IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 10, May 2026
Impact Factor: 8.2

AI-Based Vehicle Monitoring System

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Abstract: *This project is based on creating an AI system that can be used to monitor vehicles and improve their safety and performance. These days, with the increasing number of vehicles running on the road, problems such as sudden breakdowns and accidents, and higher maintenance costs are becoming very common. The traditional systems available in the market only track the vehicle's location using GPS and do not provide complete information about the vehicle's condition. To overcome this problem, our system is based on using different sensors and microcontrollers to track the vehicle's status in real time using machine learning algorithms. Different sensors, such as temperature sensors, speed sensors, fuel level sensors, vibration sensors, and alcohol sensors, are used to collect essential information regarding the vehicle's status. These sensors track the vehicle's status in real time and provide information regarding the vehicle's engine status, speed, fuel level, and other factors such as vibration and alcohol presence near the driver's side of the vehicle. All the information is collected and processed using a microcontroller such as ESP32 or Node MCU, which is the brain of the system and is used to collect information from the sensors and process it further. The information is collected and further processed using machine learning algorithms, and before using the information, it is cleaned and processed to eliminate the chances of receiving wrong results. After this, machine learning algorithms such as Random Forest, Support Vector Machine (SVM), K- Nearest Neighbour (KNN), etc., can be used to analyse the data. These machine learning algorithms can be used to detect unusual patterns in the data, which can be used to predict possible faults in the system before they actually happen. The system can also be used to display the status of the vehicle in real-time using a user interface. Alerts can be sent in case of any faults in the system using a buzzer or display. The system can also include a GPS module to track the location of the vehicle, which can be useful in fleet management. From the above block diagram (page 2), it can be concluded that the system can be divided into the following components: collect data from sensors, process the data using a microcontroller, use machine learning to analyse the data, display the output in the form of Normal, Warning, or Fault, etc. This system can be useful in various areas, such as personal vehicles, fleet management, logistics, smart transport, etc. It can be used to improve safety, reduce maintenance costs, increase efficiency, etc. By using sensor technology coupled with artificial intelligence, this system can be used to provide a smart solution for vehicle monitoring systems.*

Keywords: *AI system*

I. INTRODUCTION

The rapid growth of Artificial Intelligence (AI), Internet of Things (IoT), and intelligent monitoring technologies is transforming modern transportation systems by improving vehicle safety, performance, and maintenance efficiency. One of the major advancements in this field is the development of AI-based vehicle monitoring systems that combine embedded sensors, machine learning algorithms, and real-time data analysis for intelligent fault detection and predictive maintenance. These systems create a seamless connection between physical vehicle conditions and digital monitoring platforms, enabling continuous supervision of important parameters such as engine temperature, speed, fuel level, vibration, and driver safety conditions. Through real-time data acquisition and intelligent processing, the system

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can detect abnormal vehicle behaviour at an early stage and provide timely alerts to prevent accidents and unexpected failures. Recent developments in IoT communication, cloud computing, and wireless technologies have further improved the scalability, reliability, and remote accessibility of smart vehicle monitoring systems. Sensors such as DHT11, Hall Effect sensor, Ultrasonic sensor, SW-420 vibration sensor, and MQ-3 alcohol sensor are widely used for collecting accurate real-time data from vehicles. The collected sensor data is processed using machine learning techniques such as Random Forest, Support Vector Machine (SVM), and K-Nearest Neighbour (KNN) to classify vehicle conditions into Normal, Warning, or Fault categories. These intelligent systems also support IoT-based remote monitoring through Wi-Fi communication, allowing users and fleet managers to track vehicle health and performance from any location. Real- time dashboards, OLED displays, buzzer alerts, and LED indicators improve driver awareness and help in taking preventive actions before critical failures occur. The integration of AI and IoT technologies in vehicle monitoring not only reduces maintenance costs and vehicle downtime but also supports predictive maintenance and smart transportation systems. This study presents an AI Based Vehicle Monitoring System that uses an ESP32 microcontroller and multiple sensors to continuously monitor vehicle parameters and provide intelligent analysis through machine learning models. The proposed system offers a low-cost, scalable, and efficient solution for enhancing vehicle safety, operational reliability, and overall transportation efficiency.

