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Intelligent Road Accident Detection and Emergency Response System Using IOT

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Abstract
Delays in reporting road accidents can hinder timely medical assistance, particularly when victims are unable to call for help or an accident occurs in an isolated location. This paper presents an Internet of Things (IoT)-based road accident detection and emergency alert system that combines motion and impact sensing with GPS positioning and GSM communication. An Arduino Uno microcontroller reads data from an accelerometer and a vibration sensor. Sensor readings are compared with predefined thresholds, and an abnormal event is treated as a potential accident after a verification step. The system then obtains latitude and longitude from a GPS module and sends an SMS alert through a GSM module to predefined emergency contacts. The thesis underlying this paper describes simulated tests involving normal operation, vibration, tilt, and impact. These tests are reported to have triggered alerts under abnormal conditions while avoiding alerts during normal conditions. However, numerical measurements of detection accuracy, latency, false-positive rate, and sample size are not provided; therefore, the findings should be interpreted as preliminary functional observations rather than a statistically validated evaluation. The proposed design offers a practical prototype for automated accident notification, with future scope for machine-learning-based classification, mobile and cloud integration, and field testing.

Keywords: Internet of Things, road accident detection, Arduino Uno, accelerometer, vibration sensor, GPS, GSM, emergency alert

1. Introduction
Road traffic accidents can result in serious injury and loss of life. In addition to the severity of the crash, the time taken to communicate the incident and identify its location can affect how quickly assistance is dispatched. Conventional reporting often depends on a victim or witness making a phone call. This approach may fail when the victim is unconscious, unable to use a phone, or outside a populated area.

IoT technologies provide a way to monitor vehicle motion, process sensor measurements locally, and communicate an alert when an abnormal event is detected. The system discussed in this paper combines an accelerometer, a vibration sensor, a microcontroller, GPS, and GSM. Its principal objective is to detect possible accident conditions automatically and send location information to stored emergency contacts.

The main contributions of the prototype are: (i) continuous sensing of vehicle movement and impact, (ii) threshold-based event detection with a verification step, (iii) GPS-based location acquisition, and (iv) GSM-based SMS notification. The work is a prototype demonstration; claims about real-world lifesaving impact require larger controlled and field evaluations.

2. Related Work
The source thesis groups existing approaches into four broad categories. Manual reporting is simple but depends on a person noticing the accident and communicating details. Smartphone-based systems can use built-in accelerometers and GPS without dedicated vehicle hardware, but their operation depends on phone availability, battery state, permissions,

and reliable detection logic. GPS–GSM systems provide a practical way to send location-bearing messages, although positioning and cellular coverage may be limited in some environments. IoT-based systems combine sensors and a microcontroller to automate detection, but require hardware installation, power management, calibration, and maintenance.

These approaches reveal recurring design challenges: reducing reporting delay, limiting false alarms, obtaining useful location data, and maintaining communication under varying network conditions. The proposed prototype addresses these issues through local sensor processing and automatic alert generation. The references listed in the underlying thesis are reproduced in the References section; their bibliographic details should be checked against the original publications before journal submission.

3. Proposed System Architecture

The prototype consists of the following hardware and software elements:

- Accelerometer sensor: measures changes in acceleration and orientation that may indicate a sudden movement or collision.
- Vibration sensor: detects a strong vibration or impact event.
- Arduino Uno: reads sensor data, applies threshold-based decision logic, and controls the communication modules.
- GPS module: provides geographic coordinates (latitude and longitude) for the reported event.
- GSM module and SIM card: transmit an SMS alert to one or more predefined phone numbers.
- Power supply: provides operating power to the connected components.

At a high level, the data flow is: sensors → microcontroller → event verification → GPS location acquisition → GSM SMS alert. Following an alert, the controller returns to monitoring so that subsequent events can be observed. The prototype can be extended with a mobile interface, cloud storage, or a dashboard, but those extensions are proposed future work rather than established features of the reported implementation.

4. Methodology

4.1 Continuous monitoring

After power-on, the microcontroller initializes the sensors and communication modules. Sensor values are repeatedly sampled to monitor movement, tilt, and vibration. Under normal conditions, the measurements are expected to remain within the configured operating range.

4.2 Potential accident detection

The controller compares incoming sensor values with predefined thresholds. If a value crosses a threshold, the event is treated as a potential accident. A verification step is intended to reduce false detections caused by ordinary movement or minor vibration. The thesis does not specify the exact threshold values, sampling frequency, or full verification logic, so these parameters must be documented and calibrated before the system can be independently reproduced.

4.3 Location acquisition and alerting

After the event is confirmed, the system reads the GPS latitude and longitude. The GSM module is then instructed to send an SMS to a predefined number. The intended message contains an accident alert and the location coordinates. Successful delivery depends on GPS fix availability, SIM and module configuration, cellular coverage, and the validity of the destination number.

4.4 Algorithm

1. Start the system and initialize the microcontroller, sensors, GPS, and GSM modules.
2. Continuously read motion and vibration measurements.
3. Compare the measurements with calibrated thresholds.
4. If a threshold is crossed, perform the configured verification step.
5. If an accident is confirmed, obtain the latest valid GPS coordinates.

