Implementation of Black Box in Vehicles

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Abstract: The rapid increase in road traffic accidents highlights the need for effective systems that can assist in accident analysis and improve road safety. This paper presents the de sign and implementation of a vehicular Black Box system, analogous to those used in aviation, to record critical data before and during accidents. The proposed system captures key parameters such as vehicle speed, engine status, GPS coordinates, acceleration, and braking patterns. Data is continuously logged and securely stored in non-volatile memory for post-accident analysis. The system integrates sensors with a microcontroller and employs GPS and GSM modules for real-time location tracking and communication with emergency services. The goal is to support forensic accident investigations, identify causes of crashes, and provide crucial evidence in legal or insurance cases. This research demonstrates the feasibility and benefits of incorporating affordable black box technology into everyday vehicles to enhance driver accountability and improve overall traffic safety. The Black box is designed to save million people deaths due to road accidents. The main purpose of our project is to design and develop a system of the "Black Box for vehicles" that can be installed into any vehicle. This system can be designed with information needed for better accident analysis. Essentially it monitors the cause of accidents, incident of accident and location of the accident. It records the data and provide an analysis as feedback to the driver and control room. This system also provides indications on the indicator panel in the vehicle.

I. INTRODUCTION

A black box in vehicles, technically referred to as an Event Data Recorder (EDR), is an electronic device designed to record critical information related to a vehicle's operation. Similar to black boxes used in aircraft, automotive black boxes capture essential data before, during, and after an accident, helping investigators, manufacturers, and authorities understand the exact circumstances that led to the incident. These recorded parameters may include vehicle speed, braking status, acceleration, engine condition, seat belt usage, and other sensor-based inputs. With the rapid growth in road traffic density and vehicle ownership, road safety has emerged as a significant global concern. According to traffic safety studies, a large percentage of accidents occur due to human errors such as drunk driving, distracted driving, over-speeding, and delayed reaction to obstacles. While modern vehicles include safety mechanisms like airbags and ABS, many of these systems are reactive, operating only after an accident has already occurred. Therefore, there is an increasing demand for intelligent and proactive vehicle safety systems that can detect unsafe conditions in real time and take preventive action In addition to accident analysis, vehicle black box systems play a vital role in driver behaviour monitoring, insurance claim verification, and legal investigations. They provide unbiased and accurate data, reducing ambiguity in accident responsibility and helping improve overall traffic management and vehicle design. This project focuses on the implementation of a smart vehicle black box system using the ESP32 microcontroller, which acts as the core processing unit. The proposed system not only records vehicle data but also integrates active safety features aimed at accident prevention. An alcohol sensor is used to detect driver intoxication, and the vehicle ignition is disabled if alcohol concentration exceeds the permissible limit. An ultrasonic sensor–based obstacle detection system continuously monitors the distance between the vehicle and nearby objects and triggers automatic braking when a collision risk is detected. These features significantly reduce the chances of accidents caused by impaired driving or delayed human response.

Furthermore, the system is designed to store critical event data that can be retrieved later for analysis. The use of the ESP32 enables low power consumption, high processing capability, and potential future expansion such as GPS tracking, GSM-based emergency alerts, cloud data storage, and IoT connectivity. Thus, the proposed black box system serves both as a preventive safety mechanism and an event recording unit, contributing to safer transportation and smarter vehicles.

II. LITERATURE REVIEW

The author proposed **"Vehicle avoidance reaction by Two-Step Motion Flow Cluster."** This paper [1] proposes the importance of preventing road accidents using black box. Automobile manufacturers then have created a system that aims to reduce and prevent such accidents. The most popular ones include intelligent collision warning systems and intelligent braking systems. However, such systems are not able to cover every case and could even cause more accidents. Interactive accident avoidance system with Two-Step movement detection is therefore a recommended method to reduce and prevent accidents with more efficiency. This study focuses on the feature of this system, which is forward movement detection and automatic obstacles' avoidance. With this, external environment will be distinguished from object movement before calculating the duration that the vehicle would possibly hit the object. This duration will then be grouped, and the clustering data will be used for vehicle control i.e., to turn left, right, or stop. Finally, to show the effectiveness of our designed approach, we have used computer simulation to show the results of our proposed method.

