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Smart Vehicle Blackbox Using IoT

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***Abstract*—The increasing number of road accidents caused by reckless driving, drunk driving, and delayed emergency response has become a major concern worldwide, leading to significant loss of life and property. To address these challenges, this paper presents the design and implementation of an IoT-based Smart Vehicle Monitoring and Black Box System using the ESP32 microcontroller. The proposed system continuously monitors the vehicle and driver by integrating multiple sensors and communication modules. A force sensor detects sudden impacts or collisions, while an MQ-3 alcohol sensor identifies the presence of alcohol to help prevent drunk driving. A GPS module provides the real-time location of the vehicle, and an ESP32-CAM records a short video clip of the accident event, including moments before and after the crash, providing visual evidence for emergency response and accident investigation. The ESP32 acts as the central controller, collecting data from all sensors and transmitting it to a cloud platform via Wi-Fi for real-time monitoring and secure storage. When an accident or abnormal condition is detected, the system automatically captures an image, retrieves the current GPS coordinates, and sends an emergency alert containing the accident location and other relevant information to predefined contacts or emergency services, thereby reducing rescue response time and improving the chances of saving lives. In addition, the recorded sensor data and captured images function as a digital vehicle black box, providing valuable evidence for accident investigation, insurance claim verification, and legal proceedings. The proposed system is cost-effective, reliable, energy-efficient, and scalable, making it suitable for both personal and commercial vehicles. By combining IoT technology, cloud connectivity, intelligent sensing, and real-time communication, the system enhances road safety, promotes responsible driving behavior, improves accident management, and contributes to the development of modern Intelligent Transportation Systems (ITS), offering an effective and practical solution for future smart transportation and vehicle safety applications.**

***Index Terms*—Internet of Things (IoT), Smart Vehicle Monitoring, Vehicle Black Box System, ESP32, ESP32-CAM, Force Sensor, MQ-3 Alcohol Sensor, GPS Tracking, Accident Detection, Emergency Alert System, Real-Time Monitoring, Cloud-Based Data Storage, Intelligent Transportation System (ITS), Driver Safety, Road Safety, Wireless Communication, Vehicle Tracking, Accident Analysis, Embedded Systems, Smart Transportation.**

I. INTRODUCTION

Road accidents have become a major concern due to the increasing number of vehicles and unsafe driving practices such as over speeding, alcohol consumption, and driver negligence. Delayed emergency response and the absence of accurate accident records often increase the severity of such incidents. Hence, there is a need for an intelligent system that can monitor vehicles continuously and provide immediate assistance during emergencies. The proposed Smart Vehicle Black Box using IoT is designed to improve vehicle safety by integrating a GPS module, Force Sensitive Resistor (FSR), MQ-3 alcohol sensor, ESP32-CAM module, Firebase cloud services, and a Flutter-based mobile application. The system continuously monitors vehicle conditions and detects accidents in real time. When an accident occurs, the current vehicle location and sensor data are transmitted to the cloud, and an emergency alert is generated for quick response. The proposed system provides real-time vehicle monitoring, automatic accident detection, secure cloud data storage, and location tracking. It also supports accident investigation and insurance verification by maintaining accurate vehicle records. Thus, the developed IoT-based Vehicle Black Box offers a reliable and cost-effective solution for enhancing road safety and emergency management.

II. LITERATURE REVIEW

A. Deeksha K. et al. (2025)
Deeksha K. et al. proposed a Lightweight Vehicle Black Box System with Automatic Emergency Assistance. Their system records vehicle information during accidents and automatically sends emergency notifications along with the accident location. The proposed model improves accident response time and enhances passenger safety by integrating GPS and communication technologies.

B. Mahmood Thanzeel et al. (2025)
Mahmood Thanzeel et al. developed a Proactive Vehicle Monitoring System with Real-Time Data Logging and Alerting. The system continuously monitors important vehicle parameters and stores the collected data for future analysis. It also generates instant alerts whenever abnormal vehicle conditions are detected, improving safety and preventive maintenance.

