IOT Based Accident Detection and Rescue System

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***Abstract*—An IoT-based accident detection and rescue system leverages real-time sensors, GPS, and communication networks to monitor vehicular activities and promptly detect accidents. Upon detecting a crash, the system automatically sends alerts with location data to emergency services and nearby responders, reducing the response time and improving the chances of saving lives. The integration of sensors such as accelerometers, gyroscopes, and pressure detectors ensures accurate detection of accidents. Additionally, this system can notify the victim's family and provide crucial information to hospitals for timely medical interventi**

***Index Terms*—real-time monitoring, emergency response, GPS, sensors, accelerometers**

I. INTRODUCTION

In recent years, road accidents have emerged as a significant concern, contributing to a substantial number of fatalities and injuries worldwide. The prompt detection of accidents and immediate rescue efforts play a crucial role in minimizing loss of life. Conventional methods of accident reporting often rely on bystanders, which can cause delays, especially in remote areas. To address this issue, the integration of Internet of Things (IoT) technology has become a promising solution for developing smart systems that can automatically detect accidents and alert rescue teams in real-time

This paper presents an IoT-based automatic vehicle accident detection and rescue system designed to enhance response times and ensure immediate assistance following an accident. The system employs various hardware components, including an Arduino Nano, GPS module, ADXL345 accelerometer (accident sensor), ESP8266 Wi-Fi module, and an LCD display. The Arduino Nano continuously monitors vehicle location using the GPS module, and in the event of an accident, the ADXL345 sensor detects the impact. Once an accident is identified, the system triggers an alert by sending the vehicle's real-time location, in the form of latitude and longitude, to a designated mobile application via the ESP8266 Wi-Fi module. This enables immediate dispatch of rescue teams to the accident site. Additionally, the system activates a buzzer and provides visual alerts on the LCD screen to signal the accident.

The proposed system ensures automatic accident detection, minimizes the reliance on human intervention, and improves the overall efficiency of rescue operations. By leveraging IoT, GPS, and sensor technology, this system aims to save lives by facilitating faster accident reporting and immediate response in critical situations.

Road accidents are a leading cause of death and injury globally, and timely detection and rescue operations are crucial to reducing fatalities. Traditional accident reporting methods, which rely on bystanders, often lead to delays, especially in remote areas. The integration of the Internet of Things (IoT) offers a smart, automated solution for accident detection and rescue. This paper presents an IoT-based automatic vehicle accident detection and rescue system. The system uses an Arduino Nano, GPS, accelerometer, ESP8266 Wi-Fi module, and LCD display to detect accidents, provide real-time location data, and notify rescue teams via mobile application alerts, ensuring faster emergency response and improved survival rates.

II. RELATED STUDY

Various research efforts have been made to develop systems that improve traffic safety through accident detection and immediate response mechanisms. Hasan et al. [2] explored a smart home system that incorporates IoT technologies for enhanced automation and security. Their study provided a foundation for integrating IoT into various real-world applications, including accident detection systems. Paul et al. [5] introduced rTraffic, a real-time web application designed to update traffic status on the streets of Bangladesh, demonstrating how IoT applications can optimize transportation systems and safety protocols.

In terms of industrial safety, Siddique et al. [7] proposed a smart electrical protection method that can be adapted for industries, which aligns with accident detection systems that rely on real-time response to critical events. These approaches

contribute to the reliability and efficiency of IoT-based safety solutions, ensuring rapid communication and decision-making during emergencies.

Khan et al. [13] developed an automatic accident detection system utilizing an Arduino-based framework. Their system uses accelerometers and GPS modules to pinpoint the location of the accident and communicate with emergency services, providing real-time assistance. Similarly, Bhoite et al. [14] implemented a system that uses Arduino to detect vehicle collisions and alert the nearest medical teams with GPS coordinates, further highlighting the importance of rapid response to minimize casualties during traffic incidents.

