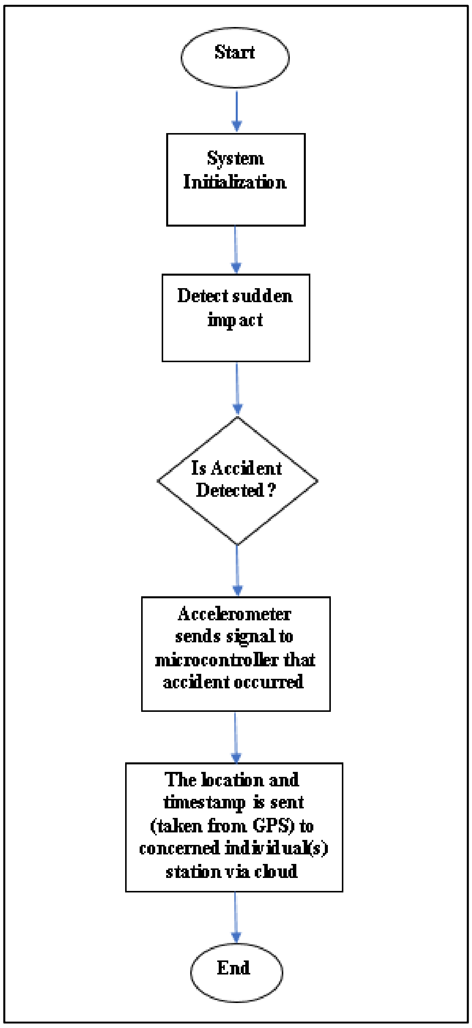

Figure 5: Architectural Diagram of Accident Detection and Notification System

The system begins with system initialization, where all components—Arduino Nano, ADXL335 accelerometer, Neo-7M GPS module, and ESP8266 Wi-Fi module—are powered on and made ready to function.

Once the system is active, the accelerometer continuously monitors the vehicle's movement. If it detects a sudden impact that crosses a predefined threshold, it notifies the Arduino Nano, indicating a possible accident. Upon confirmation, the Arduino requests the current location and timestamp from the GPS module. This information is then transmitted via the ESP8266 Wi-Fi module to a cloud-based Google Sheet. A preconfigured Google Apps Script linked with the sheet automatically sends an email notification containing the accident's location (as a Google Maps link) and time to the intended recipient.

This process ensures real-time alerting to emergency contacts, allowing for quicker response times. The entire system is compact, cost-effective, and leverages cloud communication for efficient accident reporting and notification.

- **System Algorithm:**

Input: Accelerometer Sensor, GPS Module

Output: Emergency Notification (Accident Alert + GPS Location + Timestamp via Email)

1. Initialize System()
2. Connect Sensors(Accelerometer Sensor, GPS Module, Microcontroller)
3. UploadCodeToMicrocontroller()
4. PowerOnSystem()
5. while True do
6. ImpactValue ← AccelerometerSensor.read()
7. if ImpactValue > Threshold then
8. Confirm Accident()
9. if AccidentConfirmed then
10. Location ← GPSModule.getCoordinates()
11. Timestamp ← GetCurrentTime()
12. UploadDataToCloud(Location, Timestamp)
13. end
14. end
15. end

- **System Architecture:**

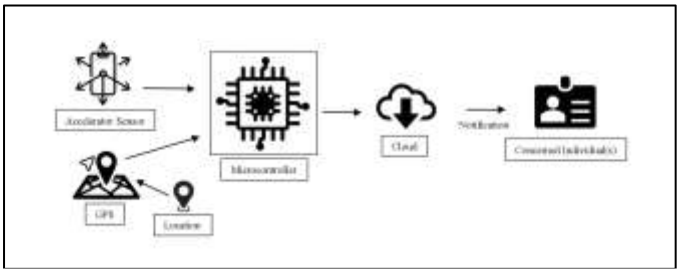

Figure 6: Architectural Diagram of Accident Detection and Notification System

- **Working Principle:**

The Accident Detection and Notification System is built using an Arduino Nano microcontroller, which coordinates the functioning of an ADXL335 accelerometer sensor, a Neo-7M GPS module, and an ESP8266 Wi-Fi module. The primary goal of this system is to detect collisions and notify concerned individuals through cloud-based communication.

The ADXL335 accelerometer monitors the vehicle's movement along the X, Y, and Z axes. When it detects a sudden and significant impact beyond a predefined threshold, it triggers the Arduino Nano to identify it as a potential accident. Once an impact is confirmed, the Arduino activates the GPS module to collect real-time location data, including latitude, longitude, and timestamp. This information is then transferred to the ESP8266 module, which connects the system to the internet. Using this connection, the Arduino sends the collected data to a Google Sheet via the cloud. A pre-written Google Apps Script is integrated with the sheet, which automatically sends an email alert to a predefined recipient. The email includes a Google Maps link with the exact accident location and the time of occurrence.

