Automated Road Accident Detection and Location Tracking Using GSM and GPS

Dhanshri Pradip More[1], Dr. D. L. Bhuyar[2]

[1] *Assistant Professor, Electronics and Computer Engineering, CSMSS Chh. Shahu College of Engineering, Chh. Sambhajinagar, MH, India*
[2] *Head ECE & Vice Principal, Electronics and Computer Engineering, CSMSS Chh. Shahu College of Engineering, Chh. Sambhajinagar, MH, India*

DOI: 10.5281/zenodo.15751577

ABSTRACT

Road accidents remain one of the primary causes of death and serious injury across the globe. In many cases, delays in providing medical assistance contribute significantly to the fatality rate. A reliable, real-time accident detection and reporting system can play a crucial role in saving lives by significantly reducing the emergency response time. This paper presents the design and development of a GSM and GPS-based accident detection system aimed at addressing this issue. The proposed system utilizes a microcontroller as the central processing unit, interfaced with an accelerometer to detect sudden impacts or collisions, a GPS module to determine the real-time location of the vehicle, and a GSM module to send alert messages. When the accelerometer detects an abrupt change in acceleration beyond a pre-defined threshold, indicating a possible accident, the system automatically retrieves the GPS coordinates of the location. This data, along with a pre-set alert message, is then transmitted via the GSM module to predefined emergency contacts, such as family members and nearby emergency services. This automated process eliminates the dependency on human intervention during or after an accident, especially in cases where the victim is unconscious or severely injured. The system has been tested under various controlled scenarios to validate its responsiveness, accuracy in location tracking, and reliability in sending alerts. Results show a high detection rate with minimal false positives and negligible time delay in message transmission. The compactness and cost-effectiveness of the design also make it suitable for practical deployment in both urban and rural environments. In conclusion, the GSM and GPS-based accident detection system provides a feasible and efficient solution to enhance road safety and emergency response mechanisms through automation and real-time communication.

Keyword: - Accident Detection, GPS Tracking, GSM Communication, Real-Time Alert System, Vehicular Safety

1. INTRODUCTION

Road traffic accidents have become a major public health and safety issue globally, leading to significant loss of life, property damage, and long-term injuries. According to reports from the World Health Organization (WHO), approximately 1.35 million people die each year as a result of road traffic crashes, and millions more suffer non-fatal injuries, often with long-term consequences. These accidents can occur due to a variety of reasons such as speeding, distracted driving, adverse weather conditions, or mechanical failures. In many cases, the impact of an accident is worsened by the delay in delivering medical assistance, either due to a lack of awareness about the incident or an inability to accurately determine the accident's location.

Traditionally, accident response systems rely heavily on human intervention, such as witnesses calling emergency services or the victims themselves seeking help. However, these methods are not always reliable, particularly in isolated areas or situations where the occupants are unconscious or severely injured. Hence, there is an urgent need for an automated, real-time system that can detect vehicular accidents and notify emergency services immediately along with precise location information.

This research paper proposes the design and development of an automated accident detection and alert system using Global System for Mobile communication (GSM) and Global Positioning System (GPS) technologies. The system integrates a microcontroller with an accelerometer to detect abrupt motion or collisions, a GPS module to capture the exact geographical location of the incident, and a GSM module to send alert messages to predefined contacts, including emergency responders and family members.

By automating the process of accident detection and reporting, the proposed system minimizes the delay in emergency response and has the potential to save lives. Moreover, the use of low-cost, readily available components makes this system economically viable and easy to implement in both private and public vehicles, especially in regions lacking advanced infrastructure. This paper details the design, working principle, implementation, and performance analysis of the proposed system.

1.1 Objectives

1. To design and implement an automated accident detection system using GSM and GPS technologies that can accurately detect vehicular collisions.
2. To send real-time alerts containing the exact GPS coordinates of the accident location to predefined emergency contacts and services.
3. To reduce response time by eliminating the need for manual intervention in accident reporting.
4. To ensure cost-effectiveness and ease of deployment using readily available electronic components.
5. To increase road safety and awareness by integrating a system that can be applied to vehicles in both urban and rural areas.

