Vehicle Accident Detection And Monitoring System Using Data Analytics

VINIGA U[1], SADHANA R [2],MRS .PRADEEPA K[3]

1, 2, Members - 5th Semester B.E Students, Department of Computer Science and Engineering, E.G.S.Pillay Engineering College, Nagapattinam, Tamilnadu, India
4 Professor, Department of Computer Science and Engineering, E.G.S.Pillay Engineering College, Nagapattinam, Tamilnadu, India

***Abstract* —** Road accidents remain one of the major causes of fatalities worldwide, largely due to delayed emergency response and lack of real-time accident information. This paper presents the design and implementation of a Vehicle Accident Detection and Monitoring System (VADS) that enables automatic accident detection and immediate alert transmission to emergency contacts and authorities. The system integrates multiple sensors such as an accelerometer, vibration sensor, impact force sensor, tilt angle sensor, and GPS module to continuously monitor vehicle dynamics. When abnormal parameters such as high G-force, sudden tilt, or strong impact are detected, the system identifies the event as an accident and automatically sends the vehicle's exact location and status via a communication module. This reduces response time, improves rescue efficiency, and enhances road safety. The proposed system is cost-effective, reliable, and suitable for real-time deployment in vehicles.

Keywords: Accident Detection, Vehicle Monitoring, Accelerometer, GPS Tracking, Emergency Alert System, IoT, Road Safety, Real-time Monitoring

I. INTRODUCTION

Road traffic accidents cause significant loss of life and property every year. One of the primary reasons for high fatality rates is the delay in providing medical assistance to accident victims. In many cases, accidents occur in remote areas where immediate help is not available, and victims are unable to inform others about their situation. This highlights the need for an automated system that can detect accidents and notify emergency services without human intervention.

Advancements in embedded systems, sensors, and communication technologies have made it possible to design intelligent systems for vehicle safety. By integrating sensors capable of measuring acceleration, vibration, tilt, and impact force with GPS and communication modules, it is possible to monitor vehicle conditions continuously and identify abnormal events that indicate accidents.

The proposed Vehicle Accident Detection and Monitoring System (VADS) is designed to address this issue by automatically detecting accidents in real time and sending alerts containing precise location details to predefined contacts. This system not only reduces emergency response time but also contributes to improving overall road safety. The system is affordable, efficient, and can be easily installed in vehicles, making it practical for real-world implementation.

II. PROBLEM STATEMENT

Despite improvements in road infrastructure and vehicle safety, accident fatality rates remain high due to delayed emergency response and lack of immediate accident information. Victims often cannot communicate their location after a crash, especially in isolated areas. Existing systems rely heavily on manual reporting or smartphone usage, which may not be feasible during severe accidents. There is a need for an automated, sensor-based accident detection system that can accurately identify accidents and instantly transmit the vehicle's location and status to emergency contacts, thereby minimizing response time and saving lives.

Diagram Representation:

III. OBJECTIVES

 To design and develop a real-time vehicle accident detection system using multiple sensors such as accelerometer, vibration, tilt, and impact sensors.

 To continuously monitor vehicle dynamics and identify abnormal conditions like high G-force, sudden tilt, or strong impact that indicate an accident.

 To integrate a GPS module for accurate location tracking of the vehicle during emergency situations.

 To automatically send emergency alert messages with location details to predefined contacts and nearby hospitals immediately after accident detection.

 To reduce the emergency response time and increase the chances of saving lives after road accidents.

 To create a low-cost, reliable, and easily installable system that can be implemented in any vehicle.

 To maintain real-time monitoring and data logging for post-accident analysis.

 To ensure the system works without human intervention during critical situations.

 To improve road safety by enabling fast communication between the accident vehicle and emergency services.

 To develop a prototype that can be extended for integration with IoT and smart transportation systems in the future.

IV. SYSTEM ARCHITECTURE

The Vehicle Accident Detection and Monitoring System (VADS) is organized as a layered architecture that connects in-vehicle sensing, edge processing, communication, cloud services, and user/emergency interfaces for real-time accident detection and alerting.

1) Sensing Layer (In-Vehicle Sensors)

This layer continuously measures vehicle dynamics and environmental impact.

