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Intelligent Smart Data Recorder for Vehicle Tracking and Accident Response System

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Abstract **–** Due to the increase in the number of vehicles, accidents have emerged as a major problem, leading to critical situations due to the delayed response of emergency services. This paper proposes a study on an Intelligent Smart Data Recorder for Vehicle Tracking & Accident Response System, which aims to improve accident detection and response systems. The proposed system uses Internet of Things technology along with an ESP32 Wi-Fi module to collect real-time data from vehicles regarding their speed, location, and impact, thereby improving the accuracy of accident detection. It sends an emergency alert to remote users immediately after an accident is detected, thereby helping in faster response. It also performs basic recording of vehicle parameters including location, which proves to be useful for simple analysis during abnormal conditions, thereby improving road safety. The use of Internet of Things technology is the core idea of the system which enables real-time communication.

Keywords — Accident Detection, IoT, Smart Data Recorder, Vehicle Tracking, Emergency Response, Road Safety.

I.INTRODUCTION

The Intelligent Smart Data Recorder is designed to improve vehicle safety by providing better accident detection and faster emergency response. Nowadays, the number of road accidents is increasing, and delays in emergency services can lead to serious consequences. To overcome this problem, this system continuously monitors important vehicle parameters using sensors such as an accelerometer, speed sensor, GPS module, and altitude sensor.

The ESP32 microcontroller collects and processes this data to identify abnormal situations like accidents or over-speeding. When an accident is detected, the system immediately triggers a buzzer alert, stops the motor using a motor driver, and sends real-time notifications along with the vehicle's location through an IoT platform.

In addition to real-time alerts, the system also records important data such as speed, impact, altitude, and location, which can be useful for analyzing accidents later. By combining sensor data with IoT technology, the proposed system helps in improving road safety, enabling quick emergency response, and supporting accident investigation. Furthermore, system ensures continuous monitoring and real-time data transmission, making it more reliable and efficient compared to traditional methods. The integration of multiple sensors improves detection accuracy and reduces false alerts.

II. LITERATURE REVIEW

[1]. Smart Helmet for Motorcycle Accident Detection and Safety Monitoring

The proposed system offers a smart helmet concept for the reduction of motorcycle accidents using advanced wireless technologies. It incorporates alcohol sensor devices and a helmet wear verification component to ensure the vehicle is only started if the rider is wearing a helmet and not under the influence of alcohol. In the event of a crash, the GSM component sends a message with the rider's location to emergency contacts. It also incorporates accelerometer and gyroscope sensor components for fall detection and a Bluetooth component for smartphone integration with the hands-free communication feature. This approach encourages the rider to be responsible on the road and improves safety.

[2]. Sudden Unintended Acceleration Avoidance, Drowsiness Detection System

This system aims to prevent automobile accidents by monitoring the physical condition of the driver in real-time. The system detects drowsiness by analyzing the movement of the driver's eyes and the rate of blinking. An alarm sounds if the driver is found to be drowsy. This system also prevents pedal misapplication accidents, in which the driver mistakenly presses the accelerator instead of the brake. This system prevents accidents caused by driver drowsiness, inattention, and other errors.

[3]. Vehicle Speed Control and Accident-Avoidance System

This system describes an intelligent vehicle speed control and accident-avoidance system. This system is aimed at providing safety on the road by helping the driver in critical situations. This intelligent speed control and accident-avoidance system use ultrasonic sensors located at the front of the vehicle to monitor the surroundings and detect any obstacle in the way. This obstacle can be a person, another vehicle, or a barrier on the road. These sensors measure the distance between the vehicle and the obstacle and send signals to a processing unit. Once the distance is less than a predetermined safe distance, the processing unit analyzes the signals and sends appropriate signals to activate an automatic braking system to decrease the speed of the vehicle.

In addition to the frontal obstacle detection feature, the system also includes a warning feature that utilizes a buzzer to warn the driver when an obstacle approaches from the rear. Therefore, the proposed system not only provides the benefits of an automatic system but can also minimize the number of accidents that might occur due to the slow response of the human driver, as well as the possibility of reckless driving. In this context, the proposed system can also illustrate the benefits of embedded technology for improving the safety of vehicles, minimizing the possibility of accidents, and providing greater reliability for the driving process.