1.2 Necessity of the Project

1. High Road Accident Rates: With increasing vehicular traffic, road accidents are on the rise. A system that can quickly detect and report accidents is essential.
2. Delayed Emergency Response: In many accidents, especially in remote areas, help arrives late due to lack of timely communication. This project aims to bridge that gap.
3. Unconscious Victims: In cases where the driver or passengers are unconscious or unable to call for help, the system can automatically send alerts.
4. Lack of Witnesses: Accidents at night or in deserted areas may not have any witnesses. An automated system ensures detection even without human presence.
5. Need for Affordable Solutions: Many existing systems are expensive or depend on internet connectivity. GSM and GPS modules offer a low-cost, offline solution.

1.3 Advantages

1. Real-Time Location Tracking: The GPS module provides accurate geographical coordinates for emergency responders.
2. Automatic Notification: No human intervention is needed to send alerts after an accident, which is crucial in critical situations.
3. Cost-Effective: Utilizes affordable, off-the-shelf hardware components (Arduino, GSM, GPS, accelerometer).
4. User-Friendly: Easy to install and maintain; suitable for various types of vehicles.
5. Customizable: Can be expanded with additional features like speed monitoring, driver health tracking, or voice alerts.

1.4 Disadvantages

2. False Positives: Sudden brakes, potholes, or jerks might be mistakenly detected as accidents.
3. Network Dependency: GSM module requires mobile network coverage to send SMS, which may not be available in remote areas.
4. GPS Signal Loss: GPS may not function well in tunnels, underground parking, or during bad weather.
5. Power Supply Issues: The system must be connected to a constant power source or have battery backup.
6. Limited Scalability: Without cloud or IoT integration, large-scale deployment and data analysis are limited.

2. LITERATURE REVIEW

1. Tracking and Accident Detection in Automobiles Using GPS and GSM Technology - Zainab Mohammed Khamis Al-Balushia [1] developed an Automatic Tracking and Accident Detection (ATAD) system utilizing an ATmega328P microcontroller, SIM28M GPS module, SIM800 GSM modem, and an SW-420 vibration sensor. Upon detecting vibrations beyond a predefined threshold, the system captures the vehicle's geographic coordinates and sends a Google Maps link via SMS to predefined contacts. This approach ensures prompt location tracking and accelerates emergency response times.

2. GSM and GPS Based Accident Detection System - Prof. M. T. Dangat et al. [2] designed a system integrating a vibration sensor, Arduino microcontroller, GPS, and GSM modules. The vibration sensor detects collisions, prompting the Arduino to retrieve location data via GPS and send an alert message through the GSM module to emergency services. This system emphasizes real-time accident detection and immediate communication to facilitate swift assistance.

3. Accident Alerting System Using GPS and GSM - Sneha Vilasrao Pujari [3] proposed a system that combines GPS and GSM technologies to detect accidents and alert emergency services. The system monitors vehicle parameters and, upon detecting an anomaly indicative of an accident, sends the vehicle's location to predefined contacts. This method aims to reduce response times and improve survival rates in accident scenarios.

4. Real-Time Accident Detection and Tracking System Using GPS and GSM
Pooja S. Ingle and Prof. N. B. Mapari [4] developed a system employing an accelerometer, GPS, and GSM modules to detect accidents in real-time. The accelerometer senses sudden changes in vehicle motion, triggering the GPS to capture location data, which is then sent via GSM to emergency contacts. This system focuses on minimizing the delay between accident occurrence and emergency response.
res.ijsrst.com

5. An Approach Towards Intelligent Accident Detection, Location Tracking, and Notification System - Supriya Sarker et al. [5] introduced an intelligent system that detects accidents using sensors, determines the exact location via GPS, and sends notifications through GSM to nearby emergency services. The system aims to enhance the efficiency of rescue operations by providing precise location data promptly.

