iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** IV **Month of publication:** April 2025

DOI: https://doi.org/10.22214/ijraset.2025.68537

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue IV Apr 2025- Available at www.ijraset.com

Lightweight Vehicle Black Box System with Automatic Emergency Assistance

Deeksha. K[1], Jeyamani. J[2], Ranganathan. V[3], Harikrishnan. K[4], Shoba. M[5]
Electronics and Communication Engineering, United Institute of Technology

Abstract: In the context of increasing road traffic incidents and the demand for smarter transportation systems, the need for advanced vehicle monitoring solutions has become critical. This paper presents the design and development of an IoT-based Vehicle Black Box system that records and transmits real-time vehicular data to support accident analysis and emergency response. The proposed system integrates various sensors, including an accelerometer, GPS module, alcohol sensor, and microcontroller, to collect data such as speed, impact force, location, and driver condition. Through IoT connectivity, this information is stored in a cloud database, enabling remote access and live monitoring. In the event of an accident, the system automatically triggers an emergency alert containing the vehicle's coordinates, significantly reducing the time taken for rescue and investigation.

The system offers a scalable and cost-effective solution for both personal and commercial vehicles, with potential applications in fleet management, insurance validation, and driver behavior analysis. Its modular architecture allows easy integration with additional technologies such as predictive analytics and Vehicle-to-Everything (V2X) communication. Moreover, the secure and tamper-resistant data logging ensures the reliability and integrity of evidence in post-accident scenarios. The experimental results demonstrate the system's effectiveness in capturing critical information in real-time, making it a valuable tool in advancing road safety and intelligent transportation frameworks.

Keywords: Vehicle black box, IoT, accident monitoring, GPS tracking, emergency alert system, intelligent transportation, vehicle data logging, driver behavior analysis, road safety.

I. INTRODUCTION

Road traffic accidents remain a significant global concern, causing millions of injuries and fatalities each year. Despite advancements in automotive technology, the lack of reliable real-time monitoring and post-accident data limits the ability to investigate accidents effectively and improve road safety. In many cases, determining the exact cause of an accident is difficult due to the absence of objective data, which hampers legal proceedings and delays emergency response. To address this challenge, there is a growing need for systems that can continuously monitor, record, and transmit critical vehicle information in real time.

The concept of a "vehicle black box" — inspired by the flight data recorders used in aviation — is gaining traction in the automotive domain. A black box system for vehicles aims to log essential data such as speed, acceleration, location, and impact forces during an incident. While several commercial systems exist, most are limited to data storage alone, lacking real-time connectivity and remote monitoring features.

Moreover, such systems are often proprietary and costly, restricting their accessibility, especially for developing regions where road safety is a major concern.

The integration of the Internet of Things (IoT) with vehicle monitoring systems offers a transformative solution. IoT enables real-time data acquisition, cloud-based storage, remote access, and instant notifications, making it ideal for critical applications such as accident reporting and driver behavior analysis. By leveraging sensors, GPS, microcontrollers, and communication modules, an IoT-based black box can provide comprehensive insights into a vehicle's condition and driving patterns. It can also facilitate faster emergency response through automated alerts, potentially saving lives in critical situations.

This paper proposes the design and implementation of an IoT-enabled vehicle black box system capable of real-time monitoring and accident detection. The system records key vehicular parameters using onboard sensors and transmits the data to a cloud platform via wireless communication. In the event of a crash or abrupt deceleration, the system automatically sends an alert to designated emergency contacts along with the precise GPS location of the vehicle. The collected data is also stored locally on an SD card, ensuring redundancy and data recovery for post-incident analysis.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue IV Apr 2025- Available at www.ijraset.com

II. OBJECTIVE

The main objective of this project is to build a vehicle black box system that can track and record important data like location, alcohol content and sudden movements while the vehicle is in operation. The system is designed to help in understanding the cause of accidents and monitoring driving behavior by sending this data to a cloud server using ESP8266. The goal is to create a simple, low-cost solution that can be installed in any vehicle to improve safety, assist in investigations, and support better fleet management.

III. RELATED WORK

The integration of Internet of Things (IoT) technology into vehicular systems has led to significant advancements in vehicle safety and accident analysis. Researchers have developed various IoT-based Vehicle Black Box Systems (VBBS) to monitor and record vehicular parameters, aiming to enhance road safety and facilitate accident investigations.