- **Accelerometer (e.g., Analog Devices ADXL series) – detects sudden G-force.**
- **Vibration/Impact Sensor – senses collision shock.**
- **Tilt/Orientation Sensor (Gyroscope) – detects rollover or abnormal tilt.**
- **GPS Module (e.g., u-blox NEO series) – provides real-time latitude/longitude.**
- **Optional: Microphone/airbag signal for crash confirmation.**

These sensors feed raw signals to the controller in real time.

2) Edge Processing Layer (On-Board Controller)

- **Microcontroller (e.g., Arduino / Espressif Systems ESP32) collects sensor data.**
- **Performs threshold analysis (G-force, vibration, tilt).**
- **Runs the accident detection algorithm.**
- **Filters noise and validates multi-sensor triggers to avoid false alarms.**

3) Communication Layer

- **GSM/GPRS Module (e.g., SIMCom SIM800/900) for SMS/data alerts.**
- **Sends accident alerts with GPS coordinates to cloud/server and emergency contacts.**
- **Optional: Wi-Fi (ESP32) for internet connectivity.**

4) Cloud / Server Layer

- **Receives accident packets from vehicles.**
- **Stores data in a database for logging and monitoring.**
- **Provides APIs for dashboard and emergency services.**
- **Can be hosted on platforms like Amazon Web Services or Google Cloud.**

5) Application & Alert Layer

- **Web/mobile dashboard for live vehicle status.**
- **Automatic SMS to emergency contacts and hospitals.**
- **Map visualization using Google Maps with crash location.**
- **Authorities can view accident history and analytics.**

6) User / Emergency Response Layer

- **Vehicle owner receives instant alert.**
- **Nearby hospital/police receive location details.**
- **Faster emergency dispatch reduces response time.**

Architecture Flow

Sensors → Microcontroller (Edge Processing) → GSM/Wi-Fi → Cloud Server →
Web/App Dashboard → SMS/Map Alerts → Emergency Services

Working Principle (Data Flow)

1. **Sensors continuously monitor vehicle parameters.**
2. **Microcontroller analyzes values against accident thresholds.**
3. **On detection, GPS location is fetched.**
4. **GSM/Wi-Fi sends alert data to server and contacts.**
5. **Server updates dashboard and triggers map/SMS alerts.**
6. **Emergency responders navigate to the exact location.**

V. LITERATURE REVIEW (SUMMARY)

Road accidents are a major global issue, and many researchers have worked on systems to reduce accident fatalities through faster detection and emergency response. Earlier approaches mainly relied on manual reporting, CCTV monitoring, or eyewitness communication, which often resulted in delays in providing medical assistance to victims.

Several studies introduced **sensor-based accident detection systems** using accelerometers and vibration sensors to identify sudden changes in vehicle motion. These systems could detect collisions by measuring abnormal G-force values, but many lacked accurate location tracking and real-time alert mechanisms.

Later research integrated **GPS and GSM modules** to transmit accident location and alert messages to emergency contacts or control rooms. While these systems improved response time, they often relied on a single sensor, which sometimes produced false alarms due to road bumps or sudden braking.

Recent works have focused on **multi-sensor integration**, combining accelerometers, tilt sensors, impact force sensors, and gyroscopes to improve detection accuracy. Machine learning techniques have also been explored to distinguish between actual accidents and normal driving conditions, thereby reducing false positives.

Some researchers proposed **IoT-based vehicle monitoring systems** that continuously track vehicle parameters and send data to cloud servers for analysis. These systems enabled real-time monitoring but required stable internet connectivity and higher infrastructure cost.

VI. METHODOLOGY / ALGORITHM

The methodology of the VADS is designed to **continuously monitor vehicle motion**, **detect abnormal accident conditions**, and **automatically send emergency alerts** with location details for quick response.

Step 1: System Initialization

- Power ON the system.
- Initialize **Arduino Uno**, **NEO-6M GPS Module**, **SIM800L GSM Module**, accelerometer, vibration sensor, and tilt sensor.
- Set threshold values for accident detection (G-force, tilt angle, vibration level).

Step 2: Continuous Sensor Monitoring

- The accelerometer continuously measures X, Y, Z axis acceleration.
- The vibration sensor monitors sudden shocks.
- The tilt sensor checks abnormal vehicle angle (rollover condition).
- All sensor values are read at regular intervals.

Step 3: Abnormal Condition Detection

- If any sensor value exceeds the predefined threshold:
  - High G-force → Possible collision
  - High vibration → Impact detected
  - Excessive tilt angle → Vehicle rollover
- The system confirms accident by validating multiple sensor triggers to avoid false alarms.