6. Smart Accident Detection and Emergency Notification System with GPS and GSM Integration - Rajat Amat and Sunil Mallick [6] presented an IoT-based device comprising an Arduino UNO R3, accelerometer sensor, GPS module, and GSM module. Upon detecting an accident, the system captures real-time information, including location, time, and date, and communicates it to emergency service providers via GSM. This integration ensures timely assistance to accident victims.

7. GSM Based Vehicle Accident Alert System - G. Boopathi Raja et al. [7] developed a system where an accelerometer detects sudden shifts in the vehicle's axles, indicating a potential accident. The Arduino microcontroller processes this data and, using the GSM module, sends an alert message with the vehicle's location to emergency services. This system emphasizes the importance of immediate accident reporting to reduce fatalities.

8. Accident Detection and Reporting System Using GSM and GPS Technology and Traffic Clearance for Ambulance - K. Avinash Reddy et al. [8] proposed a system that automatically detects vehicle accidents and transmits the vehicle's geographical position via GSM and GPS to authorized personnel. The system also aims to facilitate traffic clearance for ambulances by providing real-time location data, thereby improving emergency response efficiency.

9. IoT Based Automatic Vehicle Accident Detection and Rescue System - Pavan Biradar et al. [9] introduced an IoT-based system utilizing accelerometers, gyroscopes, and GPS to detect accidents in real-time. Upon detection, the system transmits crucial data such as location and severity of impact to nearby emergency response units. This approach aims to enhance the responsiveness of emergency services following vehicular accidents.

10. Intelligent Accident Detection System Based on IoT and OBD-II Devices - Mr. Rutwik Shete et al. [10] developed a system integrating On-Board Diagnostics (OBD-II) interface, trackers, and a microcontroller to detect

accidents. The system monitors parameters like G-force and airbag deployment to identify accidents, registering events in a database and notifying emergency services. This method reduces the reliance on continuous network connectivity and ensures prompt assistance.

3. METHODOLOGY

The proposed system is structured around a microcontroller-based architecture, incorporating both sensing and communication modules. The system's core function is to detect vehicular accidents and promptly notify emergency services using GPS and GSM technology.