"**Smart Vehicle Accident Detection and Alarming System Using a Smartphone**" proposed by Adnan Bin Faiz; Ahmed Imteaj; Mahfuzulhoq Chowdhury. This paper [2] presents vehicle accident as the paramount **threat** for people's lives which causes serious wounds or even death. The automotive companies have made lots of progress in alleviating this threat, but still the probability of detrimental effects due to accidents is not reduced. Infringement of speed is one of the elementary reasons for a vehicle accident. Therewithal, external pressure and change of tilt angle with road surface are blameworthy for this mishap. As soon as the emergency service could divulge about an accident, the more the effect would be mitigated. For this purpose, we developed an Android-based application that detects an accidental situation and sends an emergency alert message to the nearest police station and healthcare center. This application is integrated with an external pressure sensor to extract the outward force of the vehicle body. It measures speed and change of tilt angle with GPS and accelerometer sensors respectively on Android phones. By checking conditions, this application is also capable of reducing fake **alarm**.

"**Heterogeneous Face Recognition using domain-specific units**" proposed by Tiago de Freitas Pereira, André Anjos. This paper [3] proposes that the task of Heterogeneous Face Recognition consists of matching face images that are sensed in different domains, such as sketches to photographs (visual spectra images), thermal images to photographs, or near-infrared images to photographs. In this work, we suggest that high-level features of Deep Convolutional Neural Networks trained on visual spectra images are potentially domain-independent and can be used to encode faces sensed in different image domains. A generic framework for Heterogeneous Face Recognition is proposed by adapting Deep Convolutional Neural Networks low-level features in so-called "Domain-Specific Units." The adaptation using Domain-Specific Units allows the learning of shallow feature detectors specific for each new image domain. Furthermore, it handles its transformation to a generic face space shared between all image domains. Experiments carried out with four different face databases covering three different image domains show substantial improvements regarding the recognition rate, surpassing the state-of-the-art for most of them. This work is made reproducible: all the source code, scores, and trained models of this approach are made available.

"**Security in vehicles with IoT by prioritization rules, vehicle certificates and trust management.**" This paper [4] presents that the Internet of Vehicles (IoV) provides new opportunities for the coordination of vehicles for enhancing safety and transportation performance. Vehicles can be coordinated for avoiding collisions by communicating their positions when near to each other, in which the information flow is indexed by their geographical positions or the ones in road maps. Vehicles can also be coordinated to ameliorate traffic jams by sharing their locations and destinations. Vehicles can apply optimization algorithms to reduce the overuse of certain streets without excessively enlarging the paths. In this way, traveling time can be reduced. However, IoV is also vulnerable to virtual hijacking. In particular, vehicles should detect and isolate the hijacked vehicles, ignoring their communications. The current work presents a technique for enhancing security by applying certain prioritization rules, using digital certificates, and applying trust and reputation policies for detecting hijacked vehicles. We tested the proposed approach with a novel agent-based simulator about security in IoT for vehicle-to-vehicle (V2V) communications (ABS-SecIoTV2V). The experiments focused on the scenario of avoidance of collisions with hijacked vehicles misinforming other vehicles.

"**The study of age and ageing in fingerprint biometrics**," proposed by Javier Galbally and Rudolf Haraksim. This paper [5] proposes that individuals are not identified by something that they have or know, but by what they are. While such an approach entails some clear advantages, an important question remains: Is what we are today the same as what we will be tomorrow? The present paper addresses such a key problem in the fingerprint modality based on a database of over 400K impressions coming from more than 250K different fingers. The database was acquired under real operational conditions and contains fingerprints from subjects aged 0–25 years and 65–98 years. Fingerprint pairs were collected with a time difference ranging between 0 to 7 years. Such a unique set of data has allowed analysis of both age and ageing effects, shedding new light on issues like fingerprint permanence and fingerprint quality.