[4]. Smart System for Accident Prevention Using Environmental and Driver Monitoring

This system focuses on reducing accidents by monitoring both external environmental conditions and internal driver-related factors that affect safe driving. External conditions such as fog, poor visibility, and road conditions are analysed, while internal factors like driver fatigue, oxygen level variations, carbon dioxide concentration, and humidity inside the vehicle are monitored to assess safety. By continuously evaluating these parameters, the system can identify potentially dangerous situations before they lead to accidents.

When unsafe conditions are detected, the system provides preventive assistance by issuing warnings or activating safety mechanisms to alert the driver. This approach emphasizes accident prevention rather than post-accident response, demonstrating how multi-parameter monitoring can improve driving safety.

III. METHODOLOGY

The proposed system is an intelligent smart data recorder for vehicle monitoring and accident detection system designed to enhance road safety and reduce the impact of road accidents. In recent years, the number of road accidents has increased significantly, and delays in emergency response often lead to serious consequences, including loss of lives. To address this issue, the system continuously monitors important vehicle parameters in real time using multiple sensors and a microcontroller. These parameters include motion variation, acceleration, speed, impact force, location, and altitude, which are critical for identifying abnormal driving conditions and potential accidents.

The system uses sensors such as an accelerometer, speed sensor, GPS module, and altitude sensor to collect accurate real-time data from the vehicle. This data is processed by the microcontroller using predefined threshold values to determine whether an accident has occurred. By combining data from multiple sensors, the system improves detection accuracy and minimizes false alarms that may occur due to road irregularities, vibrations, or sudden braking. This multi-sensor approach ensures reliable performance under different driving conditions.

When an accident is detected, the system immediately triggers alert mechanisms such as a buzzer and a display unit to notify the occurrence of the accident locally. In addition to this, the system sends real-time notifications through an IoT-based communication module, providing instant updates along with the vehicle's location. This allows emergency services or concerned persons to respond quickly without any delay. The integration of IoT technology ensures continuous monitoring and remote accessibility of vehicle data, making the system more efficient and responsive.

Unlike traditional vehicle black box systems that mainly focus on storing data for later analysis, the proposed system emphasizes real-time monitoring, quick decision-making, and immediate alert generation. However, it also records essential parameters such as speed, impact, altitude, and location, which can be useful for post-accident analysis and investigation. This combination of real-time response and data recording makes the system more practical and beneficial compared to conventional methods.

The entire system is implemented as a compact embedded solution that integrates sensing, processing, and communication into a single platform. It is designed to be cost-effective, easy to implement, and suitable for modern vehicles. By reducing response time and providing accurate accident detection, the system contributes significantly to improving road safety and emergency management.

Table 3.1: Hardware Description

COMPONENTS	TYPE	OPERATING VOLTAGE (DC)
Microcontroller	ESP32 wi-Fi Module	3.3V
Buzzer	Piezo Buzzer	5V
Power Supply	Regulated DC	5V
LCD	16x2 Display	5V
MEMS Sensor	ADXL335	3.3V-5V
Speed Sensor	Hall Effect Type	5V
Altitude Sensor	BMP280	3.3V
Driver Circuit	L293D	5V
DC Motor	Brushed DC Motor	6V-12V

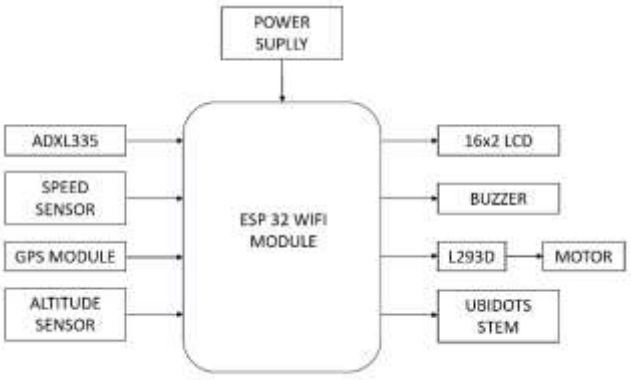

Fig 3.1: Block Diagram

Operational Flow:

»When the system power supply is turned ON, the ESP32 initializes all connected modules including the ADXL335 accelerometer, speed sensor, GPS module, altitude sensor, LCD display, buzzer, and motor driver to begin system operation.

»The accelerometer, speed sensor, and altitude sensor continuously monitor vehicle parameters such as vibration, speed variation, and altitude changes, while the GPS module provides real-time location data. All sensor data is sent to the ESP32 for processing.