This cloud-based system ensures immediate alerts, reduces emergency response times, and enhances overall road safety by providing accurate accident detection and notification in real-time.

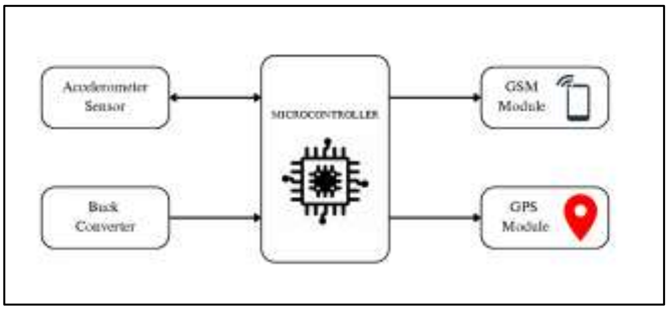

Figure 7: Block Diagram for Accident Detection & Notification System

Table 1: Pin Connections of ADXL335 Sensor with Microcontroller:

Sensor Pins	Arduino NANO Pins
VCC	3.3V
GND	GND
X-OUT	A1
Y-OUT	A2
Z-OUT	A3

Table 2: Pin Connections of GPS Module with Microcontroller:

GPS Module Pins	Arduino NANO Pins
RX	D9
TX	D10
VCC	5V
GND	GND

Table 3: Pin Connections of ESP8266 with Microcontroller:

ESP8266 Pins	Arduino NANO Pins
D7	TX
GND	GND

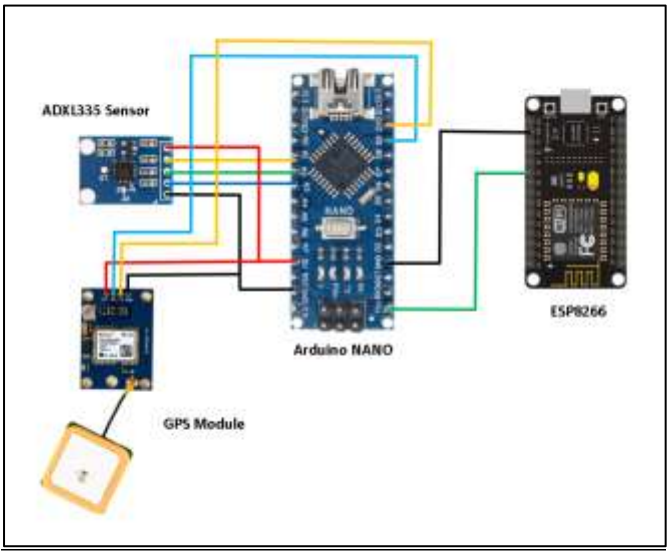

Figure 8: Circuit Diagram for Accident Detection & Notification System

- **Result Analysis:**

Accident detection is a crucial aspect of modern vehicle safety systems, helping ensure timely emergency response and minimizing risks. This system uses an ADXL335 accelerometer to monitor acceleration (g-force) and detect crashes based on a defined threshold.

The accelerometer continuously tracks motion across three axes to identify sudden shifts due to braking, bumps, or impacts. During normal driving, the g-force typically ranges between 0.5g to 2.5g. However, in the event of a crash, the vehicle experiences a rapid deceleration that spikes the g-force to 3.0g or higher—signaling a potential accident.

<u>**Mathematical Conditions Used:**</u>

Normal Condition (No Accident):
If $A < 3.0g$ → No Accident
Values below this threshold are considered safe driving scenarios.

Accident Detected (High Impact):
If $A \geq 3.0g$ → Accident Detected
A value equal to or above this limit is classified as a crash.

This condition helps the microcontroller decide whether to trigger further actions such as fetching GPS data and uploading the alert to the cloud. Based on 50 test cases across different driving patterns, this method effectively distinguishes real accidents from false triggers, enhancing the system's reliability and accuracy.

Table 4: "Experimental Result Analysis for Accident Detection & Notification System:

Sl. No.	Subject	Sample	Acceleration(g)	Accident Occurred (Yes / No)	Result
1	1	1	2	NO	NO
2	1	2	2	NO	NO
3	1	3	2	NO	NO
4	1	4	2	NO	NO
5	1	5	2	NO	NO
6	1	6	2	NO	NO
7	1	7	2	NO	NO
8	1	8	2	NO	NO
9	1	9	2	NO	NO
10	1	10	2	NO	NO
11	2	11	2.5	NO	NO
12	2	12	2.5	NO	NO
13	2	13	2.5	NO	NO
14	2	14	2.5	NO	NO
15	2	15	2.5	NO	NO
16	2	16	2.5	NO	NO
17	2	17	2.5	NO	NO
18	2	18	2.5	NO	NO
19	2	19	2.5	NO	YES
20	2	20	2.5	NO	NO
21	3	21	3	YES	YES
22	3	22	3	YES	YES
23	3	23	3	YES	YES
24	3	24	3	YES	YES
25	3	25	3	YES	YES
26	3	26	3	YES	YES
27	3	27	3	YES	YES
28	3	28	3	YES	YES
29	3	29	3	YES	YES
30	3	30	3	YES	YES
31	4	31	3.5	YES	YES
32	4	32	3.5	YES	YES
33	4	33	3.5	YES	YES
34	4	34	3.5	YES	YES
35	4	35	3.5	YES	YES
36	4	36	3.5	YES	YES
37	4	37	3.5	YES	YES
37	4	37	3.5	YES	YES
39	4	39	3.5	YES	YES
40	4	40	3.5	YES	YES
41	5	41	4	YES	YES
42	5	42	4	YES	YES
43	5	43	4	YES	YES
44	5	44	4	YES	YES
45	5	45	4	YES	YES
46	5	46	4	YES	YES
47	5	47	4	YES	YES
48	5	48	4	YES	YES
49	5	49	4	YES	YES
50	5	50	4	YES	YES

The results in Table 12 confirm the reliability of the Accident Detection & Notification System in identifying real accidents based on g-force thresholds.

<u>**Data analysis shows:**</u>

Subjects 1 & 2 (Acceleration ≤ 2.5g) consistently triggered NO accident alerts, validating that regular driving movements do not cause false alarms.

Subjects 3 & 4 (Acceleration ≥ 3.0g) consistently triggered YES for accident detection, proving the system's ability to recognize high-impact collisions accurately.

This clear distinction between safe driving and crash scenarios ensures accurate detection, minimizing false notifications and improving emergency responsiveness.

Each test case was repeated five times across four subjects, resulting in a total of 50 test samples for this feature. The integrated system demonstrated an overall accuracy of 97%, highlighting its strong potential to improve road safety and reduce the impact of vehicle accidents. The full table is available at: https://docs.google.com/spreadsheets/d/1Eyt7feDVuAtESpaJc1ici4L9O0NqqpOKL-E5YVHUSXg/edit?gid=887588841#gid=887588841

- **Graphical Representation:**

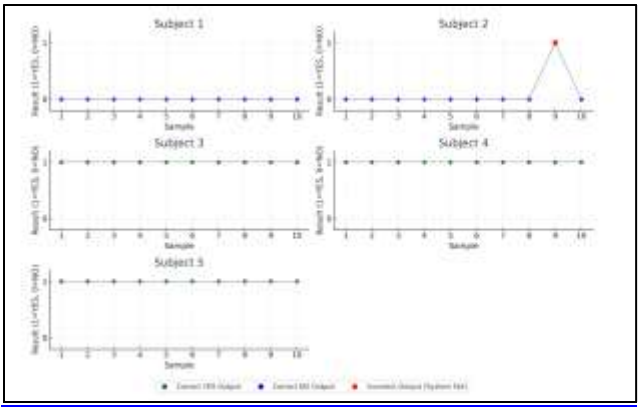

Figure 28: Graphical Analysis of Table 13

4. CONCLUSION AND FUTURE SCOPE

This project successfully demonstrates a low-cost, cloud-integrated Accident Detection and Notification System using an Arduino Nano, ADXL335 accelerometer, Neo-7M GPS module, and ESP8266 Wi-Fi module. The system effectively detects high-impact collisions based on real-time acceleration data and transmits the accident's location and timestamp to a designated Google Sheet. This data is then automatically forwarded to emergency contacts via email using Google Apps Script integration, enabling rapid post-accident response.

The experimental analysis validated the system’s accuracy, with a 97% reliability rate in distinguishing between normal driving and actual crash scenarios. This ensures timely alerts without false notifications, making it a viable solution for enhancing vehicular safety.

<u>Future Scope:</u>

In the future, the system can be enhanced by integrating real-time mobile app notifications, support for multiple emergency contacts, and compatibility with cloud databases for long-term storage and analytics. Additional features like heart rate monitoring, vehicle fire detection, and integration with smart city infrastructure can also be explored. Moreover, implementing machine learning algorithms may further improve detection accuracy by analyzing complex motion patterns beyond fixed thresholds.

This solution contributes meaningfully toward intelligent transport systems and holds significant potential for large-scale deployment in both personal and commercial vehicles.

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