C. R. Satheesh et al. (2024)
R. Satheesh et al. presented an IoT Based Black Box for Trucks Using LabVIEW. Their system records operational vehicle data, monitors truck performance, and stores accident-related information for investigation. The integration of IoT technology enables continuous monitoring and improves accident analysis for heavy vehicles.

D. Akhil K. et al. (2023)
Akhil K. et al. proposed a Cloud Based Black Box System for Vehicles. The system securely stores accident data on cloud servers, enabling remote access to vehicle information. This approach improves data reliability, simplifies accident investigation, and assists insurance claim verification.

E. Sasi Rekha P. et al. (2023)
Sasi Rekha P. et al. developed an Intelligent Vehicle Black Box System Using IoT. Their system integrates multiple sensors with cloud technology to detect accidents, monitor driver behaviour, detect alcohol consumption, and securely store vehicle information. The proposed solution enhances road safety through real-time monitoring and automated emergency support.
From the reviewed literature, it is observed that existing vehicle black box systems mainly focus on accident detection, vehicle monitoring, cloud storage, and emergency alert generation. However, many systems provide only limited functionalities. The proposed Smart Vehicle Black Box integrates accident detection, GPS tracking, alcohol detection, image capture, real-time alerts, and cloud-based data storage into a single IoT-enabled platform, providing a more comprehensive and reliable vehicle safety solution.

III. PROBLEM IDENTIFICATION AND OBJECTIVES

A. Limitations of Existing Systems
Existing vehicle safety and monitoring systems mainly focus on isolated functionalities such as accident detection, GPS tracking, or video recording and do not provide a unified framework for complete vehicle monitoring and emergency response. Conventional vehicle black box systems depend on local storage mechanisms, which may fail or become inaccessible after severe accidents, leading to loss of critical accident information.
Most available systems also lack real-time monitoring and automated communication capabilities. Delayed accident reporting reduces the effectiveness of emergency services and increases response time. In addition, absence of integrated alcohol detection and evidence collection mechanisms limits their reliability for accident prevention and investigation.

B. Proposed System
The proposed Smart Vehicle Black Box Using IoT introduces an integrated monitoring and safety framework for vehicles. The system continuously collects data from connected sensors and processes accident-related events in real time.
The system combines FSR-based accident detection, MQ3 alcohol sensing, GPS-based vehicle tracking, ESP32-CAM image capture, and cloud-based data storage. When abnormal conditions or accidents are detected, the system automatically captures evidence, records sensor values, obtains vehicle location, and transmits emergency alerts to improve response efficiency and support accident investigation.

C. Objectives
- Develop an IoT-enabled vehicle black box system for continuous monitoring.

- Detect accidents using sensor-based event analysis.
- Identify alcohol consumption using MQ3 sensor.
- Capture accident-related video evidence using ESP32-CAM and store it securely in Firebase cloud storage.
- Track vehicle location through GPS integration.
- Generate real-time emergency notifications.
- Store collected information securely using cloud services.
- Improve vehicle safety and support post-accident analysis.

IV. SYSTEM DESIGN AND METHODOLOGY

A. High-Level System Architecture

The proposed Smart Vehicle Black Box Using IoT is designed as an integrated vehicle monitoring and emergency response system. The architecture consists of sensing, processing, communication, and cloud storage layers working together to improve vehicle safety and accident analysis.

