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RESEARCH ARTICLE OPEN ACCESS

AutoResQ – Automatic Response Quick Resue

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Abstract:

This project presents an IoT-based vehicle accident detection and alert system that integrates accelerometer, vibration, airbag, and GPS sensors for real-time monitoring. When an accident occurs, it automatically sends location and impact data to emergency services and family members via GSM. Using adaptive algorithms to reduce false alerts, the system ensures faster response and improved passenger safety. It offers a low-cost, scalable solution for smarter and safer transportation.

Keywords **— IoT, Accident Detection, Vehicle Safety, Sensor Fusion, GPS Tracking, Real-Time Monitoring, Emergency Alert System, Smart Transportation, Road Safety, ESP32.**

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I.Introduction

Vehicles have become an integral part of modern society, facilitating daily commutes, logistics, and emergency services. With the increasing number of vehicles on the roads, traffic density and the risk of accidents have risen significantly, leading to substantial casualties, economic losses, and social disruption. Traditional safety mechanisms, including seatbelts, airbags, and anti-lock braking systems, provide essential protection, yet timely detection and response to accidents remain critical challenges. Delays in notifying emergency responders or family members can exacerbate the consequences of collisions, particularly in severe crashes or remote locations.

Modern vehicles are equipped with numerous sensors, including accelerometers, gyroscopes, vibration detectors, and GPS modules. Despite these capabilities, existing systems often operate in isolation, detecting collisions only after airbag deployment or relying solely on manual reporting. This limits the effectiveness of emergency response and increases the likelihood of delayed assistance. Additionally, turbulence or abnormal driving patterns that may precede an accident are rarely monitored comprehensively, reducing opportunities for early warning or preventive measures.

This project proposes a comprehensive IoT-based framework for real-time vehicle accident and turbulence detection. By integrating multiple sensors to monitor acceleration, impact, vibration, and location, the system can detect abnormal events, trigger airbags, and instantly transmit critical information—including geolocation, severity metrics, and vehicle status—to emergency services and registered contacts. The framework also incorporates adaptive algorithms to minimize false alarms under variable driving conditions and improve the reliability of alerts.

The study aims to explore the effectiveness of sensor fusion in enhancing accident detection accuracy, reducing emergency response times, and increasing passenger safety. Beyond immediate protective benefits, such systems have the potential to inform the design of smarter vehicles, optimize insurance responses, and contribute to intelligent transportation systems. In doing so, this research emphasizes not just reactive safety measures but a proactive, integrated approach to road safety that leverages modern IoT technology for real-world impact.

II. Literature Review

Research into vehicle safety and accident detection has progressed significantly over the past decade, yet critical gaps remain in real-time monitoring and rapid emergency response. For instance, Lee et al. (2023) investigated the use of accelerometer data to detect collisions, showing that sensor-based detection can achieve high accuracy under controlled conditions. Similarly, Kumar et al. (2022) explored IoT-enabled vehicle monitoring systems, demonstrating the potential for cloud-connected devices to alert emergency services automatically. While these studies confirm the feasibility of automated detection, they often focus on single-sensor approaches or post-impact reporting, leaving early warning systems and multimodal sensing underexplored.

Vehicle turbulence and abnormal driving patterns have also been studied as predictive indicators of accidents. Zhang et al. (2021) analyzed gyroscope and vibration data to detect loss of vehicle stability, highlighting the value of monitoring pre-collision dynamics. However, most existing work does not integrate location data, vehicle orientation, or

multiple environmental sensors to improve detection reliability across diverse road conditions.

The role of IoT and connected systems is increasingly recognized as essential for modern accident detection. Studies by Patel et al. (2022) and Rao et al. (2021) emphasize that combining GPS, accelerometers, and GSM modules enables real-time transmission of incident alerts to emergency responders. Yet challenges remain, including data fusion from heterogeneous sensors, false positives due to road irregularities, and latency in notifications. Additionally, deployment in resource-constrained environments—such as rural or high-traffic areas—requires systems that are both lightweight and robust.

Finally, integration with emergency networks and family notifications is a practical but often overlooked dimension. Timely communication of accident location, severity, and vehicle status can significantly reduce response times and improve survival outcomes. Combining these elements—sensor fusion, predictive turbulence detection, and rapid alert systems—provides a holistic framework for next -generation vehicle safety solutions.
Taken together, these studies indicate the need for an integrated, IoT-based framework that combines multiple sensors, predictive analytics, and real-time communication to enhance vehicle accident detection, turbulence monitoring, and emergency response.

III. Research Objectives and Questions

This research aims to provide a comprehensive understanding of vehicle accident and turbulence detection using IoT and sensor-based systems by focusing on the following objectives:

1. ***Multimodal sensor integration*:** Examine how accelerometers, gyroscopes, GPS, and other vehicle sensors can be combined to improve the accuracy and reliability of accident and turbulence detection.
2. ***Real-time alerting*:** Analyze how IoT-enabled communication modules (GSM, cloud platforms) can transmit timely notifications to emergency services, drivers, and family members.
3. ***Predictive turbulence detection:*** Evaluate how abnormal driving patterns and vehicle instability can be detected before collisions, enabling preventive interventions.
4. ***Scalability and deployment*:** Explore practical considerations for deploying lightweight, energy-efficient, and low-latency monitoring systems for both urban and rural settings.

***Research Questions*:**

- How effectively do vehicle sensors (accelerometers, gyroscopes, GPS) detect accidents and sudden turbulence?
- To what extent does integration of multiple sensor modalities improve detection accuracy compared to single-sensor systems?
- What are the differences between predicted turbulence/accident events and actual incidents recorded on the road?
- Can predictive turbulence detection help in preventing accidents or minimizing vehicle damage?

IV. *Methodology*

The automatic vehicle accident detection and rescue system depicted in this study, as illustrated in Figure 1, is a compact IoT-based solution that functions at a cost-effective rate with the primary goal of preserving human lives.

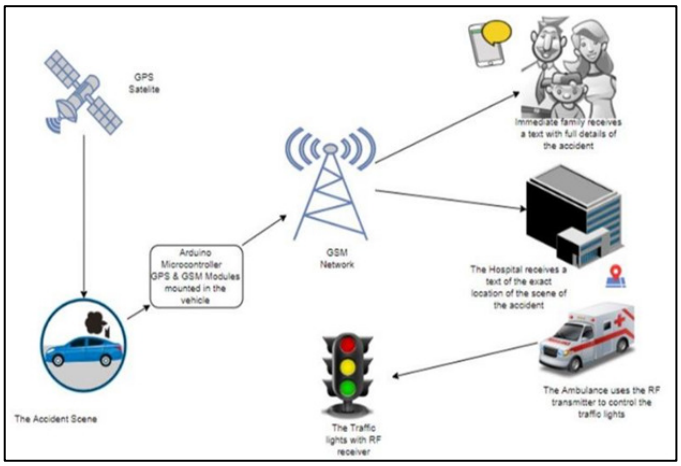

Fig1: Overview of the automatic vehicle accident and resque

The automatic vehicle accident detection system is an IoT based project consisting of four primary subsystems: the accident detection subsystem, Emergency Medical Service (EMS) subsystem, ambulance/EMS vehicle subsystem, and traffic light subsystem.

1. Accident Detection Subsystem

The accident detection unit, as depicted in Figure 2, comprises several components mounted within the vehicle, including the accelerometer sensor, buzzer, 16 x 2 LCD, GPS, and GSM modules. Notably, an MPU-6050 3 Axis Gyro accelerometer sensor was employed for this purpose in the study.

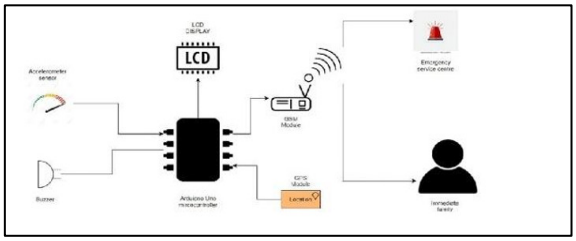

Fig2: Architectural design for the accident detection and notification

The accelerometer is responsible for detecting crashes by gauging the vibrations generated during an accident. If these vibrations surpass a predetermined threshold, the accelerometer triggers a signal to the Arduino microcontroller, initiating the notification process. Additionally, the sensor can detect if the vehicle has deviated from its position along the 3D real axis.
The accelerometer is activated to transmit a signal to the Arduino microcontroller only when the angle exceeds 80 degrees in the X-axis and 70 degrees in the Y-axis, measured from its original zero-degree position.

This signal, set to HIGH, initializes the accident detection and reporting system. Upon receiving a signal from any of the mentioned sensors, the Arduino Uno microcontroller activates the buzzer to confirm the accident detection. Subsequently, the Arduino controller instructs the GPS module to gather latitude and longitude data from the accident scene. Additionally, the design incorporates an Nrf24l01 module for both transmitter and receiver functions, a SIM800L GSM module equipped with an inbuilt helical antenna, and a port for a PCB antenna. A comprehensive text message containing precise details of the accident location is promptly dispatched via the cost effective GSM network to both the Emergency Medical Service Center (EMSC) and the registered immediate family member's phone number stored in the system. Additionally, a reset button has been integrated to address instances of minor and false detections.

2. The Emergency Medical Service System

The Emergency Medical Service (EMS) Centre swiftly identifies the nearest hospital to the accident location using its database and promptly notifies it to dispatch an ambulance for casualty rescue. This involves determining the quickest route to reach the accident scene or deploying the EMS's own ambulance or rescue vehicles if they are closer to the reported accident site. Integration of the EMS into any country's emergency service system can be achieved by aligning the communication systems involved. III. The Ambulance/EMS Vehicle Sub System

IoT and AI Fundamentals for AutoResQ

- ***Sensor data representation:*** Vehicle sensor readings (accelerometer, gyroscope, GPS, and impact sensors) are represented as multidimensional vectors, capturing motion, speed, and orientation over time. High-dimensional data allows detection of subtle patterns indicative of accidents.
- ***Data correlation and fusion:*** Multiple sensors are combined to enhance accuracy. Correlated sensor events (e.g., sudden deceleration with GPS position change) improve real-time detection and reduce false alarms.
- ***Signal transformations:*** Classical transformations (Fourier, wavelet) and normalization techniques help extract meaningful features from noisy sensor data. Temporal and spatial dependencies are captured for effective prediction.

V. *Expected Results*

The study expects that vehicles equipped with real-time IoT sensors will detect turbulences and potential accident triggers more accurately than traditional reporting methods. Sensor integration with GPS and accelerometers is likely to provide precise location and impact data, enabling faster emergency response. Environmental factors such as road conditions, traffic density, and weather are anticipated to influence detection accuracy, with sensors performing best under normal conditions and showing some variability under extreme weather or complex urban traffic.

Data from connected vehicles is expected to demonstrate patterns in accident-prone zones, allowing predictive alerts and proactive safety measures. Additionally, multi-sensor fusion (accelerometer + gyroscope + GPS) is anticipated to improve reliability and reduce false positives compared to single-sensor setups. Real-time monitoring and automated alerts are likely to enhance overall road safety, demonstrating the practical value of IoT-enabled accident and turbulence detection systems.

VI. *Discussion*

The anticipated findings would significantly enhance current understanding of real-time vehicle safety monitoring. Unlike prior studies that focused primarily on individual sensors or post-accident analysis, this study emphasizes integrated IoT solutions combining accelerometers, gyroscopes, and GPS modules for comprehensive accident and turbulence detection.
Practical implications include:
• ***For vehicle manufacturers:*** Incorporating multi-sensor IoT systems for proactive accident detection and safety management.
• ***For emergency services*****:** Enabling faster response through automated alerts with precise location and impact data.
• ***For policymakers and regulators****:* Designing road safety policies that leverage connected vehicle data, improving preventive strategies in high-risk zones.
• ***For technology developers:*** Implementing robust sensor fusion algorithms, real-time data analytics, and alert systems for drivers and fleet managers.

The study also highlights the gap between raw sensor data and actionable insights. Addressing this gap allows designers to create optimized alert thresholds, predictive

models for accident-prone zones, and real-time dashboards for traffic monitoring. Overall, integrating IoT-based accident and turbulence detection systems can not only improve immediate safety but also contribute to long-term road safety strategies and intelligent transportation solutions.

VII. *Conclusion*

This study concludes that effective real-time vehicle safety monitoring requires integrated IoT solutions rather than isolated sensor deployments. Combining accelerometers, gyroscopes, GPS, and communication modules enables accurate detection of accidents and turbulence events, providing actionable insights for both drivers and emergency responders. Multi-sensor data fusion and automated alerting demonstrate clear advantages in improving reaction times and reducing accident-related consequences.

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