»During normal operation, the motor runs continuously indicating normal vehicle movement, while the ESP32 monitors sensor data and compares the values with predefined threshold limits.

»If abnormal vibration, sudden speed variation, or unusual altitude change exceeds the predefined threshold, the ESP32 identifies it as a possible accident condition using programmed logic.

»Once an accident is detected, the ESP32 sends a control signal to the motor driver (L293D) to immediately stop the motor, preventing further movement of the vehicle model.

»At the same time, the buzzer is activated and the LCD display shows an accident alert message, indicating that a crash condition has been detected.

»Simultaneously, the ESP32 transmits accident information, including vehicle status and GPS location, to an IoT platform (such as Ubidots), enabling real-time remote monitoring and notifications (email/alerts).

»This integrated system combining sensors, ESP32 processing, alert mechanisms, and IoT communication improves accident detection accuracy and ensures faster emergency response.

Fig 3.2: Flow Chart of Accident Detection Process

IV. RESULTS AND DISCUSSION

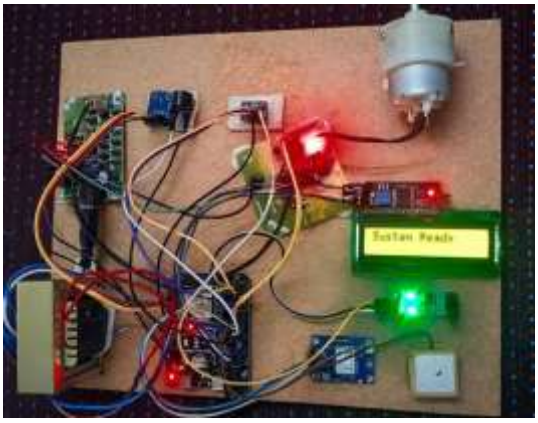

Fig 4.1: System Initialization and Ready State of the Proposed System

This figure shows the prototype system in the initialization stage. After the power supply is turned ON, the ESP32 initializes all connected sensors and system components. The LCD displays "System Ready", indicating that the sensors, motor driver, and communication modules are functioning properly. The system is now prepared to continuously monitor vehicle parameters such as speed, vibration, and location for accident detection.

Fig 4.2: Real-Time Location Monitoring of the Proposed System

This figure shows the prototype system during normal operation. After the power supply is turned ON, the ESP32 continuously monitors data from all connected sensors and processes the values. The LCD displays real-time information along with latitude and longitude coordinates, indicating that the system is actively functioning. The motor runs normally, showing that all parameters are within safe limits.

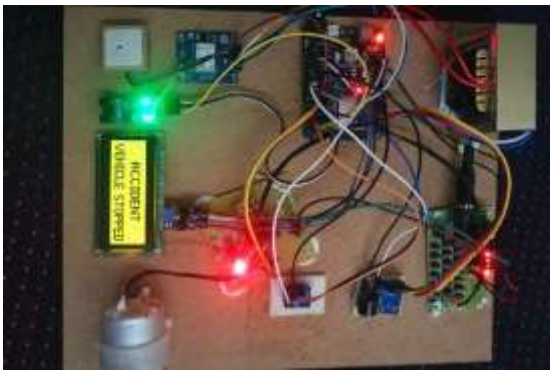

Fig 4.3: Accident Detection and Alert Generation

This figure shows the prototype system during an accident detection condition. When abnormal parameters such as sudden vibration, impact, or speed variation exceed the predefined threshold, the ESP32 identifies it as an accident. The motor is immediately stopped through the motor driver to prevent further movement of the vehicle. The LCD displays "ACCIDENT Vehicle stopped", indicating that the system has detected a crash. At the same time, alert mechanisms are activated and the system sends real-time notifications along with the vehicle's location.

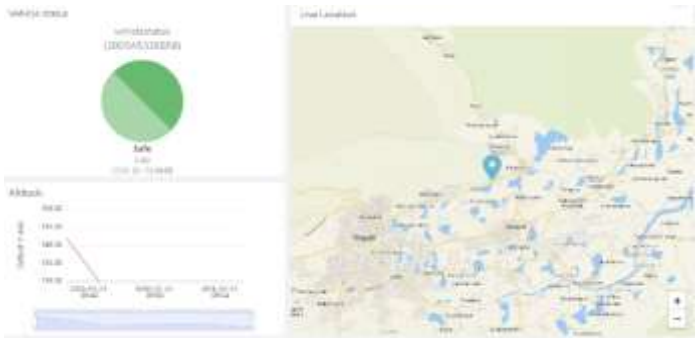

Fig 4.4: Safe Condition Monitoring (Vehicle Status = 0)

This figure shows the system under normal operating conditions. The vehicle status is indicated as Safe (0), meaning all parameters such as speed, vibration, and motion are within the predefined safe limits. The system continuously monitors the vehicle data and displays real-time altitude and location on the IoT platform without triggering any alert.

Fig 4.5: High-Speed Condition Detection (Vehicle Status = 1)

This figure represents the high-speed condition of the vehicle. When the speed exceeds the predefined threshold, the system classifies the status as High Speed (1). The system updates this condition on the IoT platform along with real-time location and altitude data, allowing remote monitoring and preventive action.

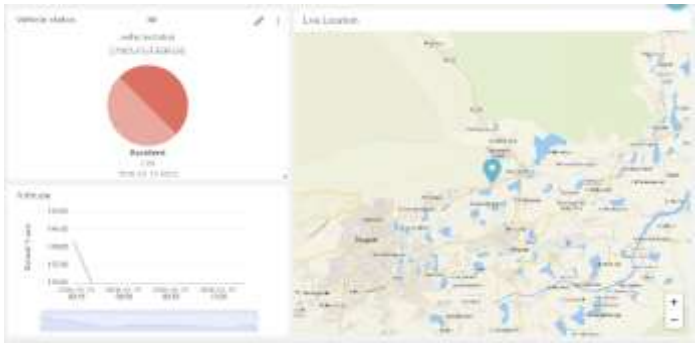

Fig 4.6: Accident Detection and Alert (Vehicle Status = 2)

This figure shows the accident condition detected by the system. When abnormal parameters such as sudden impact or vibration exceed threshold limits, the system identifies it as an Accident (2). The status is updated on the IoT platform along with the vehicle's live location and altitude, enabling quick emergency response and monitoring.

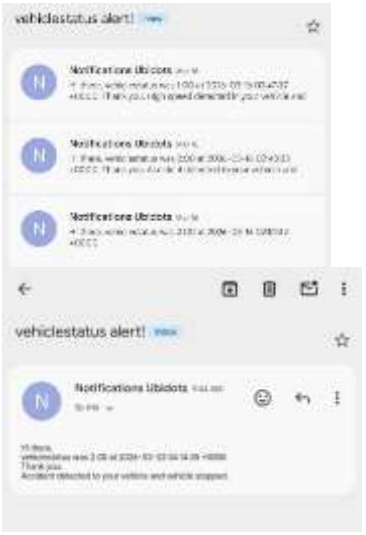

Fig 4.7: Email Notification Alerts

This figure shows the email alerts generated by the system through the IoT platform. Based on vehicle status values, the system sends notifications such as High Speed (1.00) and Accident (2.00) along with the timestamp. These alerts help in quick monitoring and timely response during critical situations

Collision Detection Algorithm: Based on data from the sensors, the microcontroller runs a collision detection algorithm. It compares sensor readings to predefined thresholds to detect impact forces and sudden changes in acceleration or velocity. The system implements a multi- layered collision detection approach using sensor fusion. Accident detection can be improved by refining the thresholds for each sensor type and incorporating machine learning models trained on real-world accident datasets. Advanced techniques such as sensor fusion and anomaly detection algorithms allow for more accurate identification of collisions, minimizing false alarms.

$$XZ = b1F + b2A + b3G$$

Where:
XZ = Collision detection score
b1, b2, b3 = Weighting factors
F = Force sensor reading
A = Acceleration magnitude
G= Gyroscopic deviation

V. CONCLUSION

The Intelligent Smart Data Recorder system developed in this project helps improve vehicle safety by providing real-time accident detection and alerting. It uses sensors such as the ADXL335 accelerometer, speed sensor, GPS module, and altitude sensor to continuously monitor important vehicle conditions. Based on this data, the system can easily identify situations like over-speeding or accidents.

The ESP32 microcontroller plays a key role by processing the sensor data quickly and making instant decisions. When an accident occurs, the system sends alerts along with location details through the IoT platform, ensuring faster response. Overall, the system is simple, reliable, and effective in enhancing road safety and emergency handling.

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