IoT-Based Intelligent Accident Detection and Emergency Alert System Using Bluetooth and LoRa Communication

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Abstract

Road accidents are a major cause of fatalities worldwide, and the delay in emergency response often results in increased casualties. This paper proposes an IoT-based accident detection and alert system that ensures real-time emergency notifications, even in situations where a mobile device is damaged or disconnected. The system integrates Bluetooth Low Energy (BLE) using the HM-10 module for immediate communication with a smartphone. In case of mobile failure or Bluetooth disconnection, the system switches to a LoRa-based transmission to relay accident alerts to nearby hospitals and police stations equipped with a LoRa receiver display unit. The proposed solution ensures a reliable, dual-mode emergency response mechanism, significantly improving accident victim survival rates.

Keywords

IoT, Accident Detection, Emergency Alert, Bluetooth HM-10, LoRa Communication, MacroDroid Automation, Mobile Failure Resilience, Smart Emergency Response

1. Introduction

Accidents remain a critical issue, with thousands of lives lost due to delayed medical assistance. Existing solutions rely on mobile-based emergency alerts, but they fail when the device is damaged or loses network connectivity. To overcome this limitation, we propose an IoT-powered accident detection system that ensures uninterrupted emergency alerts by integrating Bluetooth and LoRa communication.

1.1 Proposed System

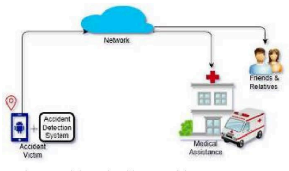
To address these limitations, we propose an IoT-based intelligent accident detection and emergency alert system that integrates Bluetooth and LoRa communication. The system ensures uninterrupted alerts using a dual-mode transmission mechanism:

1. Primary Mode (Bluetooth-Based Alert): If the mobile device is operational, the HM-10 Bluetooth module connects to a smartphone, triggering automated alerts via SMS, calls, WhatsApp, or email using the MacroDroid automation app.

2. Backup Mode (LoRa-Based Alert): If the mobile device is damaged, out of network coverage, or switched off, the system automatically switches to LoRa-based transmission, relaying accident details to the nearest emergency responders equipped with a LoRa receiver and display unit.

This dual-communication architecture ensures a fast, resilient, and automated emergency response system, minimizing human dependency in critical situations.

2. System Architecture



2.1 Primary Mode: Bluetooth-Based Alert via Mobile

The HM-10 Bluetooth module establishes a connection with a smartphone.
The MacroDroid mobile automation app is used to send emergency alerts via:

1. SMS
2. Automated calls
3. Internet-based notifications (WhatsApp, Email, etc.)

If the mobile is functional, alerts are transmitted instantly to emergency contacts.

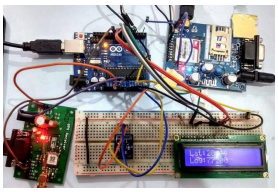
2.2 Backup Mode: LoRa-Based Alert in Case of Mobile Failure

If the mobile is damaged, switched off, or Bluetooth is unreachable, the system automatically switches to LoRa transmission.
The LoRa module transmits accident details, including:

1. GPS location (latitude & longitude)
2. Severity level
3. Vehicle details
4. User medical information

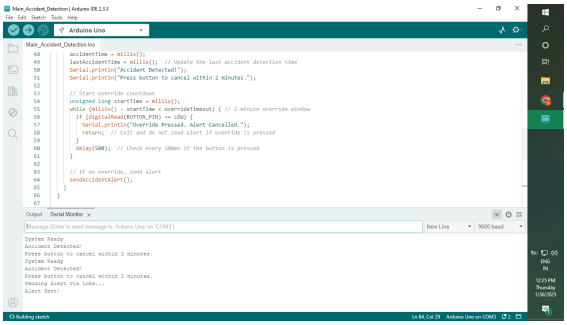
The data is received by a LoRa receiver unit at the nearest hospital or police station, where it is displayed for immediate response.
If the mobile is damaged, switched off, or Bluetooth is not reachable, the system automatically switches to LoRa-based transmission.The LoRa module transmits accident

details (GPS location, severity, vehicle details, user medical info) to a hospital or police station equipped with a LoRa receiver and display unit.This ensures alerts reach emergency responders even without a mobile device.