II. REVIEW OF LITERATURE

The development of AI and IoT-based vehicle monitoring systems has improved vehicle safety, fault detection, and maintenance efficiency. Traditional monitoring systems mainly used basic sensors and threshold-based alerts, which could only detect simple problems and lacked intelligent analysis. With the advancement of embedded systems, wireless communication, and machine learning, modern vehicle monitoring systems can now continuously monitor parameters such as temperature, speed, fuel level, vibration, and alcohol detection in real time. Researchers have used machine learning algorithms like Random Forest, SVM, and KNN to classify vehicle conditions into Normal, Warning, and Fault categories, improving fault detection accuracy. IoT technology also enables remote monitoring and real-time alerts through cloud platforms and wireless communication. Recent studies show that combining multiple sensors with AI techniques provides better fault diagnosis, predictive maintenance, and driver safety. However, many existing systems are costly, complex, or depend heavily on cloud infrastructure. The proposed AI Based Vehicle Monitoring System addresses these limitations by providing a low-cost, scalable, and intelligent solution that integrates sensors, machine learning, and real-time alerts into a single platform for smart vehicle monitoring and improved transportation safety.

III. METHODOLOGY

The methodology of the AI Based Vehicle Monitoring System explains the complete process used to design and implement an intelligent system for real-time vehicle monitoring and fault detection. The system continuously monitors important vehicle parameters such as engine temperature, speed, fuel level, vibration, and alcohol detection using multiple sensors. Sensors like DHT11, Hall Effect sensor, Ultrasonic sensor, SW-420 vibration sensor, and MQ-3 alcohol sensor collect real-time data from the vehicle and send it to the ESP32 microcontroller for processing. The collected sensor data is preprocessed using filtering and normalization techniques to remove noise and improve data accuracy. After preprocessing, important features such as abnormal temperature rise, excessive speed, unusual vibration, low fuel level, and alcohol detection are extracted for analysis. Machine learning algorithms such as Random Forest, Support Vector Machine (SVM), and K-Nearest Neighbor (KNN) are then used to classify the vehicle condition into Normal, Warning, or Fault categories. Based on the classification results, the system generates real-time alerts through an OLED display, LED indicators, and buzzer notifications to warn the driver about abnormal conditions. The system also supports Wi-Fi and IoT- based communication for remote monitoring of vehicle status. Various testing and validation methods are used to ensure accurate sensor readings, proper machine learning classification, effective alert generation, and reliable real- time system performance. The methodology provides a structured and efficient framework for developing a smart, low-cost, and intelligent vehicle monitoring system that improves vehicle safety, reliability, and predictive maintenance. Parameters used to detect the quality of water

HC-SR04 ULTRASONIC SENSOR

The HC-SR04 Ultrasonic Sensor is used in the vehicle monitoring system to measure fuel level or distance. It works by transmitting ultrasonic waves toward the fuel surface and receiving the reflected signal back. The distance is calculated using the time taken for the echo to return. This sensor provides non-contact measurement, high accuracy, fast response, and reliable fuel monitoring. In the developed prototype, the sensor continuously monitors the fuel level and sends the readings to the ESP32 controller. If the fuel level falls below the predefined limit, the system generates a warning notification for the user. This helps improve vehicle reliability and prevents unexpected fuel shortages.

DHT11 TEMPERATURE SENSOR

The DHT11 Temperature Sensor is used in the vehicle monitoring system to measure engine and environmental temperature conditions. Monitoring temperature is important because excessive heat can damage engine components and reduce vehicle performance. The sensor continuously measures temperature values and sends digital readings to the ESP32 controller at regular intervals. It is compact, low cost, and easy to interface with embedded systems. The DHT11 sensor provides continuous temperature monitoring, real-time data acquisition, overheating detection, and early fault identification. In the developed system, the sensor compares temperature readings with predefined threshold values. If the temperature exceeds the safe operating limit, the controller activates warning alerts through the OLED display and buzzer system. This helps improve vehicle safety and prevents engine failure caused by overheating.