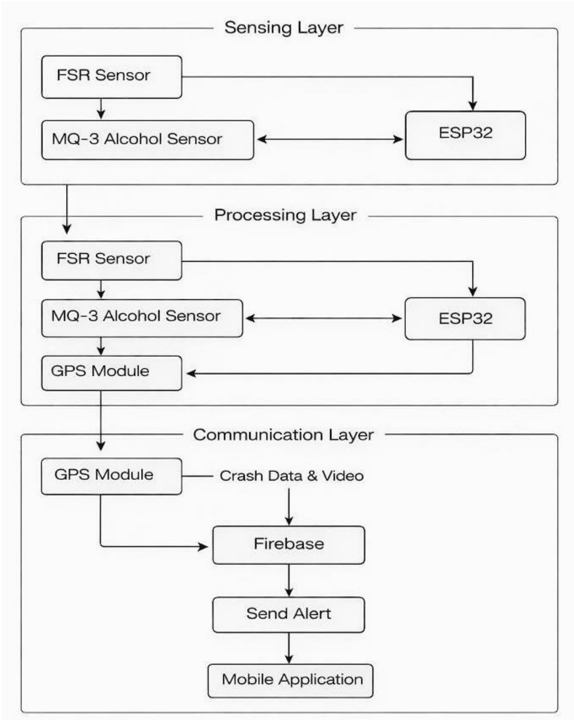

Fig. 1. High-Level System Architecture of Smart Vehicle Black Box Using IoT

The sensing layer includes FSR sensors for accident detection, MQ3 sensor for alcohol detection, GPS module for location tracking, and ESP32-CAM for visual evidence capture. The processing layer utilizes ESP32 as the central controller to collect sensor data and trigger decision-making processes. The communication layer enables transmission of alerts and monitoring data to cloud services and registered users. Firebase Cloud Firestore, Firebase Storage, and Firebase Cloud Messaging (FCM) are used for cloud storage, notification delivery, and remote monitoring.

When an abnormal event is detected, the system captures the corresponding data, obtains vehicle location, records visual evidence, and sends emergency notifications automatically.

B. Data Flow Diagram

The Data Flow Diagram illustrates the movement of information throughout the proposed system. Initially, sensor data is collected continuously from vehicle monitoring components. The ESP32 controller processes incoming values and determines whether accident conditions or alcohol detection thresholds are exceeded.

If an event is detected, the system activates image capture, records GPS coordinates, and transfers data to cloud storage for further analysis. Emergency notifications are then transmitted to authorized users.

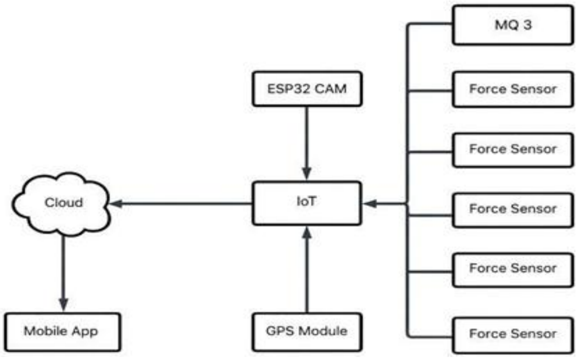

Fig. 2. Data Flow Diagram of Proposed System

C. System Modules

1.Sensor Monitoring Module:

Responsible for collecting real-time information from FSR and MQ3 sensors and continuously observing vehicle conditions.

2.Processing and Decision Module:

ESP32 processes sensor inputs and executes accident detection and event validation logic.

3.Location Tracking Module:

GPS module obtains vehicle coordinates and enables location sharing during emergency situations.

4.Evidence Collection Module:
ESP32-CAM records short video clips during accident events and stores them for later analysis

5.Alert and Cloud Module:
Uploads monitoring data to cloud storage and generates emergency notifications to users.

V. TECHNOLOGIES AND SYSTEM COMPONENTS

A. ESP32 Controller

ESP32 serves as the central processing and control unit of the proposed Smart Vehicle Black Box system. It continuously receives input data from connected sensors, processes detected events, and performs decision-making operations in real time.

The controller monitors accident conditions through Force Sensitive Resistors (FSR), analyses alcohol levels obtained from the MQ3 sensor, and coordinates communication with GPS and ESP32-CAM modules. When an emergency event is identified, ESP32 automatically activates evidence collection, obtains location information, and transmits alerts to cloud services and registered users.