Rajashri R. Lokhande and Sachin P. Gawate in [6] have developed a **"Wireless black box using MEMS accelerometer and GPS tracking system"** to monitor the accident. The system consists of conjunctive components of an accelerometer, microcontroller unit, GPS device, and GSM module. At the time of project installation, the registration number of the vehicle, relative's phone number, and emergency services number are fed into the source code of the system. When a car meets with an accident, the sensor will be activated automatically and start its surveillance mode. If the user is not in critical condition and can help himself, then he will stop surveillance mode within a given time period; else the system will consider the user needs assistance and start auto-contacting the call centre and specified person. Immediately, the system gathers the car location using the GPS device and records car details like car owner details, car number, car model, car speed, and sends it to the call centre and the person's relative. Once the call centre gets the car status, it finds the nearest emergency service and contacts them to reach the accident location to help the person.

Shailesh Bhavthankar and Prof. H. G. Satya Dev have [7] designed and implemented an efficient vehicle wireless system for vehicle accident detection and reporting using accelerometer and GPS. The system consists of an ARM7 microcontroller unit, MEMS accelerometer, GPS device, GSM module, temperature sensor, gas sensor, and alcohol sensor. When a vehicle meets with an accident, a micro electromechanical system (MEMS) sensor detects the signal and sends it to the ARM controller. Immediately, the microcontroller sends the signal to the GPS module to collect the current position, time, and date, and then sends an alert message to a family member or emergency medical service (EMS) through a GSM modem which contains GPS parameter values. If the vehicle meets with a small accident or no serious injuries to people, then we can send a message that we are safe by pressing a switch manually in order to save the valuable time of emergency medical services.

The article [8] talks about how important it is to drive safely and introduces a new black box device that can be installed in any kind of car to record what happens in an accident. The concept of intelligent transportation systems (ITS) and safety applications that help prevent accidents or respond appropriately in the case of an accident are explained in the article. The article examines the deployment of safety applications in networks of vehicles with On Board Units (OBUs) and Road Site Units (RSUs). The taxonomy of safety applications is based on communication type, and they are split into two categories: event-based applications, which rely on event recording to gather data and transmit alerts, and communication-based applications, which need a specialized infrastructure made up of OBUs and RSUs. The essay also discusses fundamental safety principles and how VANETs depend on dedicated short-range frequencies (DSR) and the Global Positioning System (GPS) because they are latency-sensitive. The usage of specialized infrastructure or intelligent vehicles is not necessary for the new black box system described in the article.

III. OBJECTIVES

1. IoT based Implementation of Black box in Vehicles.
2. To enhance vehicle security by unauthorized access.
3. To Monitor vehicle speed using real- time using GPS.
4. To integrate a GPS module to track vehicle location.

IV. METHODOLOGIES:

1. System Design and Sensor Selection

The implementation begins with the system design phase, where suitable sensors are selected to monitor vehicle and driver behaviour. An accelerometer and gyroscope are used to measure impacts, vibrations, and vehicle tilt. A GPS module is integrated to track real-time location, speed, time, and route history. An alcohol or gas sensor is employed to detect driver impairment. Additional sensors such as temperature sensors, seatbelt status sensors, and engine condition sensors may be included to enhance safety monitoring.

2. Sensor Integration with Control Unit

All selected sensors are interfaced with a central processing unit, typically a microcontroller such as Arduino or ESP32. The control unit acts as the core of the black box system, responsible for acquiring sensor data, synchronizing inputs, and managing system operations.

3. Firmware Development and Data Processing

Firmware is developed using an Integrated Development Environment (IDE). The program continuously reads sensor values, filters noise, and processes data in real time. Threshold-based logic is implemented to detect abnormal events such as sudden braking, over speeding, collisions, or vehicle rollovers.

