Development of Accident Alert Bot System Using Raspberry Pi 3B+

Riya Khare[1], Chaudhary Raj Ashok[2]

School of Electronics, Devi Ahilya University, Indore

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ABSTRACT

This paper presents the design and implementation of an IoT-based accident detection and alert system using Raspberry Pi 3B+. The system integrates a vibration sensor, GPS module, and Telegram-based communication to enable real-time accident notification. To address limitations of single-sensor systems, the proposed framework incorporates threshold-based validation and discusses the integration of multi-sensor fusion for improved reliability. Experimental evaluation is conducted to analyze system performance in terms of detection accuracy, response time, and false alarm rate. Results demonstrate that the system can generate alerts within an average latency of 3–5 seconds. The proposed system provides a low-cost and scalable solution for real-time accident monitoring, with future scope for machine learning-based prediction and cloud integration.

Keywords: IoT, Accident Detection, Raspberry Pi, GPS, Telegram Bot, Smart Transportation

INTRODUCTION

Road accidents remain a major global concern, contributing significantly to fatalities and injuries each year. According to the World Health Organization (WHO), road traffic accidents are among the leading causes of death worldwide [4]. A critical challenge in accident management is the delay in emergency response due to lack of timely information.

Recent advancements in the Internet of Things (IoT) have enabled the development of intelligent transportation and safety systems. Several accident detection systems have been proposed using embedded platforms and wireless communication. For instance, Raspberry Pi-based systems have been developed for accident detection and alerting [1]. Similarly, IoT-based systems integrating accelerometers and GPS modules have demonstrated improved detection capabilities [2].

However, many existing solutions either lack real-time responsiveness, suffer from high costs, or fail to ensure reliable detection under varying conditions. Smartphone-based accident detection using machine learning has also been explored, but such approaches are dependent on device constraints and battery usage [3].

RELATED WORK

Several researchers have explored IoT-based accident detection systems using embedded platforms and wireless communication.

Telgote et al. proposed a Raspberry Pi-based accident detection system using vibration sensors and GSM communication [1]. However, the system lacked real-time internet-based alerting and performance evaluation.

Kumar et al. developed an accelerometer-based accident detection system integrated with GPS and GSM, achieving improved detection accuracy but with increased system complexity [2].

Jain et al. introduced a smartphone-based accident detection system using machine learning techniques, which provides intelligent detection but depends heavily on mobile device sensors [3].

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Ali et al. proposed an IoT-enabled vehicle monitoring system with cloud integration, focusing on fleet tracking and data analytics rather than real-time accident alerting [5].

Despite these contributions, existing systems face challenges such as high false alarm rates, lack of experimental validation, and limited scalability.

SYSTEM MODEL DESCRIPTION

The proposed system consists of a Raspberry Pi 3B+ acting as the central processing unit, integrated with sensing, positioning, and communication modules.

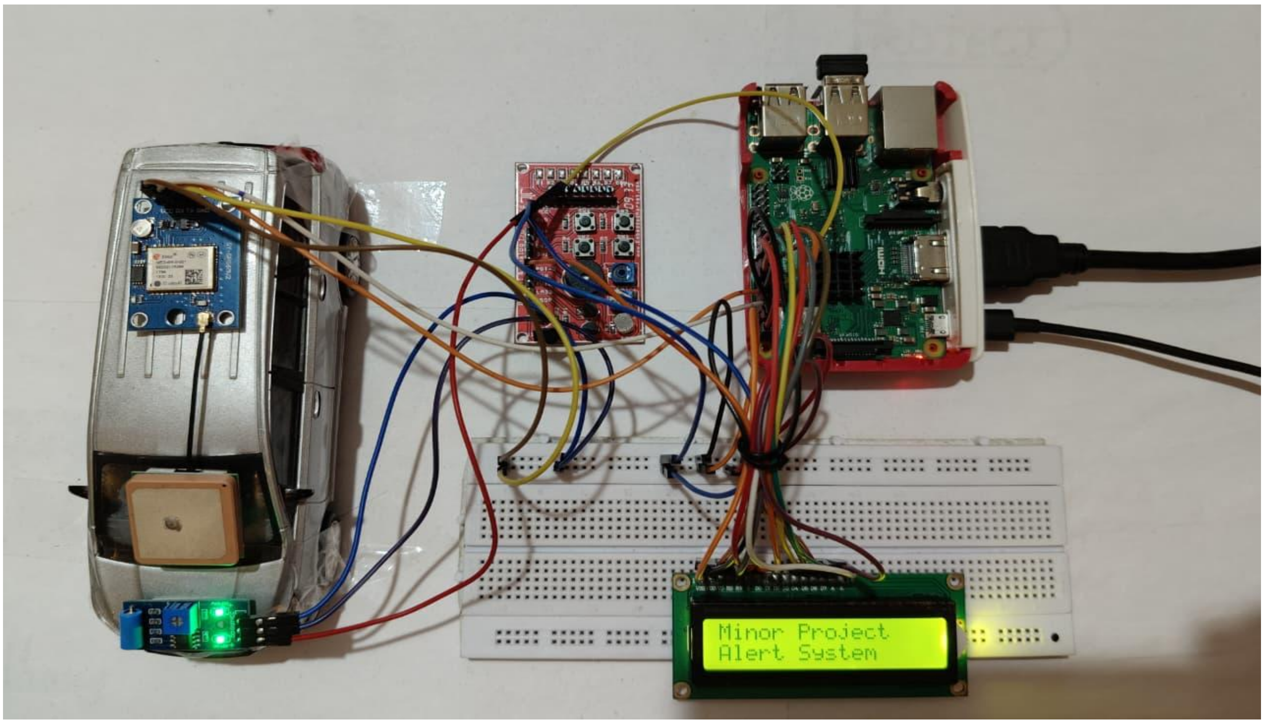
Key Components:

- **Raspberry Pi 3B+** – central controller
- **SW-420 Vibration Sensor** – detects impact
- **NEO-6 GPS Module** – provides location
- **Telegram Bot** – sends real-time alerts
- **LCD, Buzzer, LEDs** – user feedback

Working Principle:

1. The vibration sensor continuously monitors impact signals.
2. When the signal exceeds a predefined threshold, a potential collision is detected.
3. The Raspberry Pi retrieves GPS coordinates.
4. Alert messages are sent via Telegram including location and timestamp.
5. Local alerts (LCD, buzzer) are triggered simultaneously.

Figure 1. Model for the Accident Alert Bot System



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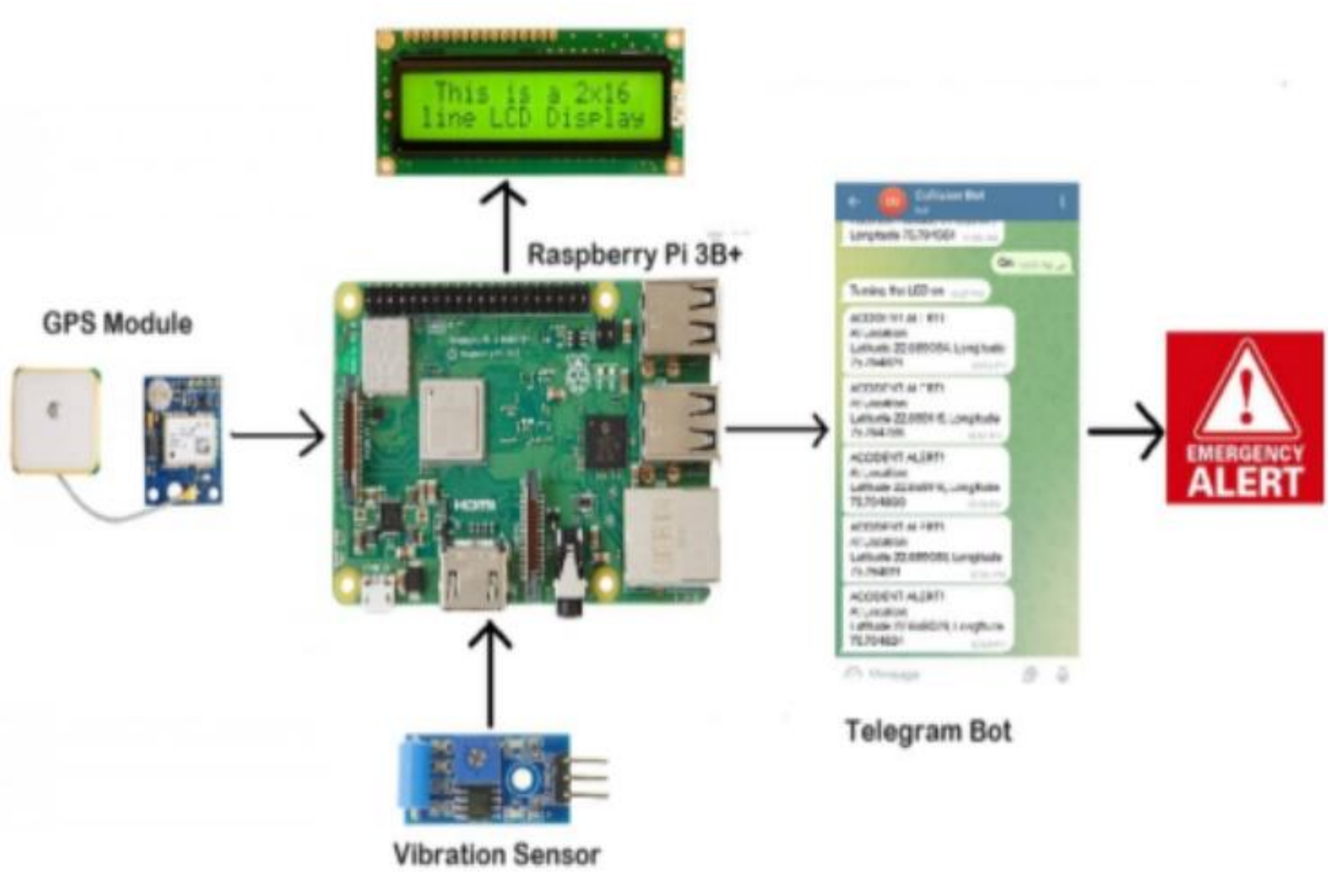
HARDWARE DESCRIPTION