Step 4: Accident Confirmation Logic

- Apply decision logic:

IF (G-force > Threshold) AND (Vibration detected OR Tilt angle abnormal)
  THEN Accident = TRUE
ELSE
  Continue Monitoring

Step 5: Location Acquisition

- When accident is confirmed, the GPS module fetches:
  - Latitude
  - Longitude
  - Time stamp

Step 6: Emergency Alert Transmission

- The GSM module sends an SMS alert to pre-stored emergency numbers.
- The message includes:
  - "Accident detected"
  - GPS location link (Google Maps format)

Step 7: Data Logging (Optional)

- Accident data and sensor values can be stored for analysis.

Step 8: System Reset

- After alert transmission, the system resets and returns to monitoring mode.

VII. ADVANTAGES

- Real-time Accident Detection
  Detects accidents instantly using accelerometer, vibration, tilt, and impact sensors without human intervention.
- Faster Emergency Response
  Automatically sends accident alerts with live GPS location to emergency contacts and hospitals, reducing rescue delay.
- Life-Saving System
  Immediate notification increases the chances of saving victims during the "golden hour".
- Accurate Location Tracking
  GPS module provides precise accident location for quick assistance.
- Continuous Vehicle Monitoring
  Monitors vehicle motion, tilt angle, and impact force continuously to ensure reliable detection.
- Low-Cost Implementation
  Uses affordable sensors and microcontroller modules, making it economically feasible.
- Automatic Alert System
  Eliminates the need for manual reporting after an accident when victims are unconscious.
- Easy Integration with Vehicles
  Can be installed in any vehicle without major modification.
- Reduced False Alarms
  Uses multiple sensor inputs together to confirm accident conditions before sending alerts.
- Data Logging for Analysis
  Accident data can be stored for future analysis and improvement **of road safety measures.**

VIII . LIMITATIONS

- **Sensor Accuracy Dependence**

The system relies heavily on accelerometer, vibration, tilt, and impact sensors. Incorrect calibration or sensor noise may lead to false accident detection or missed events.

- **False Positives in Rough Road Conditions** Potholes, speed breakers, or sudden braking on uneven roads can sometimes be misinterpreted as accidents.
- **GPS Signal Availability** In tunnels, dense urban areas, or remote regions, weak GPS signals can delay or prevent accurate location tracking.
- **Network Connectivity Requirement** The alert system depends on GSM/Internet connectivity. In areas with poor network coverage, emergency alerts may be delayed.
- **Power Supply Dependency** Continuous operation requires a stable power source from the vehicle battery. Power failure may stop the system from functioning.
- **Limited Accident Severity Assessment** The system detects abnormal motion but cannot precisely determine the severity of injuries or vehicle damage

IX . RESULTS AND DISCUSSION

The implemented Vehicle Accident Detection and Monitoring System (VADS) was tested under multiple simulated and real-time scenarios to evaluate its accuracy, responsiveness, and reliability. Experimental results showed that the integrated sensor network—comprising the accelerometer, vibration sensor, tilt sensor, impact detection, and GPS module—successfully identified abnormal vehicle conditions such as sudden collisions, rollovers, and high-impact shocks with high precision. The system was able to differentiate between normal road disturbances (speed breakers, potholes, and rough terrain) and actual accident conditions by applying threshold-based filtering and sensor data fusion. Upon detection, the system triggered an automated alert within a few seconds, transmitting the exact GPS coordinates and vehicle status to predefined emergency contacts. The response time for alert transmission was minimal, and the GPS location accuracy was found to be within an acceptable range for emergency navigation, demonstrating the system's effectiveness for real-time accident monitoring.

The discussion of the results highlights the system's potential to significantly reduce the delay in emergency response during road accidents. By automating accident detection and notification, the dependency on human intervention is minimized, which is crucial in cases where victims are unconscious or unable to call for help. The combination of multiple sensors improved detection reliability and reduced false positives compared to single-sensor approaches reported in existing literature. However, certain limitations were observed, such as sensitivity variations due to extreme road conditions and possible GPS signal loss in remote or covered areas. Despite these challenges, the overall performance indicates that VADS is a practical, cost-effective, and scalable solution for enhancing road safety and emergency communication in real-world environments.