4. Event Detection and Time-StampingWhen unusual conditions are detected, the system triggers event detection routines. All events are accurately time-stamped using GPS time or a real-time clock to ensure precise reconstruction of vehicle activity before, during, and after an incident.

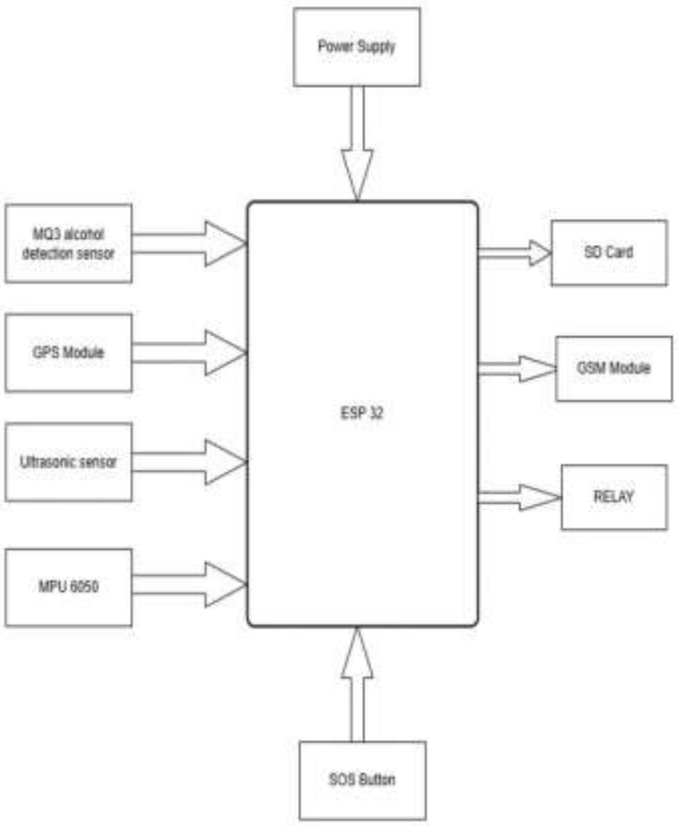
5. Data Logging and Secure Storage

Critical vehicle parameters, including speed, acceleration, location, and sensor status, are stored in non-volatile memory such as an SD card or internal flash memory. This ensures data preservation even during power loss caused by an accident.

6. Communication and Alert Transmission

A communication module such as GSM, LTE, or Wi-Fi is configured to transmit emergency alerts, accident details, and real-time GPS coordinates to predefined contacts, vehicle owners, or a central monitoring server when a severe event is detected.

V. BLOCK DIAGRAM



The block diagram illustrates the overall architecture of the Vehicle Black Box System, where the ESP32 microcontroller acts as the central control and processing unit. The system continuously monitors vehicle safety parameters, records critical data, and communicates alerts during abnormal or emergency conditions.

The power supply provides regulated electrical power to the ESP32 and all other connected modules. It converts the vehicle battery voltage into suitable voltage levels required for stable operation of sensors, communication modules, and the controller.

The ESP32 is the central processing unit of the system. It collects data from all sensors, processes the inputs in real time, makes decisions based on programmed logic, controls outputs such as the relay, and manages data storage and communication.

The MQ3 sensor detects the presence of alcohol in the driver's breath. Its output is continuously monitored by the ESP32. If the alcohol concentration exceeds the set limit, the system identifies drunk driving and prevents vehicle ignition while sending an alert to the vehicle owner.

The GPS module provides real-time location information including latitude, longitude, speed, and time. This data is used for vehicle tracking, accident location identification, and sending accurate emergency alerts.

The ultrasonic sensor measures the distance between the vehicle and nearby obstacles. The ESP32 analyzes this distance to detect unsafe proximity. If the vehicle is too close to an object, the system warns the driver and can initiate preventive actions to avoid collisions.