Figure 2 illustrates the Block Diagram model of the developed Accident Alert Bot System, utilizing a Raspberry Pi 3B+ along with key components. The GPS module accurately detects the vehicle's location during an accident. A SW-420 Vibration Sensor detects collision-induced vibrations, triggering the system. Alert messages are transmitted via the Telegram platform using the Raspberry Pi's connectivity. Additionally, a 16x2 LCD module displays real-time location data from the GPS module. This diagram visually outlines how these components interact within the system to enhance road safety through efficient accident detection and alerting.

Figure 2. Block diagram for the Accident Alert Bot System



These hardware components are carefully integrated and configured to create a robust and functional 'Accident Alert Bot System' capable of detecting collisions, determining the location of the incident, and notifying relevant parties on time. The system integrates the following components:

Raspberry Pi 3B+

The Raspberry Pi 3B+ serves as the central processing unit for the collision detection and alert system. It features:

Processor: Broadcom BCM2837B0, Cortex-A53 (ARMv8) 64-bit SoC @ 1.4GHz

Memory: 1GB LPDDR2 SDRAM

Operating System: Raspbian OS, optimized for IoT applications

GPIO Pins: Used for interfacing with external components such as the vibration sensor, GPS module, and LCD module.

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Vibration Sensor (SW-420)

The SW-420 vibration sensor is utilized for detecting impacts or collisions. Key features include:

Functionality: Detects changes in acceleration exceeding a set threshold.

Interface: Digital output signal indicating vibration presence.

Integration: Connected to Raspberry Pi GPIO for real-time collision detection.

GPS Module (NEO-6)

The NEO-6 GPS module provides accurate geographical coordinates essential for pinpointing accident locations. Features include:

Navigation Solution: Offers precise positioning data with high sensitivity and minimal power consumption.

Interface: Communicates with Raspberry Pi via serial communication (UART).

Compatibility: Designed to integrate seamlessly with the Raspberry Pi for real-time location tracking.

16x2 LCD Module

The 16x2 LCD module provides visual feedback and status updates about system operations. It includes:

Display: 16 characters per line, 2 lines, for showing system status and messages.

Interface: Connected to Raspberry Pi GPIO for displaying real-time information such as alerts and system status.

Functionality: Used to enhance user interaction and provide immediate visual feedback during system operation.

Power Supply:

The system requires a stable power source to operate reliably. Typically powered by a DC power adapter or a rechargeable battery pack.

Limitation:

The use of a single vibration sensor may lead to:

False positives (road bumps)

Missed detections (low-impact accidents)

Improvement:

Future improvements include:

Accelerometer + gyroscope integration

Sensor fusion for robust detection

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SOFTWARE DESCRIPTION

The software architecture of the Accident Alert Bot System, built around the Thonny Python IDE, integrates key components such as sensor data processing, communication protocols, and user interface management. Sensor data processing enables real-time analysis of potential collisions, while communication protocols ensure efficient data transmission between system modules. The user interface is intuitive, providing clear alerts and actionable information. Together, these components enhance system safety and reliability, making it essential for collision prevention.