In 2024, Deshpande et al. introduced a VBBS that records accident data, vehicle location, and driver sobriety through an automated breathalyzer test. The system's objective is to improve road safety by providing critical data for accident analysis and assisting insurance companies in crash investigations. The authors highlighted the potential of such systems to reduce accident-related fatalities by offering reliable evidence and enhancing vehicle safety standards.

Mateen et al. (2024) proposed an IoT-enabled Automobile Black Box System that integrates advanced sensor technologies and real-time data communication. Utilizing sensors like accelerometers, gyroscopes, and GPS modules, the system captures crucial information during accident events. The collected data is transmitted in real-time to a centralized server for comprehensive analysis, leveraging machine learning algorithms to reconstruct accident scenarios accurately. This approach aids in post-accident investigations and facilitates the development of proactive safety measures.

Patil et al. (2024) proposed an IoT-based black box monitoring system designed to enhance road safety through comprehensive crash data analysis. The system incorporates various sensors, including accelerometers, gyroscopes, and GPS modules, to continuously monitor vehicle performance and driver behavior. In the event of an accident, the system detects the impact force, captures images, records the vehicle's location, and measures speed. This data is transmitted to the cloud via the Blynk IoT platform, enabling access by emergency services and authorized personnel. The study highlights the potential of such systems to improve vehicle safety features and promote safer driving practices.

Alsahlawi and Mangoud (2023) presented a prototype of a car black box system aimed at enhancing safety standards by monitoring vehicle performance and driving behavior. The proposed solution combines hardware tools like microcontrollers and sensors with software such as MQTT and Node-Red. The data exchanged between the black box and the MQTT server is essential for assessing the severity of accidents. The authors emphasized the system's applications in insurance risk analysis and fleet management systems.

Dashora et al. (2020) developed an IoT-based framework aimed at enhancing vehicle accident detection. The system integrates sensors and communication technologies to monitor vehicular parameters and detect collisions in real-time. Upon detecting an accident, the system promptly transmits the location and relevant data to emergency services, facilitating swift response and potentially reducing fatalities. The study emphasizes the importance of IoT in creating intelligent transportation systems that improve road safety.

Sethuraman and Santhanalakshmi (2020) implemented a vehicle black box system utilizing IoT to enhance accident analysis. The system collects real-time data on vehicle dynamics and environmental conditions, transmitting it to a centralized server for analysis. In the event of an accident, the system provides immediate alerts to emergency services with precise location details. The study underscores the role of IoT in developing intelligent systems that can significantly reduce emergency response times and improve overall road safety.

Kumar et al. (2018) designed an intelligent vehicle black box system leveraging IoT technologies to monitor and record vehicular data. The system includes sensors for detecting parameters such as speed, temperature, and collision impact. Data is transmitted to a cloud platform, allowing for real-time monitoring and analysis. The authors highlight the system's potential in aiding accident investigations and enhancing vehicle safety standards.

These studies collectively underscore the transformative potential of IoT-based Vehicle Black Box Systems in enhancing road safety, providing reliable data for accident analysis, and supporting the development of proactive safety measures. The integration of advanced sensors, real-time data transmission, and machine learning algorithms enables accurate reconstruction of accident scenarios, facilitating timely emergency response and informed decision-making in traffic management and insurance assessments.

IV. METHODOLOGY

The proposed IoT-based Vehicle Black Box System is designed to continuously monitor and log critical vehicular parameters and detect accidents in real-time using accelerometer values and locates the exact co-ordinates using GPS device and transmit alerts to emergency contacts. The system utilizes multiple sensors integrated with a microcontroller to collect data, which is then transmitted over the internet using a Wi-Fi module. The methodology involves hardware design, data acquisition, event detection, cloud integration, and emergency alert generation.