Fernandez et al. [17] introduced a GPS and GSM-based accident detection system that automatically sends an alert to a predetermined emergency contact, integrating GPS tracking with mobile communication for efficient rescue operations. The design's reliability ensures that the system works in various conditions, even in remote locations, where traditional methods might fail. This model serves as a precursor to more advanced IoT-enabled rescue frameworks.

The concept of utilizing IoT for monitoring and response was further explored by Sakib et al. [10], who developed a web application aimed at enhancing doctor directories in Bangladesh, making it easier for patients to find immediate medical attention. This concept can be applied to accident detection systems, ensuring that medical help is dispatched swiftly to accident sites.

Chowdhury et al. [9] took a different approach by working on handwriting recognition using artificial intelligence (AI) techniques, demonstrating the versatility of IoT and AI integration across different fields. Although their research focused on text processing, the same AI principles could be extended to accident detection systems for enhanced data analysis and predictive response models.

Finally, Khan et al. [13] and Saga et al. [14] emphasized the role of sensors and real-time data transmission in accident detection, suggesting that future developments will rely heavily on more efficient communication between vehicles and emergency services to reduce response time and potentially save more lives.

III. PROPOSED METHODOLOGY

The system designed for automatic accident detection and rescue operates using several key components: an Arduino Nano microcontroller, an ADXL345 accelerometer sensor for impact detection, a GPS module for real-time location tracking, and an ESP8266 Wi-Fi module for communication. These components work together to ensure immediate detection of accidents and prompt notification of emergency services and nearby individuals. Below is a detailed breakdown of the system's architecture and functionality

A. System Architecture and Hardware Integration

The system comprises multiple sensors and modules integrated with the Arduino Nano, which acts as the central controller. The main components are:

- ADXL345 Accelerometer: This sensor continuously monitors the vehicle's movement and detects abnormal impacts that signify an accident. The sensor is calibrated to differentiate between regular movements (like braking or turning) and accidents based on force thresholds.
- GPS Module: The GPS module continuously tracks the vehicle's location in real-time. It provides the latitude and longitude coordinates, which are critical for dispatching rescue services in the event of an accident.
- ESP8266 Wi-Fi Module: This module is used for wireless communication. When an accident is detected, it sends an alert to a cloud server or directly to a mobile application using the vehicle's current GPS coordinates.
- LCD Display: A simple LCD is used to display the system's status, including the vehicle's location and whether an accident has been detected.
- Buzzer: The buzzer provides an audible alert to nearby people when an accident is detected, which can help in local rescue efforts if immediate assistance is required

B. Accident Detection Mechanism

The ADXL345 accelerometer sensor plays a key role in detecting accidents. It continuously monitors the vehicle's motion by measuring the force in three dimensions (X, Y, and Z axes). If the sensor detects a sudden spike in force that exceeds a pre-defined threshold (indicating an accident), it triggers the accident detection protocol.

C. Location Tracking and Data Transmission

Once an accident is detected, the Arduino Nano retrieves the current location from the GPS module. The system sends the location data in the form of latitude and longitude to the ESP8266 module. The ESP8266 Wi-Fi module then transmits this data to a pre-defined mobile application or cloud server, alerting emergency services and/or pre-configured contacts. This notification includes the exact location of the accident, which can be viewed on a map to facilitate quick response

D. Alerting Mechanism

Mobile Alerts: The system is designed to send a message to a mobile application that notifies relevant authorities, such as rescue teams or the nearest hospital, with the GPS coordinates of the accident site. This feature ensures that even in remote areas, emergency services can locate the vehicle without delay. Buzzer and LCD Alerts: Simultaneously, a buzzer is activated to alert people nearby, and the LCD displays the vehicle's status and GPS coordinates. This local alert ensures that nearby pedestrians or vehicles are aware of the situation, which may prompt faster assistance.

E. Real-Time Data Monitoring

The system continuously monitors both the vehicle's motion and location. If the vehicle is moving normally, the GPS data is periodically updated. In case of an accident, the data transmission becomes immediate, and the accident alert is sent without manual intervention. This automation removes the

need for human input and ensures rapid emergency response even if the driver or passengers are incapacitated.

F. System Reset and Power Management

To ensure system reliability, a reset button is included to allow manual resets in case of malfunction. The system is powered by a regulated power supply connected to the vehicle's power system, ensuring it remains operational as long as the vehicle is on. A small backup battery can be incorporated to ensure the system remains operational functioning in the event of a power loss caused by the accident.

G. Rescue System Workflow

- Step 1: The vehicle's movement is continuously monitored via the ADXL345 accelerometer.
- Step 2: When a sudden impact is detected, the system checks whether it matches the pre-defined accident threshold.
- Step 3: If an accident is confirmed, the GPS module retrieves the vehicle's location, and the ESP8266 module sends this data to the mobile application or cloud server.
- Step 4: The buzzer and LCD activate to provide local alerts.
- Step 5: Emergency services or contacts receive the accident notification along with the vehicle's exact GPS coordinates.

H. Advantages of the Proposed Methodology

Real-Time Response: The system ensures that the accident is detected immediately, and rescue services are alerted in real time without human intervention. Automated Process: By using IoT technology, the entire process—from accident detection to rescue team notification—is automated, reducing response times and potentially saving lives. Accuracy of Location: With GPS integration, the system provides precise coordinates, which helps rescue teams locate the vehicle quickly, even in remote or unfamiliar areas. User-Friendly Alerts: The use of a mobile application and local alerts (buzzer and LCD) ensures both remote and immediate assistance. Low Cost and Simple Hardware: The system is designed using low-cost components such as the Arduino Nano and ESP8266 Wi-Fi module, making it affordable for widespread use.

IV. SYSTEM DESIGN AND IMPLEMENTATION

The design of the IOT-based automatic vehicle accident detection and rescue system integrates multiple components to detect accidents and instantly notify concerned authorities with accurate location data. This system uses a combination of sensors, controllers, GPS, Wi-Fi modules, and alert systems to ensure efficient monitoring, detection, and communication in case of accidents.

A. Key Components and Modules

The system is primarily built around the Arduino Nano microcontroller, which serves as the central control unit. Connected to this are several essential components as illustrated in Figure 1, which includes:

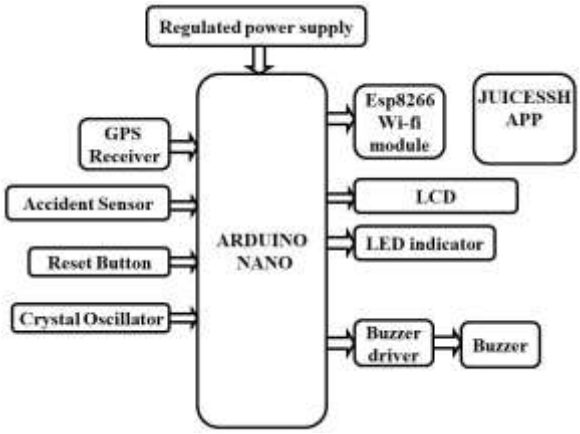


Fig. 1. Block diagram of IOT Based automatic vehicle accident detection and Rescue system

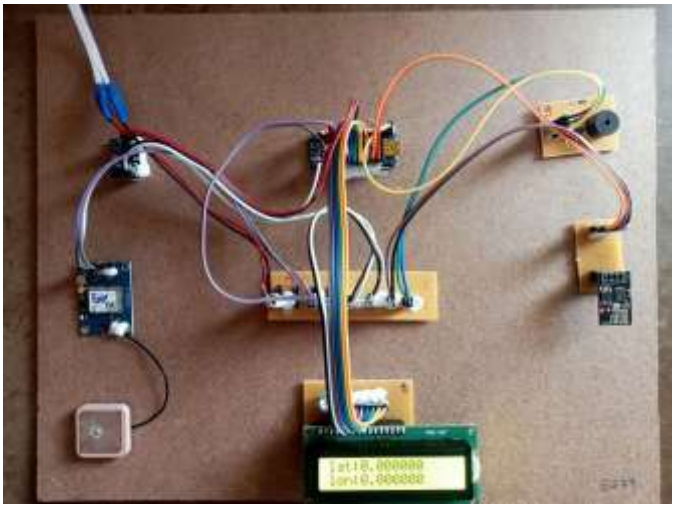
GPS Receiver: It continuously tracks the vehicle's location, providing latitude and longitude data. Accident Sensor: The system uses an ADXL345 accelerometer sensor to detect sudden changes in the vehicle's motion, indicating a possible accident. ESP8266 Wi-Fi Module: Facilitates communication between the Arduino Nano and a mobile app (e.g., JUICESSH), enabling location data and alerts to be sent to relevant authorities or pre-set contacts. LCD Display: Shows real-time status updates regarding the system's operation, including location coordinates and alert statuses. Buzzer: Provides an audible alert when an accident is detected. LED Indicator: A visual alert mechanism that signals system status. Reset Button: Allows the system to be manually reset after an accident detection. Power Supply: A regulated 5V power supply ensures that the entire system operates smoothly without fluctuations.

B. Working Mechanism

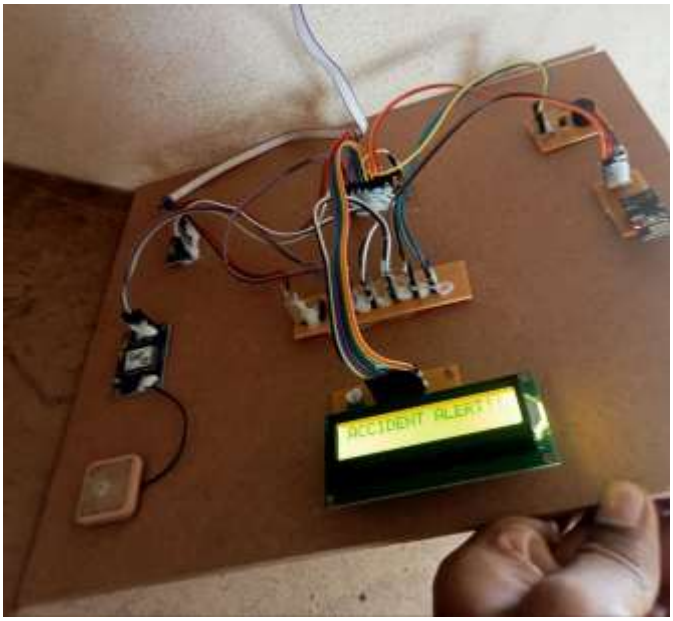
The system's operation revolves around continuous monitoring and accident detection, followed by an alert mechanism:

- GPS Tracking and Monitoring: The GPS receiver continuously tracks the vehicle's position. The Arduino Nano processes the data and displays it on the LCD screen while also preparing to send this information over the network using the ESP8266 Wi-Fi module.
- Accident Detection: The accident sensor (ADXL345) monitors the vehicle's motion. In case of an accident, it detects a significant deviation in acceleration or impact force. Once an accident is detected, the Arduino Nano automatically captures the location from the GPS module.
- Alert Generation: Upon detecting an accident, the system: Activates the buzzer and LED indicator to signal an emergency. Sends the location data (latitude and longitude) to a pre-configured mobile number or server via the ESP8266 Wi-Fi module, using IOT for communication.

Displays the accident status and location coordinates on the LCD. The system's real-time responses ensure that in case of



(a) System block diagram showing the component connections and flow



(b) Image showing the accident alert displayed on the LCD and the wiring setup of the components

Fig. 2. System Diagram

an accident, rescue operations can be initiated without delay by sharing precise location information.