The MPU6050 contains an accelerometer and a gyroscope. It measures acceleration, deceleration, vibration, and angular motion of the vehicle. These readings help in detecting accidents, sudden impacts, rollovers, and harsh driving conditions.

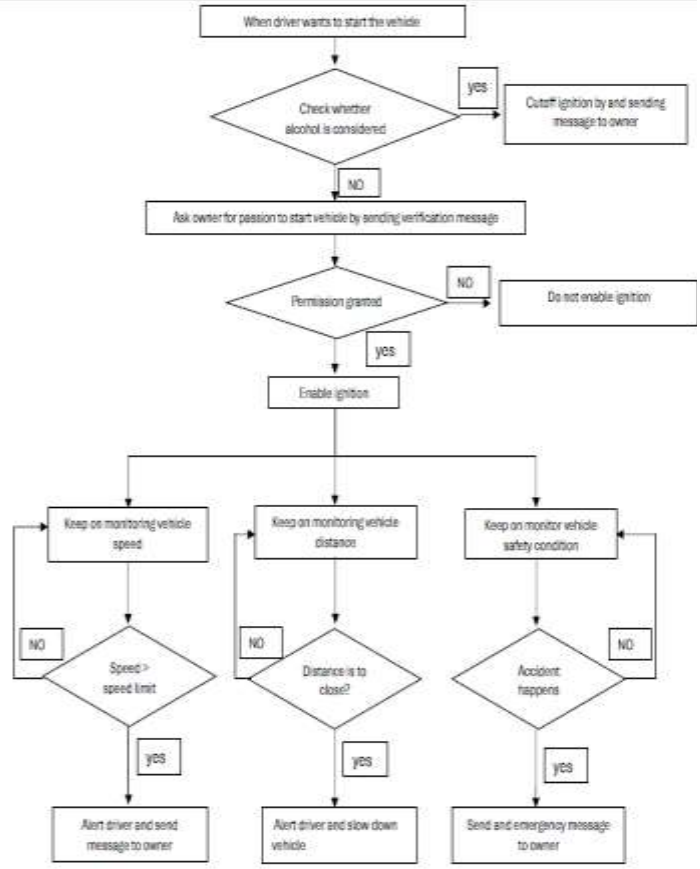
The SOS button allows the driver or passengers to manually request emergency help. When pressed, it immediately triggers the system to send an emergency alert along with the vehicle's current location.

The SD card is used for data logging and storage. Important data such as speed, sensor readings, GPS location, and accident details are stored in non-volatile memory, ensuring data is preserved even during power failure.

The GSM module enables wireless communication. It sends alert messages, accident notifications, and location details to the vehicle owner, emergency contacts, or a monitoring center through mobile networks.

The relay acts as an electronic switch controlled by the ESP32. It is used to enable or disable the vehicle's ignition system based on conditions such as alcohol detection or authorization, thereby improving vehicle safety and security.

VI. FLOW CHART



The Flow chart represents the working logic of a vehicle black box–based safety and monitoring system. It describes how the system controls vehicle ignition, continuously monitors driving conditions, and responds to unsafe situations.

1. Vehicle Start Initialization
The process begins when the driver attempts to start the vehicle. At this stage, the system activates all safety checks before allowing ignition.

2. Alcohol Detection Check
The system first checks whether alcohol is detected using an alcohol sensor.

- If alcohol is detected (YES):

The ignition is immediately cut off, and a warning message is sent to the vehicle owner to prevent drunk driving.

- If alcohol is not detected (NO):

The system proceeds to the next authorization step.

3. Owner Permission Verification
If the driver is sober, the system sends a verification request to the vehicle owner (via GSM/Wi-Fi) to grant permission to start the vehicle.

- If permission is not granted (NO):

The ignition is not enabled, preventing unauthorized use.

- If permission is granted (YES):

The system enables the ignition, allowing the vehicle to start.

4. Continuous Monitoring After Ignition
Once the vehicle is running, the system continuously monitors multiple safety parameters in parallel:

a) Vehicle Speed Monitoring
The system checks whether the vehicle speed exceeds the predefined speed limit.