X. FUTURE SCOPE

- **AI-Based Accident Prediction**
  Integrate Machine Learning models to predict possible accidents in advance using historical driving patterns, speed trends, and driver behavior analytics.
- **Integration with Smart Traffic Infrastructure**
  Connect the system with smart traffic lights and city surveillance networks to automatically control traffic flow and clear routes for ambulances.
- **Cloud and IoT Scalability**
  Deploy the system on cloud platforms with IoT dashboards for large-scale fleet monitoring, data storage, and real-time analytics across multiple vehicles.
- **Mobile Application for Emergency Services**
  Develop a dedicated mobile app for hospitals, police, and ambulance services to receive instant alerts with live GPS tracking and victim details.
- **Driver Health Monitoring**
  Add biometric sensors (heart rate, fatigue

detection, alcohol sensors) to detect driver health issues that may lead to accidents.

- **Vehicle-to-Vehicle (V2V) Communication**
  Enable communication between nearby vehicles to warn others instantly about accidents or hazardous road conditions.
- **Integration with Insurance Systems**
  Share authenticated accident data with insurance companies for faster claim processing and fraud prevention.
- **Accident Severity Classification**
  Use AI to classify accident severity (minor, major, critical) and prioritize emergency response accordingly.
- **Support for Electric and Autonomous Vehicles**
  Adapt the system for EVs and future autonomous vehicles with compatibility for onboard vehicle diagnostics.
- **Black Box Data Recorder**
  Implement a secure black-box module to store pre- and post-accident data for legal and forensic analysis.

REFERENCES

[1] World Health Organization, “Global Status Report on Road Safety,” Geneva, 2023.

[2] National Highway Traffic Safety Administration, “Traffic Safety Facts Annual Report,” U.S. Department of Transportation, 2022.

[3] S. Sharma and R. Mehta, “IoT-Based Vehicle Accident Detection and Alert System,” *International Journal of Engineering Research & Technology*, vol. 10, no. 5, 2022.

[4] K. Patel, J. Shah, and M. Desai, “Smart Accident Detection and Emergency Response System Using IoT,” *Procedia Computer Science*, vol. 171, pp. 234–241, 2020.

[5] R. Kumar and P. Singh, “Real-Time Vehicle Accident Detection Using Accelerometer and GPS,” *International Journal of Advanced Computer Science and Applications*, vol. 11, no. 3, 2020.

[6] A. Verma and S. Srivastava, “Automatic Vehicle Accident Detection and Messaging System Using GSM and GPS,” *International Journal of Scientific & Engineering Research*, vol. 9, no. 4, 2018.

[7] M. R. Khan and A. Ali, “Accident Detection and Alert System Using Vibration Sensor and Arduino,” *International Journal of Innovative Technology and Exploring Engineering*, vol. 8, no. 7, 2019.

[8] P. Gupta and N. K. Mishra, “Vehicle Monitoring and Accident Detection System Using IoT,” in *Proc. International Conference on Intelligent Systems and Signal Processing*, 2021.

[9] T. Nguyen and H. Tran, “Tilt Angle and Impact Force Based Accident Detection System,” *IEEE Access*, vol. 8, pp. 145623–145632, 2020.

[10] D. Lee and J. Park, “Embedded System for Vehicle Accident Detection Using MEMS Sensors,” *Sensors*, vol. 19, no. 12, 2019.

[11] S. R. Reddy and V. Lakshmi, “Real-Time Accident Detection and Ambulance Notification System,” *International Journal of Computer Applications*, vol. 177, no. 39, 2019.

[12] N. Ahmed, F. Rahman, and T. Islam, “IoT-Based Smart Vehicle Accident Prevention and Detection System,” *Journal of Network and Computer Applications*, vol. 148, 2019.

[13] B. Singh and A. Kaur, “Accident Detection and Location Tracking System Using GPS, GSM, and Arduino,” *International Journal of Engineering and Advanced Technology*, vol. 8, no. 6, 2019.

[14] H. Chen, Y. Li, and Z. Wang, “Machine Learning Approach for Vehicle Accident Detection Using Sensor Data,” *IEEE Internet of Things Journal*, vol. 7, no. 4, 2020.

[15] R. S. Patel, M. Joshi, and D. Trivedi, “Comparative Study of Sensors for Vehicle Accident Detection Systems,” in *Proc. International Conference on Electronics and Sustainable Communication Systems*, 2021.