

**IOT-INTEGRATED SMART INFRASTRUCTURE FOR PREDICTIVE ROAD
SAFETY AND AUTONOMOUS ACCIDENT AVOIDANCE****Adhith MB**(Reg. No.: 23UGCA001)
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nascselvavinayaki@nehrucolleges.com**Abstract**

Every year, thousands of people die because they don't get medical help quickly enough after a road accident. Road accidents still rank among the top causes of death worldwide, and honestly, the time it takes for someone to alert emergency services can mean the difference between life and death. That's where IoT-based accident detection steps in—it's a smart, automated way to make sure help gets there fast. Here's how it works. The system uses a mix of hardware and communication tools. Accelerometers and vibration sensors keep an eye out for sudden impacts, harsh tilts, or weird movements—things you'd expect during a crash. If the readings go past a certain threshold, the system knows there's been an accident. Right after that, GPS kicks in and pinpoints the exact location. This way, rescue teams know exactly where to go, wasting no time. For sending out alerts, the system uses a GSM module or another communication device. It instantly notifies emergency contacts, hospitals, or control centers and sends them the location data. To avoid false alarms, a microcontroller runs the show, checking everything with logic and validation before calling for help. The paper breaks down the whole system—what it's made of, how it works, and where you can use it. This IoT solution brings together real-time monitoring, automatic alerts, and spot-on location tracking to make roads safer. It speeds up emergency response and helps rescue teams coordinate better, raising the chances that accident victims get the right care in time.

Keywords: Internet of Things (IoT), Accident Detection, GPS, GSM, Arduino, Road Safety, Emergency Alert System.

Introduction

Road accidents are one of the leading causes of death and serious injuries worldwide. Every year, millions of people lose their lives due to road mishaps, and many more suffer permanent disabilities. One of the major reasons for increased fatalities is the delay in providing medical assistance after an accident occurs. In many cases, victims are unable to call for help due to severe injuries or unconsciousness. Therefore, there is a strong need for an automated system that can detect accidents instantly and inform emergency services without human intervention. Accident Detection Using IoT is a smart and innovative solution designed to address this problem. The Internet of Things (IoT) refers to a network of interconnected devices that communicate and share data through the internet. By integrating sensors, microcontrollers, and communication modules, IoT enables real-time monitoring and automatic response systems. In this project, IoT technology is used to detect vehicle accidents and send immediate alerts to emergency contacts. The system mainly consists of an accelerometer sensor, Arduino Uno microcontroller, GPS module, and GSM module. The accelerometer continuously monitors the movement and vibration of the vehicle. When a sudden impact, collision, or abnormal tilt is detected, the sensor sends a signal to the Arduino microcontroller. The microcontroller processes this data and determines whether an accident has occurred based on predefined threshold values. Once an accident is confirmed, the GPS module retrieves the exact geographical location of the vehicle. The GSM module then sends an emergency SMS containing the accident notification and location details to predefined contacts, such as family members, ambulance services, or nearby hospitals. This ensures faster communication and quick medical response. The main objective of this project is to reduce the response time between accident occurrence and emergency assistance. By providing real-time accident detection and automatic alert transmission, the system enhances road safety and improves survival chances. Additionally, it can be implemented in cars, school buses, public transport vehicles, and commercial fleets. Thus, the IoT-based accident detection system offers a reliable, cost-effective, and life-saving technological solution to minimize the impact of road accidents and improve emergency response efficiency.

Problem Statement

This accident detection system keeps a constant eye on your vehicle, ready to send out an emergency alert the moment it senses a crash. It works by tying together a few key parts: an accelerometer, a microcontroller, a GPS unit, and a communication module. Each piece does its job so the system can spot accidents fast and get help on the way. It all starts with the accelerometer. This little sensor keeps tabs on how the car moves—any bumps, shakes, or sudden stops. When it picks up things like a big jolt, rapid acceleration, hard braking, or a sharp tilt, it checks those against safe limits set in advance. If something crosses the line, the accelerometer tells the microcontroller, which quickly double-checks what's going on. It tries to figure out if it's a real accident or just a pothole, a speed bump, or a hard stop. If the weird movement keeps up, the system decides it's dealing with an actual crash. Once it's sure, the GPS kicks in to lock down the car's exact spot—latitude, longitude, sometimes even a nearby landmark. That info goes straight to the communication module, which blasts out an emergency alert to a list of contacts. Family, first responders, hospitals, the police—they all get the notification, complete with the accident details, location, and time. This way, help can get there fast. There's also a manual override in some models. If you're in the car and it wasn't a real

emergency, a buzzer or pop-up lets you cancel the alert before it goes out. That keeps false alarms to a minimum without making the system any less trustworthy. In the end, this setup boosts road safety by spotting accidents right away, sharing the location, and getting emergency teams on the move. By cutting down response times and making sure medical help arrives when it's needed most, it helps save lives and makes travel a whole lot safer.