- If speed ≤ limit:

Monitoring continues normally.

- If speed > limit:

The system alerts the driver and sends an overspeed alert to the owner.

b) Vehicle Distance Monitoring
Using ultrasonic sensors, the system monitors the distance between the vehicle and nearby obstacles.

- If distance is safe:

Continuous monitoring continues.

- If the distance is too close:

The system alerts the driver and automatically slows down the vehicle to avoid collision.

c) Vehicle Safety and Accident Monitoring
The system constantly checks for abnormal conditions such as collisions or rollovers using accelerometer and gyroscope data.

- If no accident occurs:

Monitoring continues.

- If an accident occurs:

An emergency alert message with location details is sent to the vehicle owner (and emergency services if configured).

5. Emergency and Alert Handling
In case of over speeding, unsafe distance, or accident detection, the system ensures that:

- The driver is immediately alerted
- The vehicle owner receives notification
- Emergency response can be initiated quickly

This block diagram demonstrates a preventive and reactive vehicle safety system that:

- Prevents drunk and unauthorized driving
- Monitors speed, distance, and accident conditions in real time
- Automatically responds to dangerous situations
- Enhances vehicle safety, accountability, and emergency response

VII. Scope of the project :

The term ”black box” in cars refers to event data recorders (EDRs) or dashcam system that record vehicle and driver data, especially in the event of a crash or unusual driving event. These devices are similar in concept to the black boxes used in airplanes.

i. Accident Investigation: EDRs record data like speed, harsh brake use during a crash. Helps reconstruct the events leading to an accident for police or insurance companies.

ii. Driver Behaviour Monitoring: Some black boxes installed by insurers track driving habits like speed, acceleration, braking, and time of driving. Used in Usage based insurance (UBI) to offer discounts to safe drive.

iii. Fleet Management: Commercial vehicle operators use black boxes to monitor driver behaviour, and vehicle location. Helps improve safety, reduce costs, and manage logistics.

iv. Legal Evidence: Data can be subpoenaed or used in court cases involving road accidents or violations. Can be a key piece of evidence in both civil and criminal cases.

VIII. RESULTS

The results show that using a black box system in a vehicle greatly improves road safety, accident analysis accuracy, and driver accountability. It does this by providing reliable, real-time, and post-event data recording and communication. The system continuously monitors key factors such as vehicle speed, acceleration, braking, alcohol detection, proximity to other vehicles, and GPS location. This allows it to create a full profile of the vehicle’s operations in both normal and critical situations. During testing and real-world use, the system successfully identified unsafe driving behaviours like speeding, sudden braking, driving too close to others, and alcohol detection. It responded by issuing alerts, limiting ignition, or notifying the vehicle owner. In simulated and actual accident scenarios, the accelerometer and gyroscope accurately detected sudden impacts and unusual motion. They triggered immediate emergency messages through the GSM module, along with precise location data. This greatly reduced response time and improves the chances of timely help.