C. Implementation Details

To implement this system, the following key processes were carried out:

- Interfacing the Sensors and Modules: All components including the GPS, accelerometer, and Wi-Fi module were interfaced with the Arduino Nano. Data transfer between the modules was achieved via serial communication protocols.
- Power Supply: The entire system was powered using a regulated 5V DC supply. The power is drawn from a household 230V AC supply, which is stepped down using a transformer and rectified to produce stable DC output.
- IOT and Communication Protocol: The ESP8266 Wi-Fi module was configured to communicate with a mobile app (such as JUICESSH) to transmit the accident data. The system can be remotely monitored and controlled using the app.
- Buzzer and LED Alerts: For physical alert mechanisms, the buzzer driver and LED indicators are activated upon accident detection. The buzzer provides an audible signal, and the LED gives a visual confirmation.

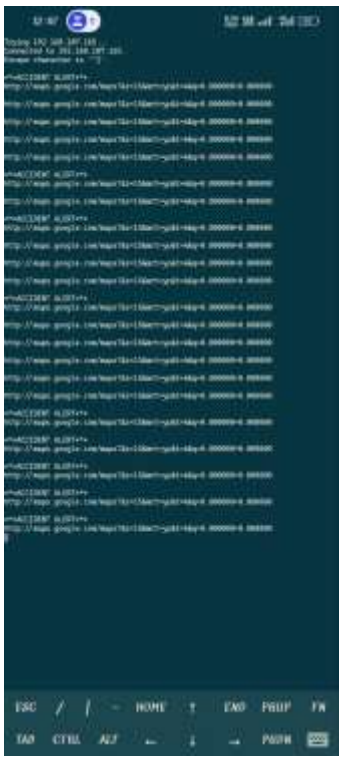


Fig. 3. JUICESSH app displaying the accident alert with GPS coordinates

V. RESULT AND DISCUSSION

The project “IOT Based automatic vehicle accident detection and Rescue system” was designed a vehicle accident detection and alerting system can be done with GPS, ESP8266 and accident sensor.

A. Integration Test

Integration testing is a testing approach in which individual modules are combined and tested as a group. Conducted after the unit testing phase, its primary purpose is to identify and expose faults in the interactions between integrated units, ensuring seamless communication and functionality among components

Table I shows test cases, expected results and observed results for each module of the system. From the results acquire from Table-I all the modules can be seen working successfully in the system.

TABLE I
INTEGRATION TEST RESULT

Test Case	Expected Result	Observed Result	Test Result
When the accident occurred the Load Cell should be able to detect the accident	can detect an accident.	Can detect accident	Pass
GPS module of this system should be able to detect vehicle location correctly	Location should be exact.	Location is exact .	Pass
The microcontroller should be able to send data to a server using the Wi-Fi module. The microcontroller should be able to retrieve data from the server	Can send and retrieve data to and from the server	Can send Can retrieve data	Pass

B. System Test

System testing checks the entire integrated system to make sure all parts work together as expected. It looks for issues that might not appear when testing individual pieces but could cause problems when everything is combined. This helps

TABLE II
SYSTEM TEST RESULT

Test Case	Expected Result	Observed Result	Test Result
User should see accident location	Accident location should be seen	Accident location can be seen	Pass
The ambulance should be able to receive directions to reach the accident locations	Ambulance should get proper notification	Receives the necessary notification.	Pass
The authority should have the ability to update the server.	can update server data	data in the server can	pass

catch problems early before they affect the whole system's performance

VI. CONCLUSION

The present study introduces and implements an intelligent accident detection and rescue system designed for busy metropolitan areas. This system facilitates smart accident detection and provides the precise location of the incident. It also helps ambulances by guiding them with directions, enabling drivers to take the shortest route to the accident site and rescue victims in the shortest possible time. Additionally, our system is more cost-effective for users compared to many other solutions, while delivering more reliable results. In the future, machine learning techniques [20] could be integrated to gain even deeper automated insights into the situation

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