Literature Review

If you look at the recent research on IoT-powered vehicle accident detection and rescue systems, you can see how quickly things are moving. Sensors are getting smarter. Communication tech is faster. Automation and intelligent responses are becoming the norm. Take Tuba Tahemeen and Ramesh Patil (2024), for example. They built a real-time accident detection system that combines accelerometers and GPS with IoT networks. When there's a sudden jolt, the system picks it up and sends an alert through GSM—fast and simple. Then there's Arun Kumar K and his team (2026), who zoom in on making emergency notifications more reliable in the real world. Their work digs into architecture and practical reliability, showing just how crucial sensor accuracy and rapid alerts are for saving time during rescues. Now, Varsha Patil and her group (2023) bring Artificial Intelligence into the picture. By adding AI to IoT-based accident detection, their system gets a lot smarter—fewer false alarms, better decisions. They send crash data to the cloud for analysis, which is a big leap from earlier methods. Compare that to Nandish B.M. and colleagues (2022), who stuck to microcontrollers and simple threshold-based detection. It's clear how much the tech has matured. Pavan Biradar's team (2024) goes even further, fine-tuning how IoT devices talk to each other and making detection more reliable and scalable. And if you want the big picture, check out Vivek Sharma's survey (2025). He lays out the whole landscape: what's trending, where the pain points are—like laggy networks or tricky sensor calibration—and what's coming next, including more AI and 5G. Han Zhang, Runze Zhang, and Jiamanzhen Sun (2025) widen the scope. Their system doesn't just stop at car crashes; it handles all sorts of public safety emergencies. They show how to scale up and plug into centralized emergency response. On the other hand, Vasireddy Satish and Pyla Karuna Sagar (2025) take a mobile-first approach, using smartphone sensors and advanced algorithms to push out faster alerts. Roll back to Ilesanmi Michael (2022), who sets the stage with a broad overview of all the key pieces: accelerometers, GPS, GSM, and alert systems. Then there's Dimitrios Zavantis and his team (2024), who stack IoT-based detection up against old-school traffic centers. The result? IoT wins with quicker response and more automation. All in all, you can trace a clear line from basic sensor-driven alerts to today's AI-powered, cloud-connected, fully automated emergency response networks. Early systems were all about detecting impacts and firing off SMS alerts. Now, researchers are mixing in AI, cloud storage, mobile platforms, and even smart ambulance tracking. Of course, it's not all smooth sailing—network hiccups, false alarms, hardware costs, and scaling up are still big hurdles. But the direction is set. The next wave will use 5G, edge computing, and predictive analytics to make accident response smarter and faster than ever.

Working Methodology

The IoT-based accident detection system is designed to automatically detect road accidents and immediately send alerts to emergency contacts. This system works by integrating different hardware components such as an accelerometer sensor, Arduino Uno microcontroller, GPS module, and GSM module. These components work together to monitor vehicle movement and

provide quick emergency communication. Initially, the system is installed inside the vehicle and powered on. The accelerometer sensor continuously monitors the movement and vibration of the vehicle. It measures parameters such as acceleration, tilt, and sudden shocks. Under normal driving conditions, the sensor values remain within a safe range. However, when a sudden collision or abnormal movement occurs, such as a strong impact or vehicle rollover, the accelerometer detects this change and sends the data to the Arduino Uno microcontroller. The Arduino Uno acts as the main processing unit of the system. It continuously receives and analyzes the sensor data. When the sensor values exceed a predefined threshold level, the Arduino identifies it as a possible accident. To prevent false alarms caused by speed breakers or sudden braking, the system includes a verification step. A short delay is provided during which a manual switch can be pressed to cancel the alert if the detection is incorrect. If the alert is not cancelled, the system confirms that an accident has occurred. Once the accident is confirmed, the GPS module becomes active and retrieves the exact geographical location of the accident. The GPS module provides the latitude and longitude coordinates of the accident spot. After obtaining the location, the GSM module is used to send an emergency alert message. The message contains information about the accident along with the GPS location link. This alert is sent instantly to predefined emergency contacts, family members, or rescue services. By using IoT technology, this system ensures faster communication during emergencies. It helps reduce the delay in providing medical assistance and improves the chances of saving lives after road accidents.