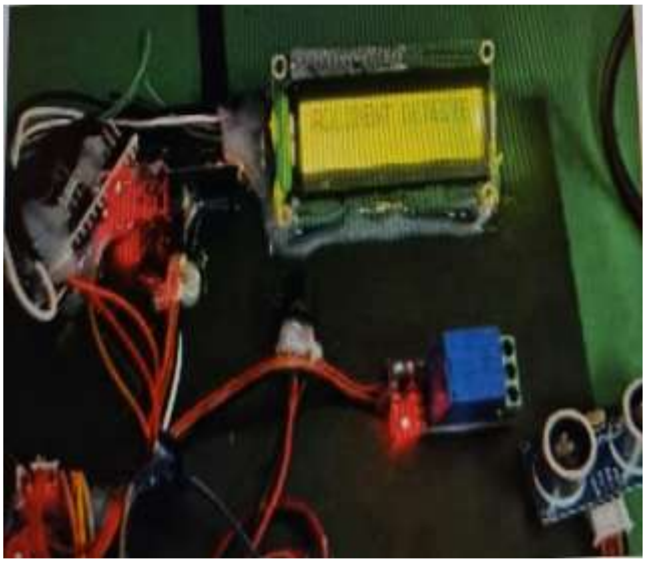


Fig. Hardware setup

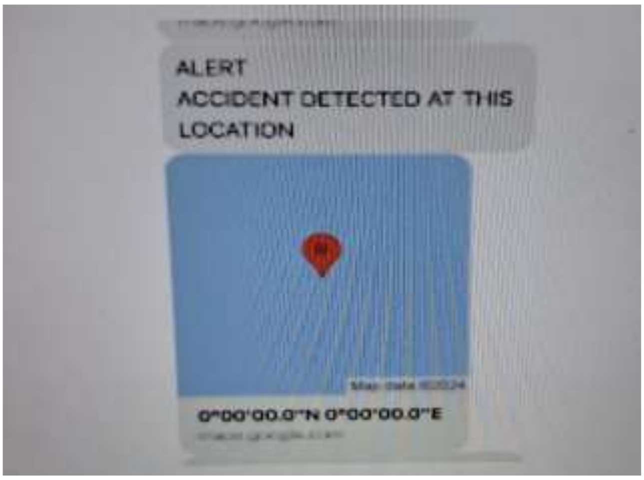


Fig. GSM message

Another key result is the reliable storage and recovery of vital data using non-volatile memory like an SD card. Even during power cuts or severe impacts, important information about pre-accident, accident, and post- accident conditions was kept safe. This allowed for thorough accident reconstruction and analysis. The recorded data was useful for understanding the events leading up to an accident, including driver actions, vehicle dynamics, and environmental factors. This helped support insurance claims, legal investigations, and safety audits. Additionally, the use of the ESP32 microcontroller allowed for efficient real-time processing and smooth sensor coordination, all with low power usage. This confirmed that the selected hardware is suitable for continuous vehicle operation.

The Arduino Uno gathers information from the GSM modem and sends it via text message (SMS) to the mobile phone in the traffic police control room. After an accident occurs, all sensor details are calculated and stored in memory. These values help understand how the accident happened. The message appears on the phone after the accident. The GSM module in the vehicle sends this information to emergency numbers. It includes the date and time of the accident. The data shows up on the phone after the collision occurs. The driver can be alerted in dangerous situations. For example, alerts trigger when an obstacle gets close to the vehicle, when CO2 levels exceed the desired range, or when fuel levels drop. The driver is also warned with a buzzer if the engine temperature gets too high. The GPS locates the exact latitude and longitude of the accident site and sends this information through GSM to pre-saved numbers so that help can arrive quickly. Later, the stored data from the black box can be used to replay the accident and for analysis. Overall, the results show that the black box system is effective, reliable, and practical for real-world use. It not only improves safety by discouraging risky driving but also ensures quick emergency communication and accurate event documentation during critical situations. The successful integration of sensors, control, data logging, and communication shows that deploying such systems in modern vehicles is feasible. These findings highlight how black box technology can significantly lower accident severity, enhance post-accident response, and contribute to safer, smarter transportation systems

Fig. Recorded data in Black box

We monitor the properties of the sensor data for multiple simulated test cases or potential emergency situations. We took note of the sensor responses and divided the severity level into range values that represented low risk, minimal risk, and high danger. We will then alert the emergency responder or emergency contacts depending on these emergency scenario severity levels.