B. Sensor Technologies

The proposed system utilizes multiple sensors to improve monitoring accuracy and emergency response.

Force Sensitive Resistors (FSR) are used for accident detection by measuring sudden variations in pressure generated during vehicle impact. Sensor values are continuously evaluated against predefined thresholds to determine accident conditions.

The MQ3 sensor is used for alcohol detection by monitoring alcohol concentration around the driver environment. When abnormal readings are identified, the system triggers warning mechanisms and updates the monitoring platform.

The GPS module enables real-time location acquisition and supports emergency communication by transmitting vehicle coordinates.

C. Monitoring and Alert System

The monitoring and alert mechanism integrates sensing, processing, evidence capture, and communication into a single framework.

ESP32-CAM continuously supports evidence collection and captures accident-related images during emergency conditions. GPS coordinates and event information are combined with captured data and uploaded to cloud services.

Once accident detection or alcohol detection occurs, the system generates emergency notifications containing location details and timestamps. Alerts are transmitted to authorized users through connected monitoring platforms to support rapid response and accident verification.

D. Technology Stack Controller:

ESP32 Development Board Sensors:
Force Sensitive Resistors (FSR), MQ3 Alcohol Sensor
Camera Module:
ESP32-CAM
Location Tracking:
GPS Module (NEO-6M)
Communication:
Wi-Fi Communication Software Tools:
ESP32 Libraries Cloud Services:
Firebase Cloud Firestore Firebase Storage
Firebase Cloud Messaging (FCM) Mobile Application:
Flutter
User Interface:
Mobile Application and Web-Based Monitoring Platform

VI. IMPLEMENTATION AND RESULTS

A. Hardware Implementation

The proposed Smart Vehicle Black Box system was implemented using ESP32 as the primary controller with integrated sensing, monitoring, and communication modules. The hardware setup includes Force Sensitive Resistors (FSR) for accident detection, MQ3 sensor for alcohol detection, ESP32-CAM for image capture, and GPS module for real-time location tracking. The controller continuously receives sensor values and executes monitoring logic to identify abnormal vehicle conditions. Upon detection of an accident or alcohol event, the system initiates emergency response procedures and transfers collected information to cloud services. Upon accident detection, the ESP32 sends a trigger signal to the ESP32-CAM module, which records a short video clip containing pre-crash and post-crash events. The recorded footage is uploaded to Firebase Storage, and the corresponding video link is associated with the accident data for future analysis and verification

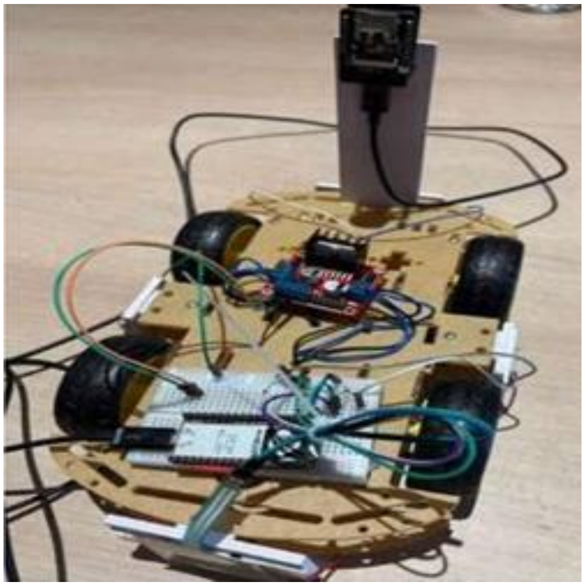

Fig. 4. Hardware Implementation of Smart Vehicle Black Box System

B. Software Implementation

The software component of the Crash Detect system is developed using Flutter and Firebase technologies. Firebase Cloud Firestore is used to store accident records, GPS coordinates, alcohol detection status, and timestamps, while Firebase Storage stores the recorded video footage. Firebase Cloud Messaging (FCM) enables real-time alert notifications to registered caretakers. The Flutter mobile application provides an interface for monitoring crash events, viewing accident details, and accessing recorded evidence, ensuring efficient communication between the hardware system and user

C. System Requirements TABLE I. System Requirements

Hardware Requirements

Controller – ESP32 Development Board Camera – ESP32-CAM

Sensors – FSR, MQ3

Location Module – GPS (NEO-6M) Power – AC-DC Supply Module Software Requirements

Software Environment – Embedded Development Environment

Communication – Wi-Fi Connectivity Storage – Cloud-Based Storage

Interface – Mobile and Web Monitoring Platform

D. User Interface and Result Analysis

The developed monitoring platform provides users with real-time access to emergency notifications, alert history, and vehicle event information. The mobile and web interfaces display accident detection events, alcohol alerts, timestamps, and GPS location details. Experimental observation shows that the system successfully detects abnormal conditions and generates emergency notifications with minimal delay. Cloud integration enables secure storage and retrieval of event information. The developed Flutter application successfully displayed crash alerts, GPS location details, alcohol detection status, and recorded accident evidence. Real-time notifications were delivered through Firebase Cloud Messaging (FCM), enabling caretakers to receive immediate updates during emergency situations.

Fig. 5. Mobile Dashboard

Fig. 6. Alert Generation and Result Screens

VII. CONCLUSION

This paper presented the design and implementation of a Smart Vehicle Monitoring System using the ESP32 microcontroller for real-time accident detection and driver safety monitoring. The proposed system integrates a force sensor for collision detection, an MQ-3 alcohol sensor for detecting driver intoxication, a GPS module for location tracking, and an ESP32-CAM module for capturing images of the accident scene. Upon detecting an accident, the system automatically acquires the vehicle's location, captures an image, and transmits the information to designated emergency contacts through Wi-Fi communication. Experimental results demonstrate that the proposed system operates reliably with low response time and provides an efficient solution for improving road safety and enabling timely emergency assistance. The developed system is cost-effective, easy to implement, and suitable for deployment in modern intelligent transportation systems.

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REFERENCES

[1] Deeksha K., Jeyamani J., Ranganathan V., Harikrishnan K., and Shoba M., “Lightweight Vehicle Black Box System with Automatic Emergency Assistance,” *International Journal for Research in Applied Science and Engineering Technology (IJRASET)*, Apr. 2025.
[2] Mahmood Thanzeel, Niranjan Thomas B., Sachin Suresh, Sidharth Sathyam Krishna, and Neetha K. Nataraj, “Proactive Vehicle Monitoring System with Real-Time Data Logging and Alerting,” International Journal of Scientific Research and Technology (IJSRT), Apr. 2025.
[3] Akhil K., Abin Rajan, Abijith Jose Thomas, Johns Raju, and Jamedar Najath, “Cloud Based Black Box System for Vehicles,” International Research Journal of Engineering and Technology (IRJET), Jun. 2023.
[4] Sasi Rekha P., Aadhav A., Dasharath D., Karthikeyan S., and Bharath Kumar S., “Intelligent Vehicle Black Box System Using IoT,” E3S Web of Conferences (ICONNECT-2023), 2023.
[5] R. Satheesh, Santhosh R., Chandru V., and Keerthi Vasan K., “IoT Based Black Box for Trucks Using LabVIEW,” International Journal of Progressive Research in Engineering Management and Science (IJPREMS), Apr. 2024.
[6] Satvik R., Sharath N., Hrithik H. S., Puneet Shridhar Naik, and B. K. Sujatha, “Wireless Black Box for Vehicle Using IoT,” International Journal of Scientific Research in Engineering and Management (IJSREM), Sep. 2023.
[7] A. L. Ashwin, E. K. Sao, K. K. Shetti, P. Jadhav, and A. Jatti, “Enhancing Vehicle Safety: Smart Accident Detection Using Vehicle Black Box Technology,” International Journal of Scientific Research in Engineering and Management (IJSREM), Jun. 2024.