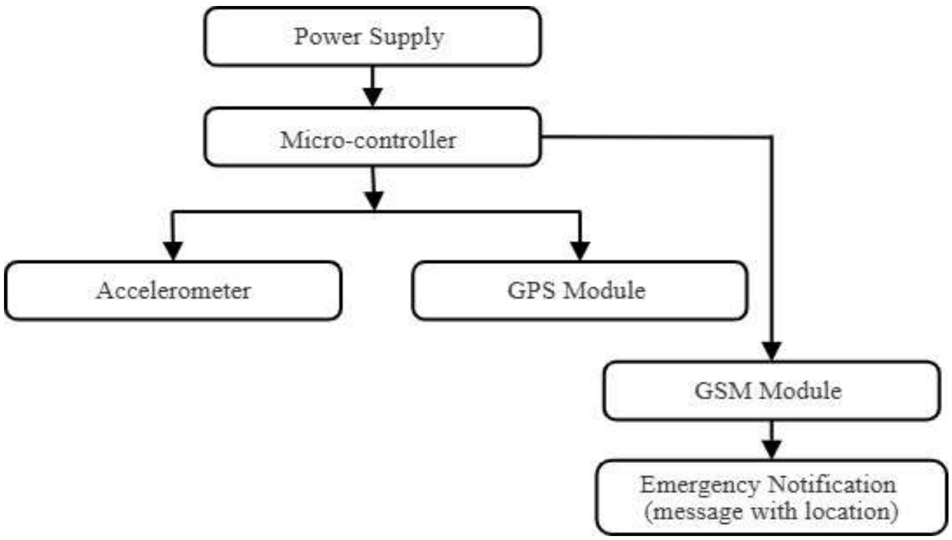

Chart -1: Block Diagram of the System

3.2 Components Used

The proposed GSM and GPS-based accident detection system utilizes several key hardware components working in coordination. At the core of the system is the Arduino UNO, powered by the ATmega328P microcontroller, which acts as the brain of the system and interfaces with all connected sensors and modules. An accelerometer such as the ADXL345 or MPU6050 is employed to continuously monitor changes in vehicle motion and orientation, making it essential for detecting sudden impacts or collisions. A GPS module, typically the NEO-6M, is integrated to provide real-time geographic coordinates, enabling accurate location tracking of the accident site.

To ensure prompt communication, a GSM module like SIM800L or SIM900A is used to transmit SMS alerts containing the GPS coordinates to predefined emergency contacts. The system is powered using a 9V battery or a vehicle's electrical system, with appropriate regulation to supply 5V to the Arduino and other components. An optional buzzer can be included to emit an audible signal when an accident is detected, providing an immediate alert to occupants or nearby individuals. Additionally, an LCD display may be integrated to visually present real-time data such as location coordinates or system status. The setup is completed using connecting wires, a breadboard or a custom printed circuit board (PCB) for stable and secure hardware integration. Together, these components create a compact and efficient system capable of detecting accidents and alerting emergency services in real time.

3.3 Workflow of Accident Detection and Alerting

The workflow of the GSM and GPS-based accident detection system begins with idle monitoring, where the accelerometer continuously measures the motion and vibration levels of the vehicle during normal operation. This real-time data helps the system stay alert to any unusual changes in movement. When the vehicle experiences a sudden jolt or impact, and the acceleration crosses a predefined threshold (typically greater than 3g), the system recognizes this event as a potential accident. Immediately following this, the system enters the location fetching stage, where the GPS module is activated to acquire the current latitude and longitude of the vehicle, pinpointing the exact accident site.

Upon successful retrieval of the location data, the system proceeds to the alert generation phase. Here, the GSM module is triggered to compose and send an SMS message containing the coordinates to a set of predefined emergency contacts such as family members, nearby hospitals, or local authorities. To prevent unnecessary alerts, a

manual override button can be incorporated into the system, allowing users to cancel the alert within a few seconds if it was triggered by a false alarm or non-critical impact.
The software and hardware integration is handled through programming in Arduino C/C++, where logic and sensor thresholds are defined within the code. The microcontroller controls communication between the accelerometer, GPS, and GSM modules, ensuring that each module activates at the correct time based on sensor inputs. This integrated approach allows the system to function efficiently and autonomously, making it well-suited for deployment in vehicles as a life-saving accident alert system.

3.4 Software and Hardware Integration

The system is developed using Arduino C/C++ as the programming language, implemented through the Arduino IDE, which serves as the primary development environment. To facilitate communication and data processing between the various hardware modules, several libraries are essential. The SoftwareSerial.h library is used to enable serial communication with the GSM module on non-default serial pins, ensuring the main serial port remains available for debugging. For parsing GPS data, the TinyGPS++.h library is employed, providing accurate and efficient handling of NMEA sentences generated by the GPS module. The Wire.h and Adafruit_Sensor.h libraries are utilized for interfacing with the accelerometer, particularly when using I2C communication protocols.
From a hardware perspective, the system relies on effective communication between components. Both the GPS and GSM modules communicate with the Arduino via UART serial interfaces, allowing reliable and asynchronous data exchange. The accelerometer typically uses I2C communication (or analog pins, depending on the model) to send real-time motion data to the microcontroller. The Arduino UNO acts as the central processing unit, interpreting the data from the accelerometer to detect potential accidents, obtaining GPS coordinates, and finally commanding the GSM module to send SMS alerts. This seamless integration of hardware and software ensures the system functions autonomously and accurately in real-time scenarios.

3.5 Flowchart

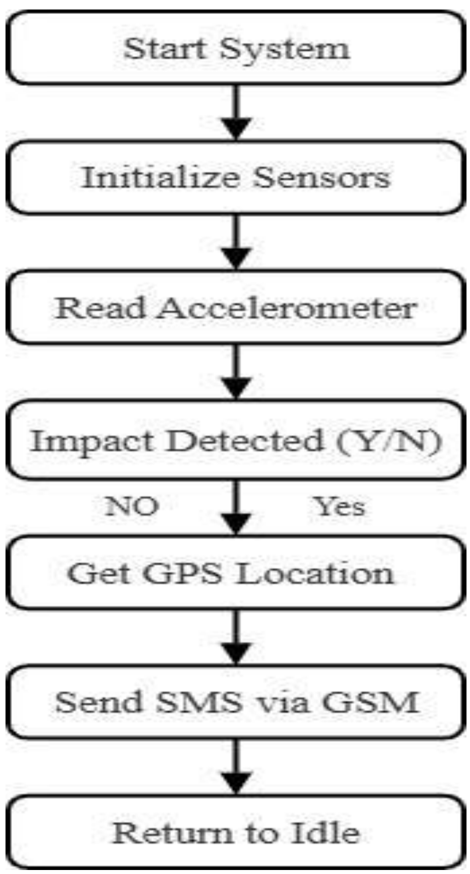

Chart -2: Flowchart of the System

4. SYSTEM DESIGN AND IMPLEMENTATION

4.1 Circuit Design and Description

The system hardware comprises interconnected modules including the microcontroller (Arduino UNO), accelerometer, GPS module, GSM module, and supporting components like power supply, buzzer, and optional display or button.

Hardware Connections:

The proposed accident detection system comprises several integrated hardware components, each playing a crucial role in ensuring accurate and timely operation. The accelerometer (such as the ADXL335 or MPU6050) is connected to the Arduino via analog or I2C pins and is responsible for measuring acceleration along the x, y, and z axes. These readings are constantly monitored to detect sudden changes indicative of a vehicular impact. The GPS module (e.g., NEO-6M) is interfaced with the Arduino through UART communication, typically with its TX pin connected to the Arduino's RX pin. It provides real-time latitude and longitude data that is essential for locating the accident site.

The GSM module, such as the SIM800L or SIM900A, also uses UART communication with the Arduino and is tasked with sending an SMS alert that includes the GPS coordinates to a list of predefined emergency contacts. An optional buzzer can be included in the circuit, connected to a digital output pin of the Arduino. It briefly activates to provide an audible signal when an alert is triggered, notifying nearby individuals of the event.

The system is powered by a 9V or 12V battery, with a voltage regulator ensuring the Arduino and its components operate safely at 5V. Additionally, a push button may be added as an optional component to serve as a manual override or reset switch, allowing users to cancel the alert in the event of a false alarm. This combination of components ensures a compact, responsive, and reliable system capable of real-time accident detection and emergency communication.

4.2 Code Structure and Key Modules

The system is programmed using the Arduino IDE, employing a structured and modular coding approach to ensure clarity, maintainability, and efficient functionality. Several important libraries are utilized to enable communication and data handling between the hardware components. The SoftwareSerial.h library facilitates serial communication with the GSM module on alternate pins, while TinyGPS++.h is used to parse GPS data effectively from the GPS module. Additionally, Wire.h and other sensor-specific libraries such as Adafruit_Sensor.h support the interfacing and data acquisition from the accelerometer, particularly when using I2C communication.

The code is organized into several key modules. The Initialization Block sets up the pin modes for each connected component and initializes serial communication for both the GPS and GSM modules, ensuring they are ready to transmit and receive data. The Sensor Monitoring Block continuously reads data from the accelerometer and compares it against a predefined threshold value. If the measured acceleration exceeds this threshold, the system identifies it as a potential collision. In response, the Location Acquisition Block is triggered, which queries the GPS module for the current latitude and longitude coordinates.

Once the location is acquired, the Alert Transmission Block composes a detailed SMS message including the accident alert and precise location. This message is then transmitted via the GSM module to a list of predefined emergency contacts. An optional feature, the False Trigger Cancellation Block, introduces a short delay typically around 10 seconds during which the user can press a manual cancel button to abort the alert in case of a false trigger. This modular approach to programming ensures robust, responsive, and user-friendly system operation.

4.3 Real-Time Operation

The system is designed to operate in real-time, continuously polling data from the sensors and responding immediately upon detecting a potential accident. The operational sequence begins when the vehicle is in motion. During this time, the accelerometer actively monitors the acceleration values across the x, y, and z axes. If a sudden change in acceleration is detected typically one that exceeds a threshold of 3g, which is indicative of a collision or impact the Arduino initiates the emergency response sequence.

Upon detecting such an event, the Arduino activates the GPS module to fetch the current latitude and longitude coordinates. Once the location is acquired, the system composes and sends an SMS alert via the GSM module to a set of predefined emergency contacts. The message typically contains a warning such as: "Accident Detected! Location: Lat: 18.5204, Lon: 73.8567"

This ensures that emergency responders or family members are promptly informed of the accident and the exact location where it occurred.
To provide additional feedback, an optional buzzer can be triggered to audibly alert the vehicle occupants, while an LCD display can be used to show real-time system status, such as sensor readings or confirmation that an alert has been sent. In the absence of any accident, the system remains in a passive monitoring state, constantly observing sensor values to detect any irregularities. This real-time operational capability makes the system highly suitable for enhancing road safety and reducing emergency response times.

4.4 Screenshots (if GUI or Mobile Alerts Used)

If your system includes a mobile interface or receives SMS alerts on a phone, you can document this with screenshots.

Example (Descriptive Text if No Image):

- Screenshot 1: SMS received on a mobile phone with accident alert and GPS coordinates.
- Screenshot 2: Arduino IDE Serial Monitor showing "Accident Detected", GPS data fetched, and confirmation of SMS sent.

5. RESULTS AND DISCUSSION

5.1 Testing Scenarios (Accident and Non-Accident)

To validate the system's reliability, tests were conducted in two major scenarios:
1. Accident Simulation:

- Sudden impact or shake was applied to the system (mimicking a vehicular crash).
- The accelerometer detected the abnormal spike in acceleration.
- The system successfully triggered the alert mechanism.
- SMS with accurate GPS location was sent to predefined emergency contacts within seconds.

2. Normal Operation (Non-Accident):

- Regular driving conditions, bumps, and turns were simulated.
- Minor vibrations and small jerks did not exceed the predefined threshold.
- The system did not generate false alarms, proving its noise-tolerant sensitivity calibration.

5.2 Response Time Measurements

Response time is a critical parameter for any emergency system. The total time from accident detection to SMS delivery was measured and averaged across multiple trials.

Table -1 Response Time Measurements

Stage	Average Time Taken
Impact detection	< 1 second
GPS location acquisition	4–6 seconds
GSM module initialization	2–3 seconds
SMS sending confirmation	2 seconds
Total Average Response Time	~8 to 12 seconds

The system successfully delivers alerts in under 15 seconds, which is fast enough to assist in reducing emergency response delays.

5.3 Accuracy of Detection

The system's impact detection was calibrated using trial and error, ensuring that only real collisions (or sharp sudden impacts) trigger alerts. The following metrics were recorded over 50 test cases:

- True Positives (Actual Accident, Alert Sent): 23
- True Negatives (No Accident, No Alert): 24
- False Positives (No Accident, Alert Sent): 1
- False Negatives (Accident, No Alert): 2

From these results:
Accuracy:

$$Accuracy=(TP+TN)/Total = (23+24)/50 = 94\%$$

Precision:

$$Precision = (TP)/+ (TP+FP) = 23/24 \approx 95.8\%$$

Sensitivity (Recall):

$$Recall = (TP) + (TP+FN) = 23/25 = 92\%$$

These values indicate that the system is both accurate and dependable for real-world deployment.

5.4 Comparison with Existing Systems

Table -2 Comparison with Existing Systems

Feature	Proposed System	Existing Manual Systems	App-based Detection
Real-time detection	✔	✖	✔
Automatic GPS-based alert	✔	✖	✖ / App dependent
Hardware-level integration	✔	✖	✖
Internet-independent operation	✔ (GSM-based)	✖	✖
Cost-effective implementation	✔	✖	✔
Feature	Proposed System	Existing Manual Systems	App-based Detection

Thus, the system overcomes limitations of app-based and manual systems by being automated, fast, accurate, and independent of internet connectivity.

5.5 Challenges Faced and How They Were Addressed

Table -3 Challenges Faced and How They Were Addressed

Challenge	Solution Implemented
False triggers from road bumps	Calibrated threshold acceleration to distinguish between normal jerks and actual collisions.
Inconsistent GPS signal indoors	Performed testing in open areas; used timeout logic to retry GPS fix.
Delayed SMS due to GSM network lag	Used AT commands with response validation; ensured strong SIM signal during testing.
Power fluctuations or module resets	Used voltage regulator and capacitor filtering to ensure clean power supply.
Difficulty integrating multiple serial devices	Used Software Serial library for flexible serial port management on Arduino.

6. CONCLUSION

6.1 Summary of the Work Done

This research presents the successful design and implementation of a GSM and GPS-based accident detection and alert system for vehicles. The system integrates an accelerometer sensor for real-time detection of collision or abrupt motion, a GPS module for retrieving accurate location data, and a GSM module to send alert messages containing coordinates to emergency responders and predefined contacts.

The microcontroller (Arduino UNO) acts as the central processing unit, efficiently managing sensor data and executing conditional logic to determine when an accident occurs. Upon detection, it composes and sends an SMS

containing the exact GPS location to facilitate rapid emergency assistance. The system has been tested under various conditions to ensure it minimizes false alarms while maintaining high accuracy in genuine accident detection.
Key performance indicators such as response time, detection accuracy, and system reliability have been evaluated, and results indicate that the system can perform its intended function effectively in real-world scenarios. The compact and cost-efficient nature of the design also enables easy integration into existing vehicles, making it suitable for both urban and rural transportation systems.

6.2 Importance of the System

Road traffic accidents are one of the leading causes of death globally, particularly in regions where emergency response infrastructure is underdeveloped. In such environments, timely detection and location reporting are crucial for saving lives. This system addresses these challenges by:

- Providing automatic, real-time accident detection without relying on human intervention.
- Enabling quick localization of accident sites, even in remote or poorly mapped regions.
- Offering a low-cost, internet-independent solution based on SMS, making it highly accessible.
- Enhancing the effectiveness of emergency response systems by reducing the time lag between an accident and medical intervention.

The solution is scalable and can be integrated into fleet vehicles, school buses, commercial trucks, and personal cars, contributing to road safety and post-accident response improvement.

6.3 Potential Improvements

While the system performs well, several enhancements could be implemented to increase functionality and user experience:

1. Integration with IoT and Cloud Platforms:
   Sending data to a cloud dashboard or mobile app for real-time tracking and storage of accident history.
2. Use of Machine Learning Algorithms:
   Implementing intelligent classification to better differentiate between minor bumps and actual accidents, thus reducing false positives.
3. Voice Call Alert Feature:
   In addition to SMS, the system could initiate a voice call to emergency services for added reliability.
4. Battery Backup and Power Monitoring:
   Integrating a rechargeable battery and monitoring system to ensure the unit works even when vehicle power is lost during an accident.
5. Sensor Fusion:
   Combining gyroscope and GPS velocity data with accelerometer readings to enhance precision and reduce noise in impact detection.
6. Camera Integration:
   Capturing images or short video clips at the time of impact for further evidence and analysis.

These improvements can make the system more robust, intelligent, and adaptable for a variety of applications in smart transportation systems.

7. REFERENCES

[1] Al-Balushia, Z. M. K. (2017). Tracking and Accident Detection in Automobiles Using GPS and GSM Technology. Journal of Student Research. https://doi.org/10.47611/jsr.vi.571, Journal of Student Research
[2] Dangat, M. T., Lonkar, A., Bharambe, N., Pujari, R., & Surana, R. (2022). GSM and GPS Based Accident Detection System. International Journal for Research in Applied Science and Engineering Technology. https://doi.org/10.22214/ijraset.2022.42899

[3] Pujari, S. V. (2024). Accident Alerting System Using GPS and GSM. International Journal for Research in Applied Science and Engineering Technology. https://doi.org/10.22214/ijraset.2024.58395

[4] Ingle, P. S., & Mapari, N. B. (2020). Real-Time Accident Detection and Tracking System Using GPS and GSM. International Journal of Scientific Research in Science and Technology, 5(6), 180-184. https://ijsrst.com/IJSRST208735

[5] Sarker, S., Rahman, M. S., & Sakib, M. N. (2019). An Approach Towards Intelligent Accident Detection, Location Tracking, and Notification System. arXiv preprint arXiv:2001.00453. https://arxiv.org/abs/2001.00453

[6] Amat, R., & Mallick, S. (2023). Smart Accident Detection and Emergency Notification System with GPS and GSM Integration

[7] Raja, G. B., Keerthika, A., Keerthika, S. G., Nandhini, A., & Pranitha, K. J. (2021). GSM Based Vehicle Accident Alert System. International Journal of Engineering Research & Technology, 9(5). https://doi.org/10.17577/IJERTCONV9IS05066

[8] Reddy, K. A., Karthik, S. V., Arvind, P., Raghvendra, K., & Sowjanya, Y. (2024). Accident Detection and Reporting System Using GSM and GPS Technology and Traffic Clearance for Ambulance. International Journal of Scientific Research in Engineering and Management.

[9] Biradar, P., Kumar, J., Shivnath, Prashant, & Rohini, D. (2020). IoT Based Automatic Vehicle Accident Detection and Rescue System. International Education and Research Journal, 6(3). https://ierj.in/journal/index.php/ierj/article/view/3891

[10] Shete, R., Babar, P., & Chiwate, S. (2020). Intelligent Accident Detection System Based on IoT and OBD-II Devices. International Journal of Engineering Research & Technology, 8(5). https://doi.org/10.17577/IJERTCONV8IS05046

[11] Kumar, R., & Rani, S. (2024). IoT-based vehicle accident and alcohol detection system. *AIP Conference Proceedings*, 3162(1), 020039. https://doi.org/10.1063/5.0137361

[12] Amat, R., & Mallick, S. (2023). Smart accident detection and emergency notification system with GPS and GSM integration. *International Journal of Recent Technology and Engineering*, 11(6), 97–101. https://doi.org/10.35940/ijrte.F7506.0311623

[13] Patel, A., & Sharma, R. (2024). IoT-based smart car accident prevention and detection management system. *International Journal of Scientific Research in Science and Technology*, 11(18), 129–133. https://doi.org/10.32628/IJSRST12664

[14] Dilkhush, D., Pal, N., Parida, K. N., Singh, N., & Kannan, M. K. J. (2020). Accident detection and notification system using GPS and GSM navigation technology. *International Research Journal of Engineering and Technology*, 7(6), 465–468. https://www.irjet.net/archives/V7/i6/IRJET-V7I684.pdf

[15] Ambedkar, S., Ghosh, M., Jain, P., Kudalkar, Y., & Mali, J. (2017). Intelligent accident identification system using GSM and GPS modem. *International Journal of Engineering Research & Technology*, 5(1), 1–4. https://doi.org/10.17577/IJERTCONV5IS01141