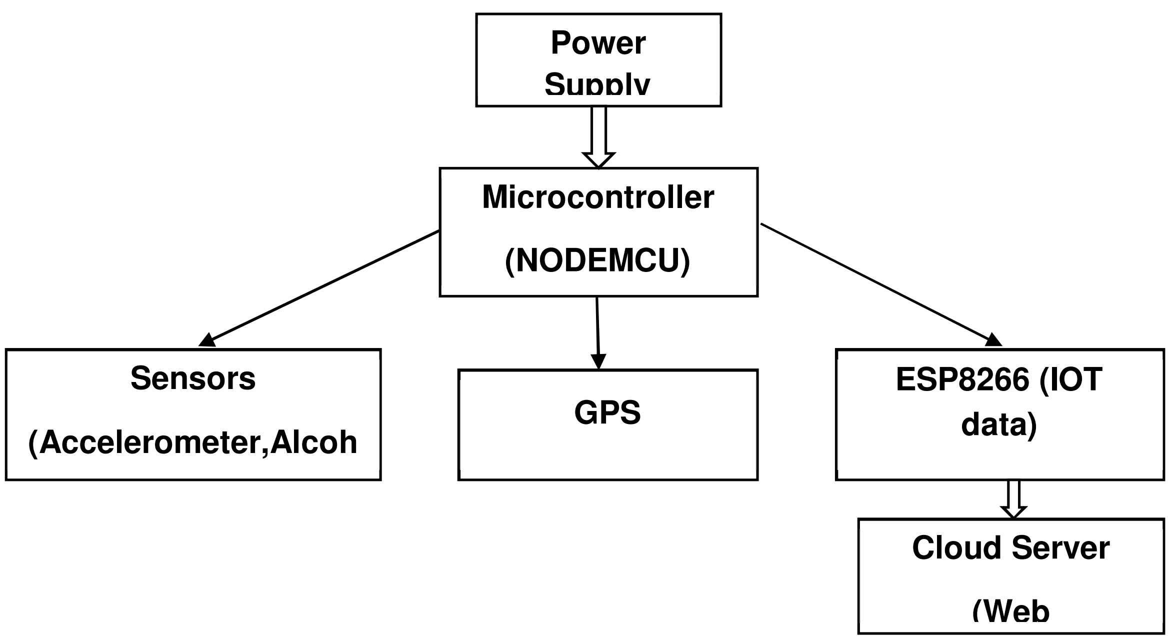
V. SYSTEM ARCHITECTURE

A. *Hardware Components*

- Microcontroller (Node MCU/ESP8266): Acts as the brain of the system, handling data from all sensors.
- Accelerometer and Gyroscope (MPU6050): Detects sudden movements, orientation, and impact forces to identify accidents.
- GPS Module (NEO-6M): Captures the vehicle's real-time location.
- Alcohol Sensor (MQ 3): Monitors internal/external temperature.
- Buzzer: Triggers alert sound for alcohol detection
- Wi-Fi Module (ESP8266): Enables data transmission to the cloud or emergency contacts.
- Power Supply: vehicle power source with voltage regulation.

B. *Software/Cloud*

- Cloud Platform (ubidots): For real-time data visualization and storage.
- Mobile App or Web Interface: Allows monitoring vehicle status remotely.
- Emergency SMS/Notification Service: Sends alerts with co-ordinates when accident conditions are detected.



VI. WORKFLOW

A. *System Initialization*

- On power-up, the microcontroller initializes all connected sensors and checks for connectivity with GPS, sensors and Wi-Fi modules.

B. *Data Acquisition*

- Sensors continuously read values (e.g., acceleration, alcohol content, location).
- Data is logged locally to the cloud server every few seconds.

C. Accident Detection

- An accident is detected based on a sudden spike in acceleration (G-force).
- A threshold is defined (e.g., ≥ 3g force) to avoid false triggers.

D. Emergency Response Trigger

- Once an accident is detected, the system:
  - Captures the last few seconds of sensor data.
  - Retrieves the current GPS coordinates.
  - Sends an alert message (SMS or push notification) to pre-defined emergency contacts.
  - Uploads all relevant data to the cloud for storage and future reference.

E. Remote Monitoring

- Authorized users can view live data such as speed, location, and alcohol through a mobile app or web dashboard.

VII. ADVANTAGES

1) Real-Time Monitoring: Immediate access to vehicle parameters from anywhere.
2) Accident Alert System: Instant notification to emergency contacts can save lives.
3) Data Redundancy: Dual logging (cloud) ensures no data loss.
4) Low Cost and Scalable: Easily deployable on commercial and personal vehicles.
5) Customizable Thresholds: Adjust sensitivity based on driving conditions.