MQ-3 ALCOHOL SENSOR

The MQ-3 Alcohol Sensor is used in the vehicle monitoring system to detect alcohol concentration near the driver and improve driving safety. The sensor detects alcohol vapours and converts them into analogue electrical signals, which are processed by the ESP32 controller to determine whether the alcohol level exceeds the predefined safe limit. The MQ-3 sensor provides alcohol vapor detection, unsafe driving condition monitoring, real-time alcohol analysis, and warning alert generation. In the developed system, if the detected alcohol concentration is above the threshold value, the controller immediately activates the buzzer and warning display. This alert mechanism improves driver awareness and enhances overall road safety, making the system more intelligent and safety-oriented.

SW-420 VIBRATION SENSOR

The SW-420 Vibration Sensor is used in the vehicle monitoring system to detect abnormal vehicle or engine vibrations. Excessive vibration may indicate mechanical problems such as loose components, engine imbalance, damaged bearings, or other abnormal operating conditions. The sensor continuously monitors vibration intensity and generates signals whenever unusual vibration patterns are detected. These signals are processed by the ESP32 controller and further analysed using machine learning techniques. The vibration sensor helps in detecting abnormal vibrations, identifying mechanical faults, monitoring engine condition, and supporting predictive maintenance. In the developed system, the sensor improves fault diagnosis capability by identifying unusual operating conditions at an early stage, helping to prevent major mechanical failures

ESP32 DEVELOPMENT BOARD

The ESP32 Development Board is used as the main controller unit of the vehicle monitoring system. All sensors are connected directly to the ESP32 input pins, and the controller continuously reads sensor data and performs real-time processing operations. The ESP32 is responsible for sensor data acquisition, data filtering and preprocessing, communication with the machine learning module, OLED display control, buzzer activation, and wireless communication support. In the developed system, the controller continuously collects real-time data from all connected sensors and prepares it for intelligent analysis and monitoring.

RASPBERRY PI ZERO BOARD

The Raspberry Pi Zero Board is used in the vehicle monitoring system for advanced processing and machine learning support. It improves the computational capability of the system and enables intelligent data analysis operations. The Raspberry Pi Zero performs functions such as advanced sensor data processing, machine learning model execution, data handling and storage, and real-time monitoring support. In the developed system, the integration of the Raspberry Pi Zero with the ESP32 enhances overall system intelligence and improves decision-making capability

MACHINE LEARNING MODULE

The Machine Learning Module is the intelligent core of the AI Based Vehicle Monitoring System. Unlike traditional systems that use only fixed threshold values, this module analyses sensor data patterns intelligently and classifies vehicle conditions accurately. After preprocessing, the sensor data is processed using machine learning algorithms such as Random Forest, Support Vector Machine (SVM), and K-Nearest Neighbor (KNN). The model classifies vehicle conditions into Normal, Warning, and Fault conditions by analyzing temperature variations, fuel level, vibration intensity, alcohol concentration, and overall sensor behavior. This intelligent analysis improves fault detection accuracy, supports predictive maintenance, generates early warnings, and enhances overall system reliability.

ALERT AND DISPLAY MODULE

The Alert and Display Module provides real-time notifications and monitoring information to the user. It ensures that the driver receives immediate updates regarding vehicle conditions. This module mainly consists of an OLED Display Module and a Buzzer system.

OLED DISPLAY MODULE

The OLED Display Module is connected to the ESP32 controller using I2C communication and is used to display real-time sensor readings and warning notifications. The display shows temperature values, fuel level status, vibration status, alcohol detection results, and overall vehicle condition messages. This continuous display of important parameters improves system usability and allows effective monitoring of vehicle conditions.

BUZZER

The buzzer is used to generate audible warning alerts whenever abnormal conditions are detected in the system. It activates during high temperature conditions, excessive vibration detection, low fuel conditions, and alcohol detection. The audible alert mechanism helps the driver immediately notice dangerous situations even without continuously observing the display, thereby improving safety and reliability.

COMMUNICATION MODULE

The Communication Module enables wireless communication and remote monitoring functionality in the system. The built-in Wi-Fi feature of the ESP32 controller is used for wireless data transmission. This module supports IoT-based monitoring, remote vehicle monitoring, real-time cloud communication, predictive maintenance applications, and wireless data transfer. The communication system allows vehicle information to be monitored remotely and supports future IoT integration for advanced intelligent applications.