[8] Thanikachalam R. et al., “Car's Black Box System Using Arduino,” 2024.

[9] Jnana K. P., Sinchana Narayan, and Shruti Gatade, “Automatic Vehicle Accident Detection and Healthcare Unit Notification using IoT Technology with ESP32,” International Journal of Innovative Research in Engineering & Multidisciplinary Physical Sciences (IJIRMPS), vol. 10, no. 4, Jul.–Aug. 2022.

[10] G. A. E. Satish Kumar, J. Swetha Priyanka, and A. Sai Deepthi, “Vehicle Accident and Alcohol Detection System using IoT Platform,” Indian Journal of Science and Technology, vol. 15, no. 39, pp. 2004–2010, Oct. 2022.

[11] Amal Hussain Alkhaiwani and Badr Soliman Alsamani, “A Framework and IoT-Based Accident Detection System to Securely Report an Accident and the Driver's Private Information,” Sustainability, vol. 15, no. 10, Art. no. 8314, May 2023.

[12] Pankaj P. Tasgaonkar, Rahul Dev Garg, and Pradeep Kumar Garg, “An IoT-Based Framework of Vehicle Accident Detection for Smart City,” IETE Journal of Research, vol. 70, no. 5, pp. 4744–4757, 2023.

[13] K. M. P. Josephinshermila, S. Sharon Priya, S. G. P. Ramakrishna Hegde, and B. Veerasamy, “Accident Detection using Automotive Smart Black-Box Based Monitoring System,” Measurement: Sensors, vol. 27, Art. no. 100721, Jun. 2023.

[14] Rohith Yerrapalem, Navya Ravuri, Bala Venkata Aditya Seelam, and Roshan Sagar Pallala, “The IoT Based Health Monitoring with Alcohol Detection and Control System,” International Journal of Engineering and Computer Science (IJECS), vol. 12, no. 3, pp. 25669–25676, Mar. 2023.

[15] A. Meghana, M. R. Bharath, Saurabh Kumar, and Neeraj Kumar, “ESP32 Based Embedded System for Level-I Vehicular Automation using IoT,” AIP Conference Proceedings, vol. 2424, Art. no. 030002, 2022.

[16] David Sherry H., Manoj Kumar D., and Ritchie Saul Daniel R., “Intelligent Accident Detection and Vehicle Security for Two Wheelers,” Journal of Ubiquitous Computing and Communication Technologies, vol. 5, no. 2, pp. 220–233, Jul. 2023.

[17] S. Jawad, H. Munsif, A. Azam, A. H. Ilahi, and S. Zafar, “Internet of Things-Based Vehicle Tracking and Monitoring System,” in Proc. 15th International Conference on Open-Source Systems and Technologies (ICOSST), 2021, pp. 1–6.

[18] S. Uma and R. Eswari, “Accident Prevention and Safety Assistance using IoT and Machine Learning,” Journal of Reliable Intelligent Environments, vol. 8, no. 2, pp. 79–103, 2022.

[19] T. Thamaraimanalan, M. Mohankumar, S. Dhanasekaran, and H. Anandakumar, “Experimental Analysis of Intelligent Vehicle Monitoring System using Internet of Things (IoT),” EAI Endorsed Transactions on Energy Web, vol. 8, no. 36, 2021.

[20] Hamza Farooq, Ayesha Altaf, Faiza Iqbal, Juan Castanedo Galán, Daniel Gavilanes Aray, and Imran Ashraf, “DrunkChain: Blockchain-Based IoT System for Preventing Drunk Driving-Related Traffic Accidents,” Sensors, vol. 23, no. 12, Art. no. 5388, Jun. 2023.