Proposed Methodology

The proposed methodology improves upon existing IoT-based accident detection systems by enhancing accuracy, communication speed, and data management capabilities.

1)Overview of Existing Systems

Most existing accident detection systems use an accelerometer sensor, GPS module, GSM module, and a microcontroller (such as Arduino). These systems detect sudden impact using threshold-based acceleration values. Once the threshold is exceeded, the system retrieves the GPS location and sends an SMS alert to predefined contacts.

However, these systems have certain limitations:

- High chances of false detection (due to speed breakers or sudden braking)
- Only SMS-based alert mechanism
- No real-time tracking
- No cloud storage for accident records
- No intelligent decision-making system

2)Proposed Methodology (Enhanced System)

The proposed system introduces additional features to improve reliability and functionality.

Step 1: Multi-Sensor Data Collection

Instead of relying only on an accelerometer, the proposed system integrates:

- Accelerometer
- Gyroscope
- Vibration sensor

This combination improves detection accuracy by analysing impact force, tilt angle, and

vibration patterns simultaneously.

Step 2: Intelligent Accident Confirmation

A basic machine learning or pattern-based verification method is proposed. The system compares current sensor data with stored normal driving patterns to reduce false alarms.

Step 3: Cloud-Based Data Storage

Unlike traditional systems that only send SMS alerts, the proposed model uploads accident data (time, location, impact force) to a cloud database. This helps in:

- Accident analysis
- Insurance verification
- Historical record maintenance

Step 4: Mobile Application Integration

A mobile application is proposed for:

- Real-time accident notification
- Live vehicle tracking
- Emergency response monitoring

Step 5: Advanced Communication

Instead of only GSM SMS, the system can use:

- Internet-based alerts
- App notifications
- Automatic emergency service integration

Feature	Existing System	Proposed System
Sensors	Accelerometer only	Multi-sensor integration
Detection	Threshold-based	Intelligent verification
Alerts	SMS only	SMS + App + Cloud
Data Storage	No storage	Cloud-based records
Tracking	No live tracking	Real-time tracking

Components Used

Let's break down how everything fits together. The Arduino Uno sits at the center of it all, kind of like the brain. It listens to every sensor and module hooked up to it, makes sense of the info, and decides what to do next. Everything talks through this little controller, so the whole system stays sharp and reacts fast—especially when something goes wrong. One of the main players

is the accelerometer. This sensor keeps an eye on how the vehicle moves and tilts around. It's always on the lookout for sudden jolts, weird angles, or big shocks—anything that screams “accident.” As soon as it picks up a movement that blows past the safety limits, it pings the Arduino to check things out. Then there's the GPS module. When the system thinks there's been a crash, the GPS jumps in and figures out exactly where the vehicle is—latitude, longitude, maybe even the nearest street. With this pinpoint info, help knows exactly where to go, no guessing, no wasted time. The GSM module handles getting the word out. Once an accident's confirmed and the system knows the location, this part fires off a text alert. It sends a warning plus the exact GPS spot to everyone you set up ahead of time—family, friends, rescue teams, whoever. This way, help's on the way without you lifting a finger. To keep things from getting out of hand, there are manual switches, too. You can reset the system or stop an alert if, say, a speed bump sets it off by accident. So, you avoid false alarms but still have solid protection when it counts. Put it all together—sensing, tracking, quick alerts, and a bit of manual control—and you've got a system that actually makes driving safer and gives you some real peace of mind.

Algorithm

Step 1: Start

Power on the system installed inside the vehicle.

Step 2: Initialize Components

Initialize Arduino Uno microcontroller, accelerometer sensor, GPS module, GSM module, and emergency cancel switch. Set a predefined threshold value for accident detection.

Step 3: Continuous Monitoring

Continuously read acceleration and vibration data from the accelerometer sensor. Monitor vehicle movement in real time.

Step 4: Detect Abnormal Movement

Compare the sensor values with the predefined threshold value. If the values are within the normal range, continue monitoring. If the values exceed the threshold, treat it as a possible accident.

Step 5: Verification Process

Wait for a few seconds to confirm the impact. During this delay, check whether the emergency cancel switch is pressed.

If the switch is pressed, cancel the alert and return to continuous monitoring. If the switch is not pressed, confirm the accident.

Step 6: Get Location Details

Activate the GPS module and retrieve the current latitude and longitude coordinates of the accident location.

Step 7: Send Emergency Alert

Compose an alert message containing:

Accident notification

GPS coordinates or Google Maps link

Use the GSM module to send the SMS to predefined emergency contacts and rescue services.

Step 8: Resume Monitoring

After sending the alert, return to monitoring mode for detecting future accidents.

Step 9: Stop (System runs continuously)

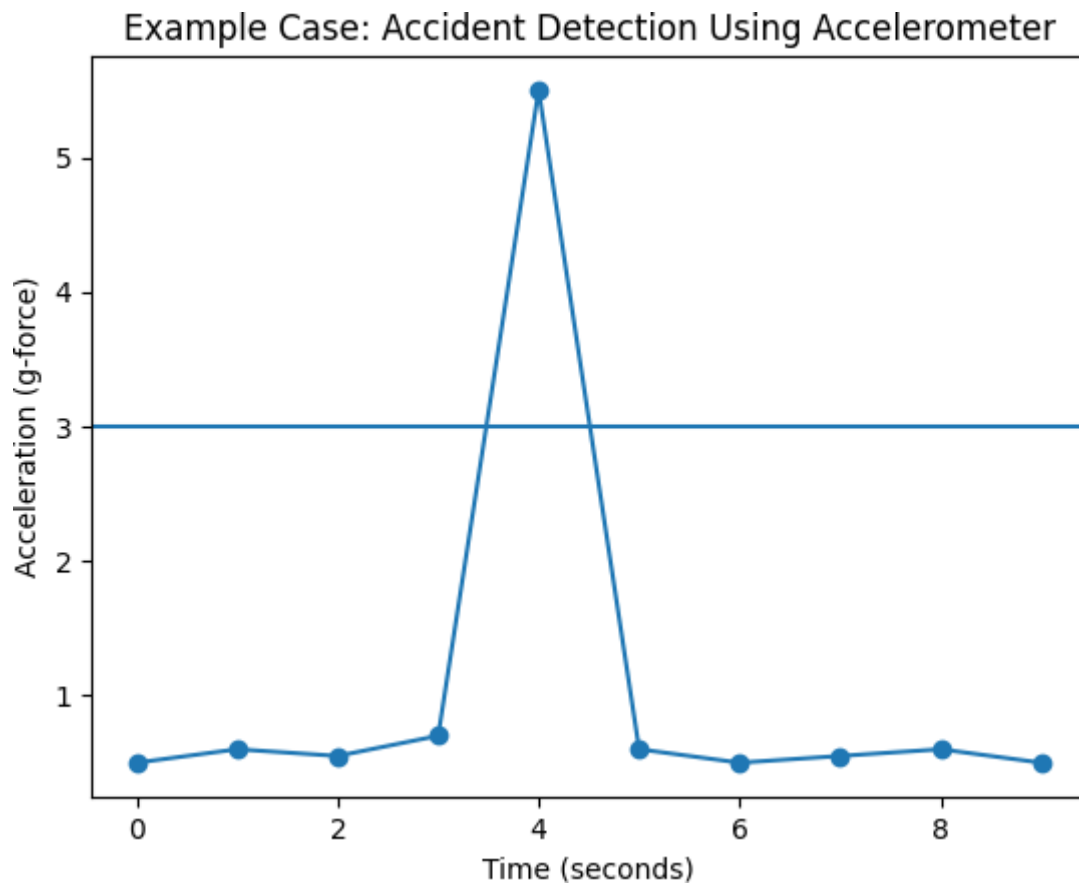


FIG : 1 (Accident Detection Using Accelerometer)

In this example:

- From **0 to 3 seconds**, the acceleration values remain between **0.5 to 0.7 g**, which represents normal vehicle movement.
- The **threshold value is set at 3.0 g**.
- At **4 seconds**, the acceleration suddenly spikes to **5.5 g**, which is much higher than the threshold.
- This spike indicates a **strong impact or collision**.
- Since the value exceeds the threshold, the system:
 1. Confirms possible accident
 2. Starts verification delay
 3. Activates GPS
 4. Sends GSM alert

After 4 seconds, the values return to normal, but the system has already detected and

processed the accident.

Accident Detection System Flowchart

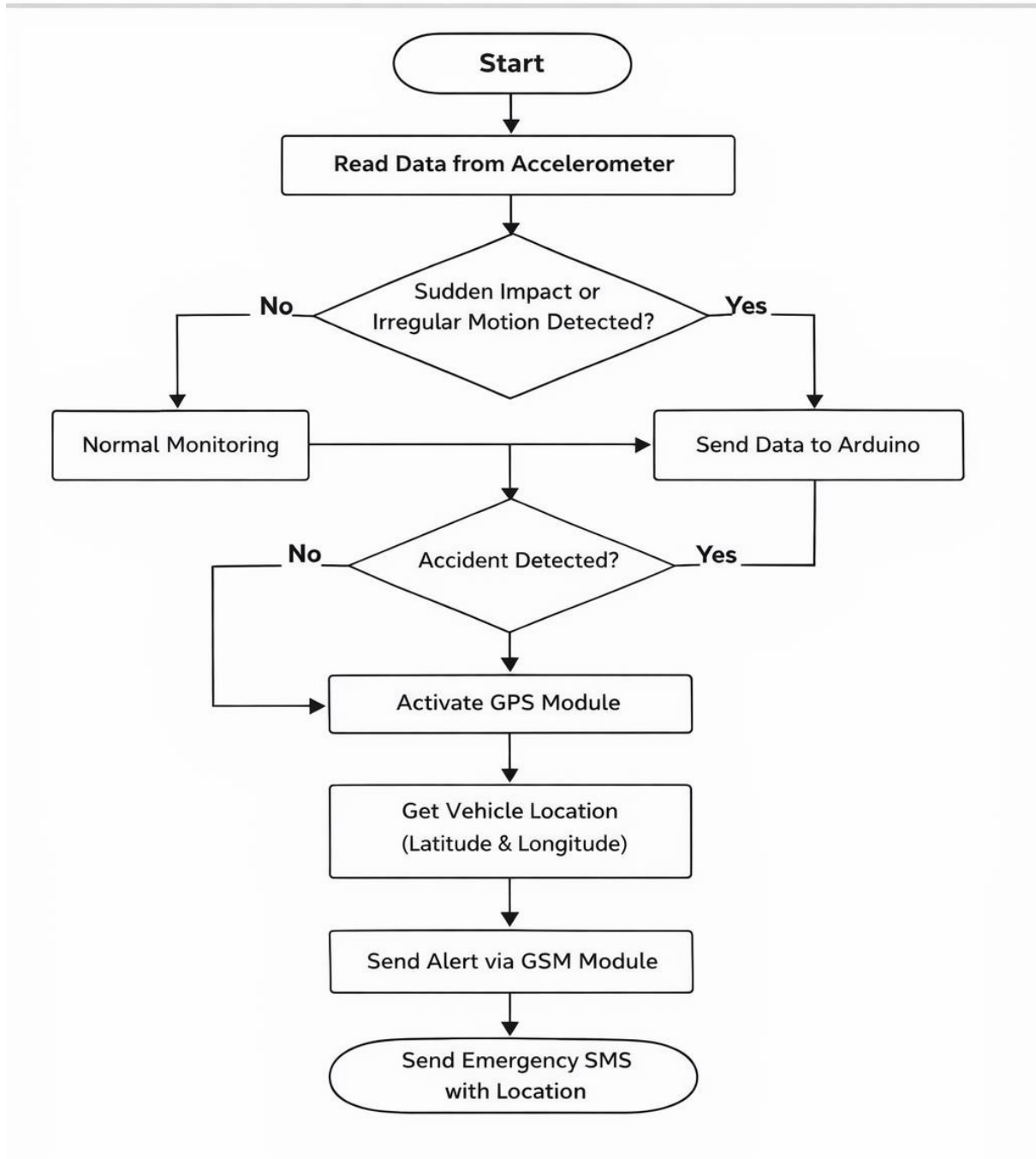


FIG : 2 (Flow chart of Accident Detection Using Acceleromete)

Results and Discussion

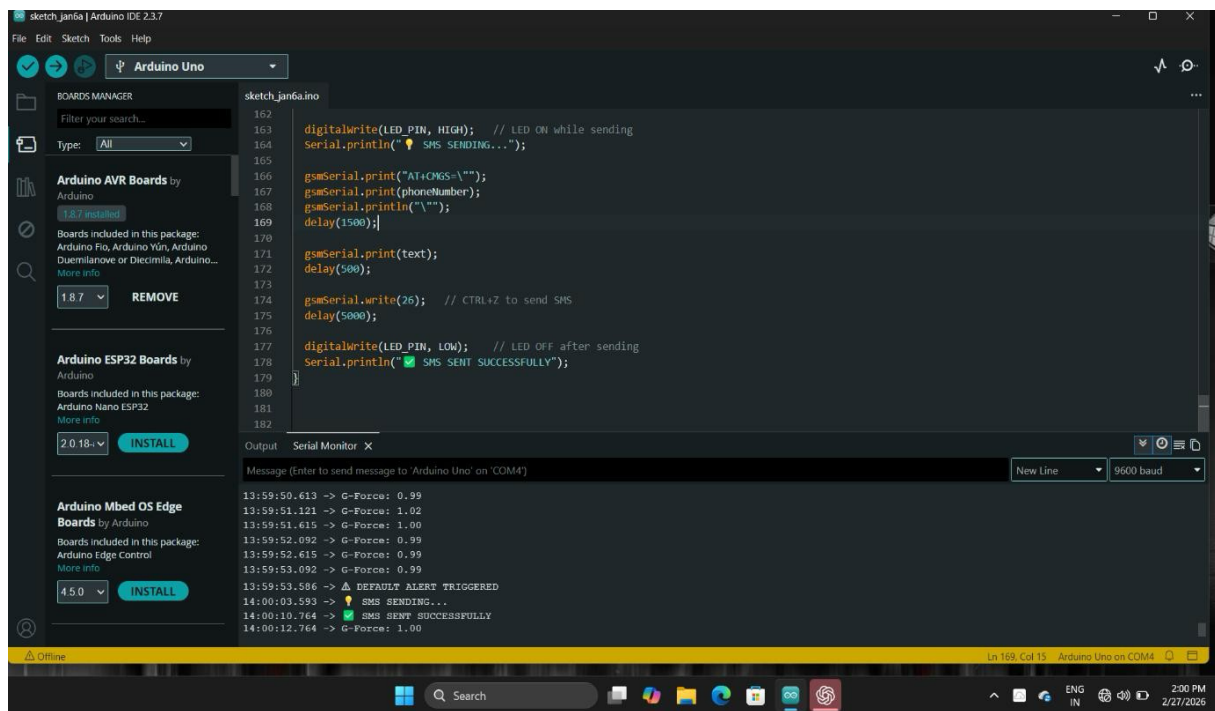


FIG :3 (Result when the Accident Occurs)

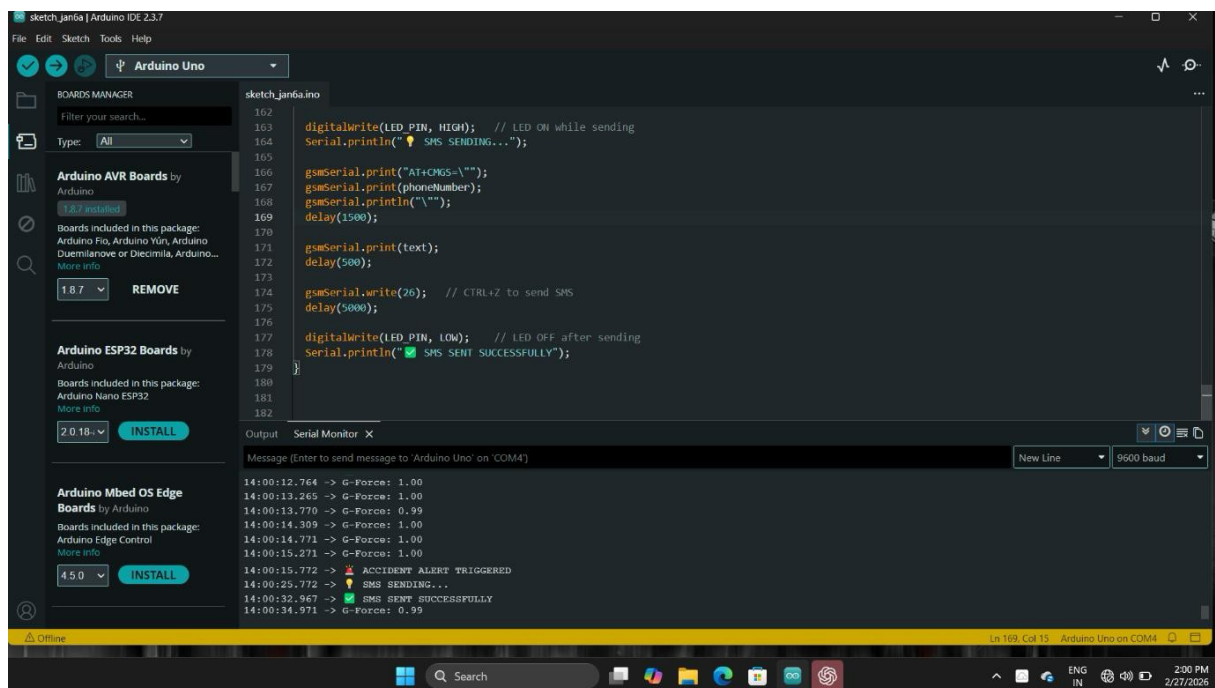


FIG:4 (Result of Default Alert)

The main objective of the system is to automatically detect vehicle accidents and immediately send an emergency SMS alert to a predefined phone number. The system uses an accelerometer sensor to continuously monitor the vehicle's movement and G-force values. Under normal conditions, the Serial Monitor displays readings such as "G-Force: 0.99" or "G-Force: 1.00," which indicate stable motion. When a sudden impact, sharp tilt, or abnormal acceleration occurs beyond a predefined threshold, the system identifies it as an accident. At that moment, the Serial

Monitor shows a message like “ACCIDENT ALERT TRIGGERED.” Once an accident is detected, the Arduino activates the GSM module. The code sends AT commands such as AT+CMGS to transmit an SMS. The LED connected to the Arduino turns ON to indicate that the message is being sent (“SMS SENDING...”). After successfully sending the message, the LED turns OFF and the Serial Monitor displays “SMS SENT SUCCESSFULLY.” The GSM module sends a predefined emergency message (which can include accident information or location details if integrated with GPS) to a stored phone number. This ensures that family members, emergency services, or authorities are informed immediately. Overall, this project enhances road safety by providing real-time accident detection and rapid emergency communication. It reduces response time after accidents and can help save lives through quick medical assistance and timely alerts.

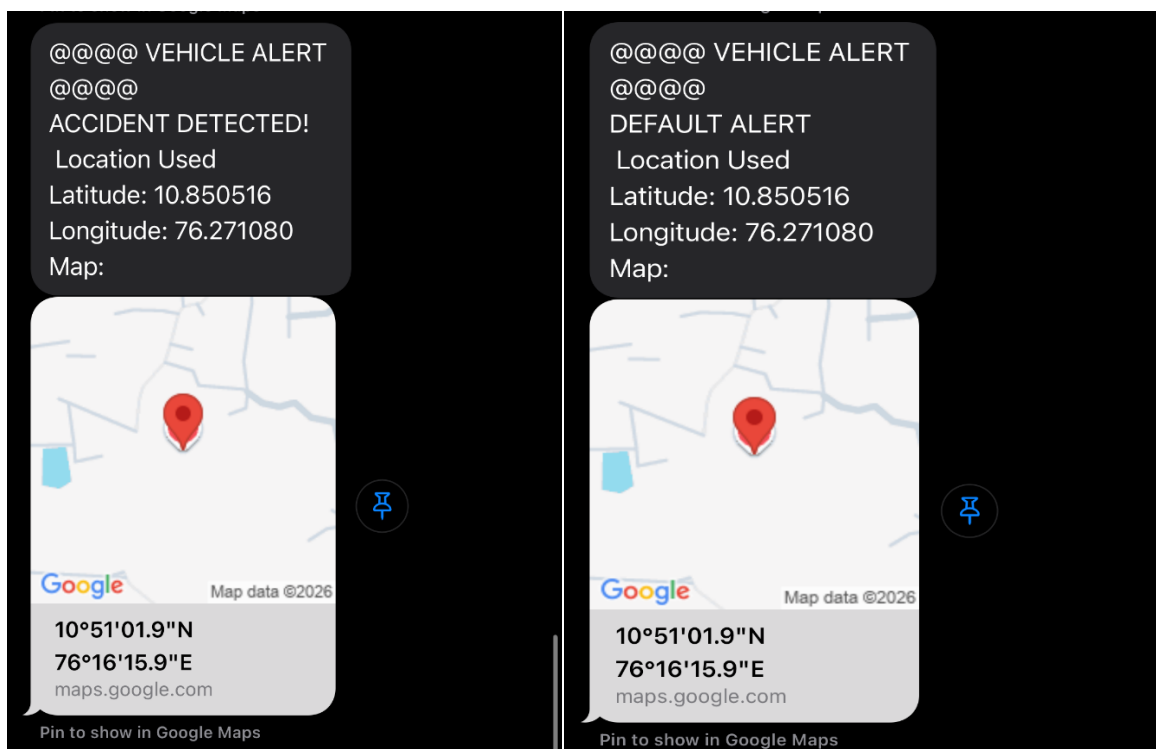


FIG : 5 (This is the SMS which comes on the Registered Mobile Number)

Applications

The IoT-based accident detection system has a wide range of practical applications that enhance safety and emergency management. One of its primary uses is in vehicle safety systems, where it automatically detects accidents and sends alerts, reducing response time and improving survival chances. It is also highly beneficial for public transport safety monitoring, enabling authorities to track buses, taxis, or other commercial vehicles and respond quickly in case of emergencies. In addition, the system can be used as an accident verification tool for insurance companies, providing accurate data such as time, location, and impact details to support claim validation and reduce fraudulent cases. The technology is especially useful in school and college bus safety monitoring, ensuring immediate notification to school authorities and parents in case of incidents. Furthermore, it plays a crucial role in remote or rural areas, where immediate human assistance may not be available, by automatically alerting emergency services and facilitating faster rescue operations.

Conclusion

Road accidents continue to be one of the major causes of death and injury across the world. A significant number of fatalities occur not only because of the severity of the accident but also due to the delay in receiving timely medical assistance. In many situations, victims are unable to communicate their condition or location to emergency services. Therefore, the development of an automated and intelligent accident detection system is essential to improve road safety and reduce loss of life. The IoT-based Accident Detection System presented in this project offers a smart and reliable solution to this problem. By integrating an accelerometer sensor, Arduino Uno microcontroller, GPS module, and GSM module, the system can automatically detect accidents and immediately send alerts to emergency contacts. The accelerometer continuously monitors vehicle movement and detects sudden impacts or abnormal tilts. Once the detected values exceed the predefined threshold, the Arduino processes the data and confirms the accident. The GPS module then retrieves the exact location of the accident, and the GSM module sends an emergency SMS containing the location details to predefined contacts. One of the key advantages of this system is its ability to function automatically without requiring human intervention. This ensures that help can be requested even if the driver or passengers are unconscious. The inclusion of a verification mechanism, such as a manual cancel switch, helps reduce false alarms and improves system reliability. The project is cost-effective, easy to install, and suitable for different types of vehicles including cars, school buses, and public transport vehicles. Moreover, this system demonstrates the practical application of IoT technology in enhancing public safety. It shows how connected devices can work together to provide real-time monitoring and communication. With further improvements such as cloud storage, mobile application integration, and AI-based detection, the system can become even more advanced and efficient. In conclusion, the IoT-based accident detection system is a life-saving technological innovation that reduces emergency response time and increases the chances of survival after road accidents. It represents a significant step toward smarter transportation systems and safer roads for everyone.

Future Enhancements

The IoT-based accident detection system provides an effective solution for real-time accident monitoring and emergency alert transmission. However, there is significant scope for further

improvement and enhancement to make the system more intelligent, accurate, and efficient. One major future enhancement is the integration of a dedicated mobile application. A mobile app can provide real-time vehicle tracking, accident notifications, and live location updates to family members and emergency responders. It can also display accident history, vehicle status, and emergency contact details. Cloud integration can be added to store accident data such as time, location, impact force, and response time. This stored data can help in accident analysis, insurance verification, and traffic safety research. Another improvement is the implementation of machine learning algorithms. By analyzing driving patterns and sensor data, the system can better differentiate between actual accidents and false alarms caused by speed breakers or sudden braking. This would significantly improve detection accuracy. Additionally, integrating more sensors such as gyroscopes, vibration sensors, and airbag status sensors can enhance reliability. The system can also be upgraded to support 4G/5G or IoT- based communication technologies like NB-IoT for faster and more reliable data transmission. Instead of sending only SMS alerts, the system can automatically notify nearby hospitals, police stations, and ambulance services through an online emergency response network. Another important enhancement is automatic engine shutdown after detecting a severe accident. This can help prevent further damage or fire hazards. A built-in camera module can also capture images or short video clips during the accident for better investigation and insurance purposes. Furthermore, integration with smart traffic systems and emergency vehicle navigation can reduce ambulance arrival time. Solar-powered modules can be added to ensure uninterrupted functioning even if the vehicle battery is damaged. Overall, future enhancements can transform the system into a smart, AI-powered, cloud-connected accident management solution, improving road safety and ensuring faster emergency response increases the chances of survival after road accidents. It represents a significant step toward smarter transportation systems and safer roads for everyone.

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