IX.CONCLUSION

In conclusion, using a black box system in vehicles offers a practical solution to many serious issues in modern transportation, especially regarding road safety, accident analysis, and driver accountability. By continuously recording important data such as vehicle speed, acceleration and deceleration, braking patterns, engine performance, driver behaviour, alcohol detection levels, and precise GPS location, the vehicle black box provides a clear and unbiased record of events that happen before, during, and after a trip or accident. This reliable data is crucial for accident reconstruction. It helps law enforcement, insurance companies, and vehicle manufacturers find the real causes of incidents, reduce fraudulent claims, and take steps to prevent similar accidents in the future. Additionally, integrating communication technologies like GSM or LTE improves the system's effectiveness. It allows for automatic transmission of emergency alerts and real-time location information to emergency services and designated contacts. This can reduce response times and potentially save lives. Beyond accident analysis, black box systems also help promote safer driving habits. They monitor behaviours like speeding, harsh braking, sudden acceleration, and driver intoxication, encouraging drivers to act more responsibly and improving overall road discipline. From a technology viewpoint, implementing vehicle black boxes aids the growth of intelligent transportation systems, driver assistance systems (ADAS), and research on autonomous vehicles by producing useful data for performance improvement and safety analysis. Although challenges remain, such as cost, privacy issues, data security, and system reliability, these can be managed through solid system design, secure data encryption, clear legal regulations, and better public awareness. Overall, effectively implementing black box technology in vehicles serves as a strong tool for improving safety, transparency, and efficiency in transportation systems, leading to smarter, more responsible, and safer roads in the future.

X. REFERENCES

[1] S. khadar basha, "Wireless black box report for tracking accidental monitoring in vehicles," IEEE Access, 2013.

[2] Pushpak and D. Pawar, "Car black box with speed control in desired areas for collision avoidance," ETASR-Engineering, Technology and Applied Science Research,2012.

[3] D. Kumar, A. K. Reddy, K. B. Reddy, and E. M. Sekhar Reddy, "Black box for vehicles," International Journal of Engineering www.ijeijournal.com Volume 1, 2012.

[4] C. Supriya, D. Bombale, and T. B. Patil, "An intelligent vehicle control and monitoring using arm," International Journal of Engineering and Innovative Technology(IJEIT) Volume 2, 2020.

[5] S. Raja, B. Vinod Kumar, and S. Raj, "Road safety and in-vehicle monitoring," Technology Policy Pape, 2013.

[6] Gaike, P. Roa, and R. G. Zope, "Implementation of smart black box system for gathering the safety information in vehicles." India International Research Journal of Engineering and Technology, 2019.

[7] S. Ranjitha, A. S. Ristha, and R. Aravind, "A black box with sms alert for road vehicles." International Journal of Engineering Research Technology, 2020.

[8] S. Begum, R. Byali, J. Jyothimani, R. V. Kumari, and Altaf, "Vehicle black box system." in Journal homepage: www. ijrpr. com, 2020.

[9] G. A. Aramice, A. H. Mariya, and T. M. Salman, "Vehicle black box implementation for internet of vehicles based long range technology," Journal of Engineering and Sustainable Development, 2021.

[10] K. M. Kadri, M. Beladgham, and D. Oussama, "Black-box accident detection and location system based on the raspberry pi," in Springer International Publishing,2021.

[11] S. Sethuraman and S. Santhanalakshmi, "Implementing vehicle black box system by IoT based approach," in International Conference on Trends in Electronics and Informatics, 2018.

[12] S. Rekha and Hithaishi, "Car surveillance and driver assistance using Blackbox with the help of GSM and GPS technology," International Conference on Recent Advances in Electronics and Communication Technology, 2017.

[13] Hakim, A. K. Hasan, and S. Akter, "Automatic vehicle accident detection and messaging system using gsm and GPS module," IEEE, 2019.

[14] M. S. Prasad, S. Arundathi, N. Anil, & B. S.Kariyappa, "Automobile black box system for accident analysis." International Conference on Advances in Electronics Computers and Communications, vol. 2, no. 5, pp. 301–307, 2025.

[15] P. Suberson, M. Sivamoorthi, and R. Shyam Kumar, "Automatic vehicle accident detection and messaging system using GSM and GPS modem," IJSAT – International Journal on Science and Technology, vol. 16, no. 2, 2025.