6. Generate and transmit an SMS alert to predefined emergency contacts.
7. Record or display the event status where supported, then resume monitoring.

5. Implementation

The reported hardware prototype uses an Arduino Uno, accelerometer, vibration sensor, GPS module, GSM module, SIM card, and power supply. The software is described as being developed in the Arduino IDE using embedded C/C++. The microcontroller acts as the central controller and coordinates sensor readings and alert transmission.

The thesis includes a basic serial communication example for GPS and GSM modules. In that example, the latitude and longitude are initialized to placeholder values, and the SMS routine is invoked during setup for testing. As written, this code illustrates basic SMS communication but does not, by itself, implement complete accident-triggered logic or parse live GPS coordinates into the message. A deployment-ready implementation should parse GPS data, check coordinate validity, trigger SMS only after confirmed events, handle module responses and timeouts, and prevent repeated alerts for one event.

The system should also include a cancellation window or manual confirmation mechanism where appropriate, a retry policy for failed messages, power-failure handling, and a way to indicate when GPS or cellular service is unavailable. These are important engineering considerations for a safety-related prototype.

6. Testing and Results

The source thesis reports simulated tests under normal, vibration, tilt, impact, and continuous-monitoring conditions. The reported outcomes are summarized below. Since the source does not provide a test count, raw sensor values, measured alert delays, or a confusion matrix, the table records qualitative observations only.

Test condition	Reported sensor/event response	Alert outcome	Reported status
Normal operation	Stable	No alert	Success
Vibration	High vibration	Alert generated	Success
Tilt	Position changed	Alert generated	Success
Impact	Sudden sensor change	Alert generated	Success
Continuous monitoring	Stable	No alert	Success

These observations suggest that the prototype's basic event-to-alert sequence was exercised under simulated conditions. The thesis also reports that threshold adjustment helped prevent minor vibrations from triggering alerts. Nevertheless, the available evidence does not establish a quantified detection rate or prove reliability on real roads. A stronger evaluation should report the number and type of trials, true positives, false positives, false negatives, GPS acquisition time, SMS transmission and delivery latency, and performance under weak or absent network coverage.

6.1 Recommended evaluation metrics

- Detection precision = true positives / (true positives + false positives).
- Detection recall = true positives / (true positives + false negatives).
- False-alarm rate during normal driving, reported per hour or per trip.
- End-to-end alert latency, measured from event onset to SMS dispatch and, separately, message receipt.
- GPS availability and coordinate error under open-sky, urban-canyon, and covered conditions.
- Operational stability, power consumption, and recovery after communication failure.

7. Discussion

The key strength of the design is its straightforward integration of sensing, local decision-making, positioning, and cellular communication. Automatic notification can reduce reliance on a victim initiating a call, while including coordinates can make the alert more actionable than a message without location details. The use of commonly available embedded components also makes the prototype suitable for academic experimentation.

Important limitations remain. Threshold-based sensing may confuse potholes, hard braking, device handling, or other non-crash events with accidents. Conversely, some crashes may not create the expected sensor signature. GPS can take time to obtain a fix or may be inaccurate near tall buildings and under cover. GSM messaging relies on network availability and does not guarantee that a recipient reads the message. In addition, the source thesis reports qualitative results but no numerical performance metrics or large-scale road trials.

The system should therefore be regarded as a supplementary notification aid, not as a replacement for official emergency systems or a certified vehicle safety device. Any real-world deployment should include extensive testing, robust fault handling, privacy safeguards for location data, and clear arrangements for responding to alerts.

8. Future Scope

- Machine-learning classification using labelled sensor data to distinguish crashes from ordinary vehicle events.
- A mobile application for alert management, location viewing, and emergency-contact configuration.
- Cloud storage and a monitoring dashboard for fleet operators and authorized responders.
- Validated integration with emergency-response organizations, rather than assuming that an SMS automatically dispatches an ambulance.
- Camera integration where lawful and appropriate, with controls for consent, retention, and access.
- A manual panic button for incidents that do not trigger automatic detection.
- Improved enclosure, vibration isolation, automotive-grade power protection, and compact installation.
- Field trials across different vehicles, speeds, road surfaces, weather conditions, and cellular coverage levels.

9. Conclusion

This paper presented an IoT-based road accident detection and emergency alert prototype using an Arduino Uno, motion and vibration sensors, GPS, and GSM. Its intended workflow monitors vehicle conditions, detects abnormal sensor readings, obtains location coordinates, and sends an SMS to predefined contacts. The underlying thesis reports successful qualitative tests for simulated vibration, tilt, and impact events, with no alert reported during normal test conditions.

The current evidence supports a preliminary functional demonstration, but not a quantified claim of high accuracy or reduced mortality. Future work should make the detection algorithm reproducible, implement complete GPS parsing and communication-failure handling, and evaluate the prototype using measured performance metrics and real-world trials. With these improvements, the design could contribute to a broader vehicle-safety and emergency-notification system.

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