POWER SUPPLY MODULE

The Power Supply Module provides stable and regulated voltage to all hardware components used in the system. Proper power regulation is important because sensors and controllers require stable operating voltage for reliable

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performance. The system uses the LM2596 DC-DC Buck Converter Module to convert the input voltage into a stable regulated output suitable for the ESP32 controller, Raspberry Pi Zero, sensors, OLED display, and buzzer module. This power supply module helps prevent voltage fluctuations and improves the overall stability and performance of the vehicle monitoring system.

IV. SYSTEM ARCHITECTURE

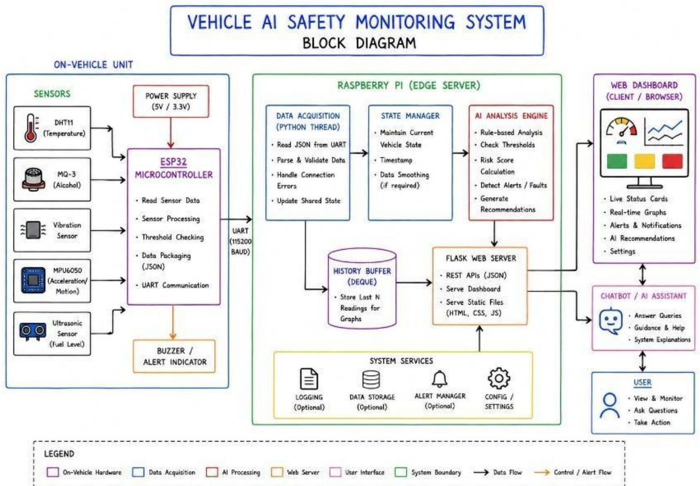

Figure 4.2. System Flowchart

The developed hardware prototype of the AI Based Vehicle Monitoring System integrates sensors, ESP32 controller, Raspberry Pi server, communication modules, and alert mechanisms into a compact real-time monitoring platform. The ESP32 collects and processes data from sensors such as DHT11, MQ-3, SW-420, MPU6050, and HC-SR04 for monitoring temperature, alcohol concentration, vibration, motion, and fuel level conditions. The Raspberry Pi performs advanced processing and AI-based analysis, while the AMS1117 voltage regulator provides stable power supply to all components. Communication between ESP32 and Raspberry Pi is achieved using UART with a TXS0102 level shifter. The system also includes an OLED display, LED indicators, and buzzer alerts for notifying abnormal conditions like overheating, excessive vibration, low fuel, and alcohol detection, making the system capable of intelligent real-time vehicle monitoring and fault detection

V. RESULTS AND DISCUSSION

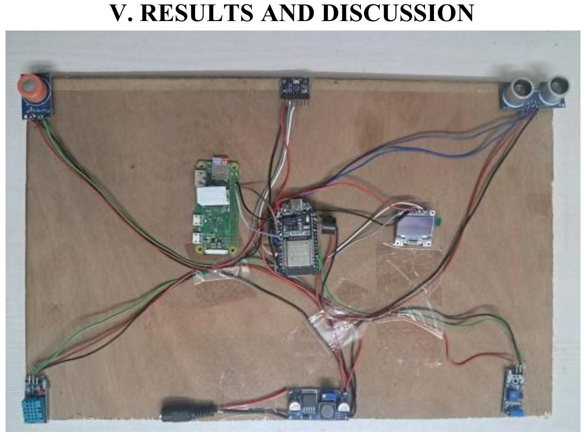

Fig. 5.1. Hardware prototype of AI Based Vehicle monitoring system.

DOI: 10.48175/IJARSCT-35708

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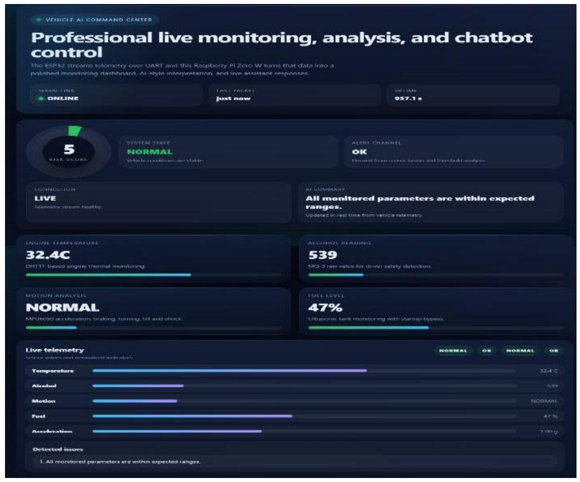

Fig 5.2: Web Server 1st Section

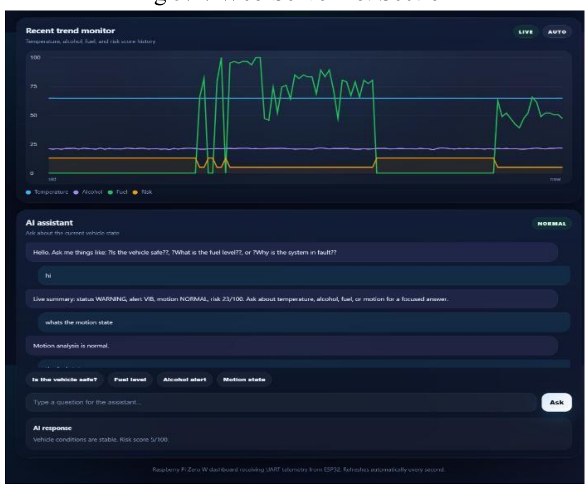

Fig 5.3: Web Server 2nd Section

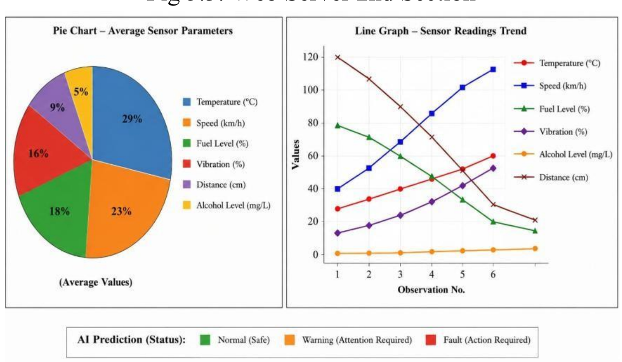

Fig 5.4: Graphical Representation of AI Based Vehicle Monitoring System Readings

VI. CONCLUSION

The AI Based Vehicle Monitoring System successfully demonstrates an intelligent real-time framework for monitoring and analysing vehicle conditions using embedded sensors, machine learning, and IoT technology. The system continuously tracks key parameters such as temperature, fuel level, vibration, motion, and alcohol detection using sensors interfaced with ESP32 and Raspberry Pi. The integration of machine learning improves fault detection by classifying vehicle states into Normal, Warning, and Fault conditions, making the system more accurate than traditional threshold-based methods. Real-time alerts through OLED display, LED indicators, and buzzer ensure immediate notification of abnormal conditions, enhancing driver safety. The IoT-based communication enables remote monitoring and future cloud integration.

Overall, the system proves to be cost-effective, scalable, and reliable, offering a smart solution for vehicle safety, fault detection, and predictive maintenance.

VII. FUTURE SCOPE

The future scope of the AI Based Vehicle Monitoring System is highly promising with several possible enhancements. Advanced machine learning and deep learning models such as ANN, CNN, and LSTM can be integrated to improve prediction accuracy and enable more intelligent fault diagnosis. Additional sensors like GPS, tire pressure, battery health, brake condition, and fuel quality sensors can make the system more comprehensive. Cloud computing and mobile applications can be implemented for remote monitoring, data storage, and real-time alerts. GPS and GSM modules can enable live tracking, accident detection, and emergency notifications, making the system useful for fleet and transportation management. The system can also be upgraded with IoT platforms for centralized monitoring of multiple vehicles. Future improvements may include industrial-grade hardware design, edge AI processing, cybersecurity enhancements, and integration with electric and hybrid vehicles for energy and battery monitoring. Overall, these advancements can transform the system into a complete smart vehicle management and predictive maintenance solution for modern transportation systems.

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