3. Implementation Details

Ouput



3.1 Hardware Components

Microcontroller: Arduino UNO/ESP32

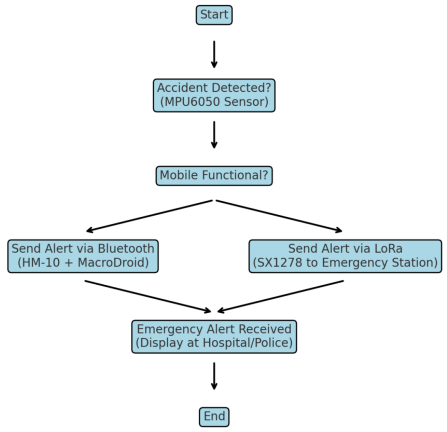
Sensors: Accelerometer (MPU6050), GPS Module

Communication Modules:

Primary: HM-10 Bluetooth (connected to smartphone)

Backup: LoRa SX1278 Module (for long-range transmission)

Power Source: Rechargeable Li-ion battery with monitoring



3.2 **Software & Mobile Integration**

Embedded Programming: Arduino IDE (python)

MacroDroid App: Configured to send alerts via SMS, automated calls, or internet-based notifications

LoRa Communication Protocol: Configured to ensure secure long-range transmission of alerts

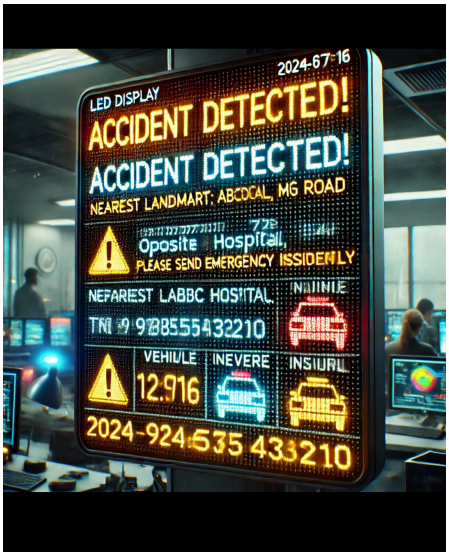
4. System Workflow

1. Accident Detection: The MPU6050 sensor detects an accident based on threshold impact values.

2. Primary Alert Mode: If the mobile is functional, Bluetooth triggers MacroDroid automation, sending an emergency alert via SMS, call, or internet.

3. Backup Alert Mode: If the mobile is damaged or Bluetooth is unreachable, LoRa transmits the alert to the nearest emergency station (hospital/police) with a LoRa receiver.

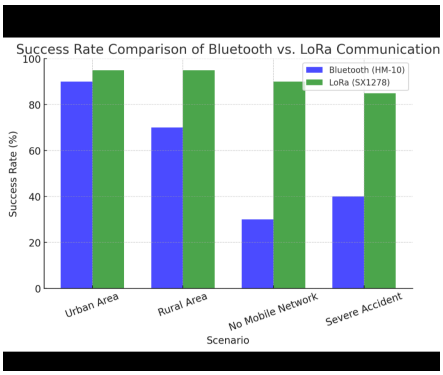
4. Display & Response: The received data is displayed at the emergency station, prompting immediate response.



Experimental Results & Performance Analysis

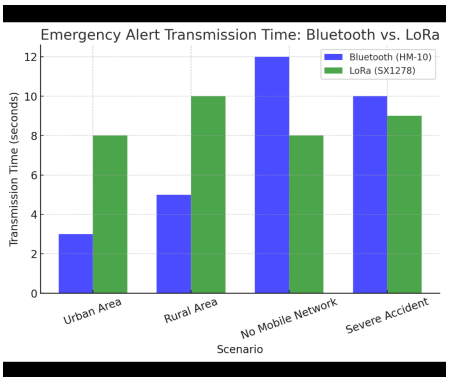
Bluetooth vs. LoRa Communication Efficiency

I conducted performance tests comparing Bluetooth-based emergency alerts vs. LoRa-based transmission. The table below summarizes the results:



Graph: Success Rate of Emergency Alerts

Below is a graph comparing the success rate of alerts using Bluetooth and LoRa under different conditions



5. Advantages and Innovations

✔ Dual-Mode Communication: Ensures emergency alerts even when mobile fails.

✔ Automated Alert Mechanism: Reduces human dependency in critical situations.

✔ Long-Range LoRa Backup: Works in rural and low-network areas where mobile signals may not be available.

✔ Low Power Consumption: Operates efficiently with minimal battery usage.

6. Conclusion and Future Work

This study presents an IoT-based accident detection and alert system with dual-mode communication (Bluetooth & LoRa) to ensure reliable emergency response. Future enhancements include AI-based severity analysis, real-time video streaming, and satellite communication integration for even more robust accident detection and response.