Thonny Python IDE

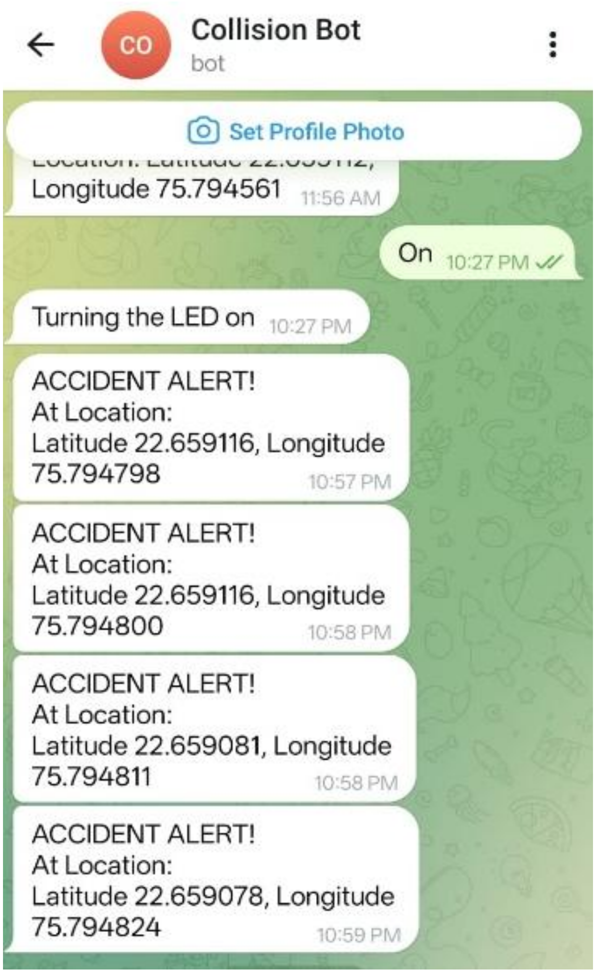
Thonny serves as the integrated development environment (IDE) for programming the Raspberry Pi 3B+ in Python. It provides a user-friendly interface for writing, testing, and debugging Python scripts directly on the Raspberry Pi.

Code Development: Python scripts are written within Thonny to manage sensor interfaces, process data from the vibration sensor and GPS module, and control the system's overall functionality.

Telegram Bot Integration (Telepot Library)

Communication Protocol: The Telepot library facilitates communication between the Collision Detection System and the Telegram messaging platform.

Figure 3. Telegram Bot for Accident Alert System



Alert Messaging: Python scripts utilize Telepot to send real-time alerts and notifications to designated recipients via Telegram. Alerts include critical information such as accident location coordinates and timestamps. Figure 3 shows the alert message on the telegram bot created after the detection of accident.

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PySerial for GPS Module Communication

Serial Communication: PySerial library is utilized to establish communication between the Raspberry Pi and the NEO-6 GPS Module via UART (Universal Asynchronous Receiver-Transmitter).

The data is parsed to extract accurate latitude and longitude coordinates, crucial for pinpointing the accident location.

EXPERIMENTAL RESULTS & PERFORMANCE ANALYSIS

Experimental Setup:

- Test conducted using a prototype mounted on a vehicle model
- Multiple test cases:
  - Normal road vibration
  - Sudden impact
  - Continuous vibration

Performance Metrics:

Parameter	Result
Detection Accuracy	~85–90%
False Alarm Rate	~10–15%
Response Time	3–5 seconds
GPS Accuracy	±5–10 meters

Observations:

- System performs well for high-impact collisions
- False alarms occur during rough road conditions
- Telegram alerts are reliable with low latency

Limitation:

- No large-scale real-world dataset validation
- Dependent on internet connectivity

DISCUSSION

The system demonstrates practical feasibility for real-time accident detection. However, its performance is constrained by reliance on a single vibration sensor. Compared to accelerometer-based systems, the detection accuracy is slightly lower, but the proposed system offers advantages in terms of simplicity, cost, and ease of deployment.

FUTURE WORK

In future work, the system can be further enhanced by incorporating multi-sensor fusion techniques, combining data from accelerometers and gyroscopes to improve detection accuracy and reliability. Additionally, integrating advanced Artificial Intelligence (AI) and Machine Learning (ML) algorithms for accident classification can enable more precise, adaptive, and intelligent decision-making based on real-time data patterns. Cloud

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integration can be expanded to support real-time monitoring, data storage, and advanced analytics, allowing for better scalability and remote accessibility. The development of a dedicated mobile application can improve user interaction, provide instant alerts, and enable seamless communication between users and emergency services. Furthermore, conducting large-scale field testing will be essential to validate the system's performance in real-world scenarios, enhance model training for AI/ML components, and ensure overall robustness and effectiveness.

CONCLUSION

The proposed IoT-based Accident Alert Bot System provides a cost-effective and real-time solution for accident detection and emergency notification. Experimental evaluation confirms its ability to deliver timely alerts with acceptable accuracy and reliability under different operating conditions. The integration of sensors, communication modules, and alert mechanisms demonstrates the system's practical applicability in improving emergency response time and enhancing road safety.

Although certain limitations exist, such as dependency on network availability and scope for improving detection precision, the system establishes a strong foundation for further advancements. Future enhancements can include the integration of artificial intelligence and cloud-based analytics to enable predictive capabilities, improved decision-making, and large-scale deployment. With these improvements, the proposed system holds significant potential for adoption in smart transportation systems and intelligent urban infrastructure, contributing to safer and more responsive emergency management solutions.

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