VIII. RESULT AND DISCUSSION

The proposed IoT-based Vehicle Black Box System was successfully designed and tested under simulated vehicle conditions. The system effectively integrated multiple sensors, including an accelerometer, gyroscope, and alcohol sensor, to continuously monitor critical vehicle parameters. Real-time location data was accurately captured using a GPS module, while the Wi-Fi module enabled reliable transmission of data to a cloud-based server. During testing, the system demonstrated high responsiveness to sudden changes in motion, such as sharp turns and abrupt braking, with data logs correctly reflecting such events. The GPS data, when visualized on a web dashboard, allowed for precise vehicle tracking, offering valuable insights into travel routes and time duration.

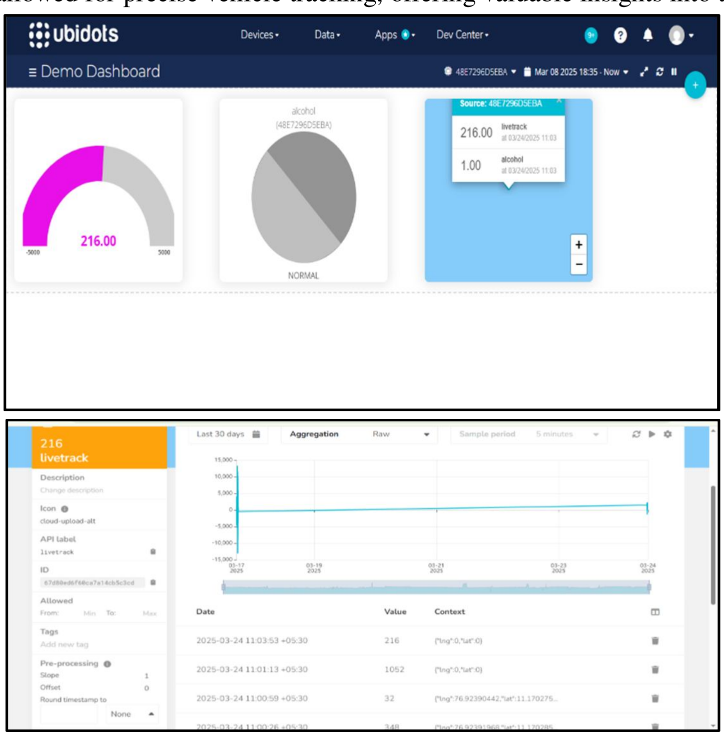


Fig.1 Ubidots output data

The combination of IoT connectivity and onboard logging enhanced both data reliability and accessibility. Furthermore, the modularity of the system allows for easy upgrades, such as the addition of cameras or more advanced environmental sensors in the future.

IX. CONCLUSION

This paper presented the development and implementation of an IoT-based Vehicle Black Box System designed to enhance vehicular safety, monitoring, and post-accident analysis. The system successfully logged key parameters, such as acceleration, alcohol, and location data, and transmitted them to a remote cloud server using Wi-Fi technology.

The results validate the system's effectiveness, reliability, and potential for real-world deployment. Future improvements may include the incorporation of video capture, AI-based accident detection, or integration with emergency response systems for automated alerts.

REFERENCES

[1] Deshpande, G., Dolli, S., Bondre, N., & Kale, D. (2024). Vehicle Black Box Systems: Evolution, Implementation, and Impact on Road Safety. Journal of VLSI Design Tools and Technology, 14(2), 38-46.

[2] Mateen, A., Ainullah, S. M., Jamadar, R., Ziaullah, M., & Satteekar, U. I. (2024). Automatic Black Box System for Accident Analysis Using IoT: A Review. Research and Applications: Emerging Technologies, 6(2), 16-22.

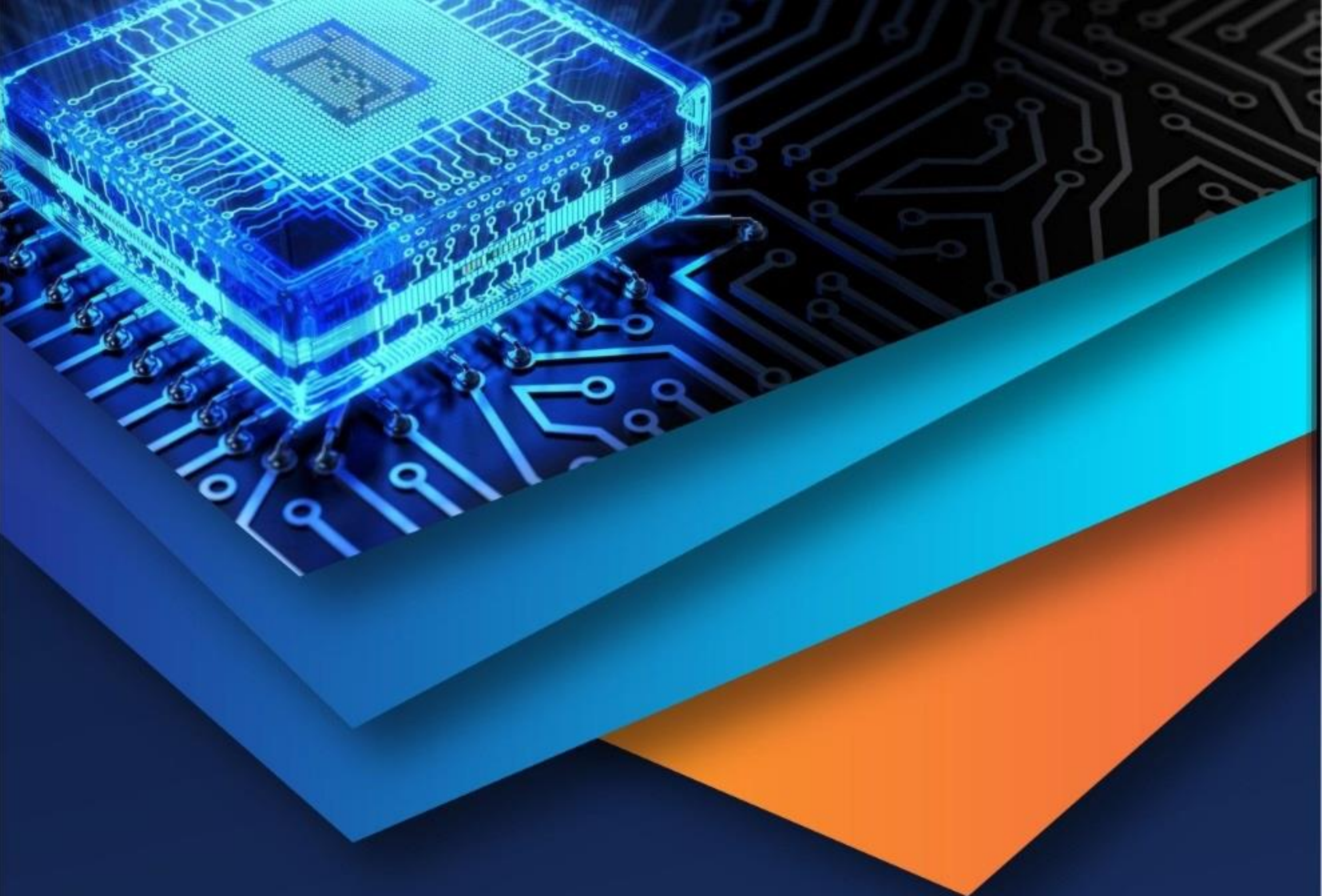
[3] Patil, A.S., Naim, H.S., Waghmare, R.N., & Rohile, S. (2024). IoT-based Black Box Monitoring for Vehicle Crash Data Analysis and Improving Safety. Research & Reviews: A Journal of Embedded System & Applications, 12(03), 7-13.

[4] Alsahlawi, A. A., & Mangoud, M. A. (2023). IoT based vehicle blackbox for enhanced safety standards. IET Conference Proceedings, 2022(26).

[5] Dashora, C., Sudhagar, P.E., & Marietta, J. (2020). IoT-based framework for the detection of vehicle accident. Cluster Computing, 23, 1235–1250.

[6] Sethuraman, S., & Santhanalakshmi, S. (2020). Implementing vehicle black box system by IoT based approach. In 2020 4th International Conference on Trends in Electronics and Informatics (ICOEI) (pp. 390-395).

[7] Kumar, M.A., Suman, M.V., Misra, Y., & Pratyusha, M.G. (2018). Intelligent vehicle black box using IoT. International Journal of Engineering & Technology, 7(2), 215-218.



10.22214/IJRASET

INDEX COPERNICUS
45.98

IMPACT FACTOR:
7.129

TOGETHER WE REACH THE GOAL
IMPACT FACTOR:
7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY