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Predictive Vehicle Maintenance

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Abstract: *Predictive maintenance for vehicles using IoT and machine learning is a modern solution aimed at improving vehicle reliability and reducing maintenance costs. The proposed system leverages ESP32 microcontrollers connected to various sensors, including DHT11 for engine temperature monitoring, DS18B20 for battery temperature monitoring, voltage and current sensors for battery level monitoring, an ultrasonic sensor for engine oil level detection, MQ-3 for smoke level detection, and an ADXL345 accelerometer for accident detection. Data collected by these sensors is transmitted wirelessly to a laptop via a Zigbee module. The system uses machine learning algorithms to predict the vehicle's condition and sends maintenance alerts to the user through Telegram messages. This approach ensures timely maintenance, prevents unexpected breakdowns, and enhances vehicle safety and longevity*

Keywords: *Predictive maintenance*

I. INTRODUCTION

In the automotive industry, timely vehicle maintenance is crucial for ensuring safety, reliability, and optimal performance. Traditional maintenance methods often rely on fixed schedules or reactive approaches, leading to inefficiencies and unexpected breakdowns. Predictive maintenance, powered by IoT and machine learning, addresses these challenges by providing real-time monitoring and intelligent predictions. The proposed system utilizes an ESP32-based IoT framework integrated with multiple sensors to continuously monitor key vehicle parameters. By analyzing the collected data, the system predicts maintenance needs and alerts users proactively, ensuring efficient vehicle operation and reducing overall costs.

II. METHODOLOGY

This system leverages IoT and machine learning to predict vehicle maintenance requirements and notify the owner for timely action. The system's components are integrated as follows:

- Sensors and ESP32 Integration: DHT11 Sensor: Monitors engine temperature.
- DS18B20 Sensor: Tracks battery temperature.
- Voltage and Current Sensor: Measures battery voltage and current levels.
- Ultrasonic Sensor: Detects engine oil level. MQ3 Smoke Sensor: Monitors smoke levels for engine health.
- ADXL345 Sensor: Detects vibration and accidents.
- Zigbee Communication: Data from all ESP32 Modules is transmitted wirelessly to a laptop via Zigbee.
- Data Processing: On the laptop, sensor data is Processed using machine learning algorithms predict vehicle condition.

The system evaluates parameters like engine overheating, low oil levels, poor battery condition, excessive vibration, and smoke levels

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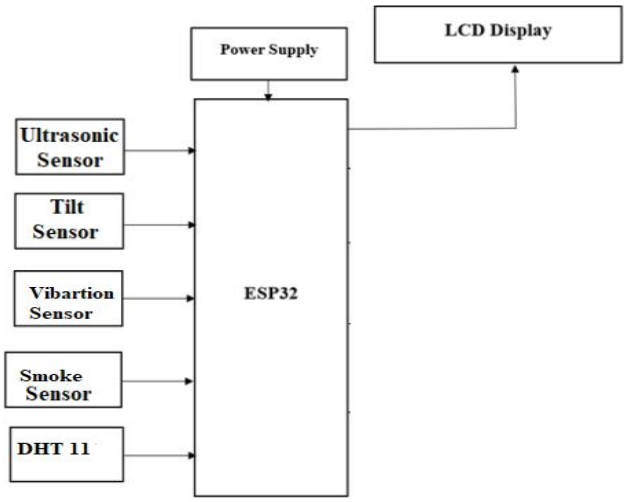

Fig 1: Block Diagram of the predictive vehicle maintenance

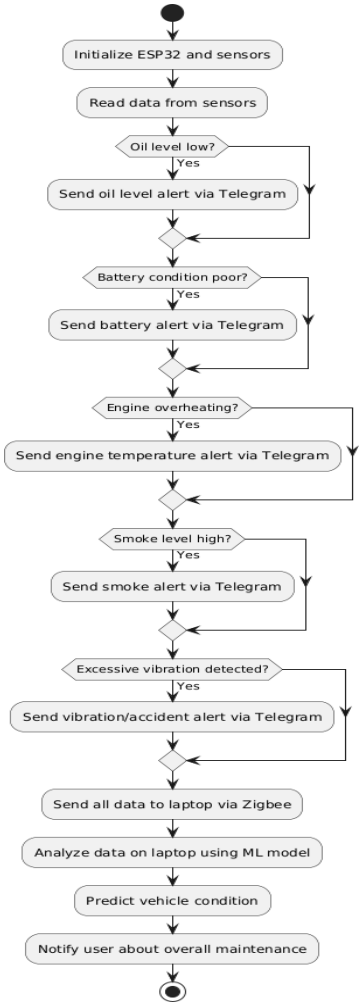

Fig 2: Flowchart of Predictive Vehicle Maintenance

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- Engine Temperature Monitoring: Uses DHT11 to ensure engine temperature stays within safe limits.
- Battery Monitoring: Uses DS18B20 for the temperature and voltage/current sensors for battery health and performance and monitors for better efficiency.
- Oil Level Detection: Ultrasonic sensor tracks oil level, prompting alerts when levels are low.
- Smoke Detection: MQ3 sensor identifies the excessive emissions.
- Vibration and Accident Detection: ADXL345 tracks abnormal vibrations or accidents.
- Wireless Communication Module: The Zigbee facilitates seamless data transfer between ESP32 modules and the laptop.
- Data Processing Module: On the laptop, for the process of collecting data to predict potential issues.
- Notification Module: Telegram API sends real time information and alerts to the user ensuring timely action.
- Maintenance Prediction Module: The data from multiple sensors are combined for evaluating the overall vehicle condition and predict the necessary maintenance actions.

III. RESULTS

Predictive vehicle maintenance uses data analytics, machine learning, and IoT sensors to anticipate vehicle issues before they occur. By analyzing real-time data from vehicle components, predictive maintenance identifies patterns and predicts potential failures, such as engine malfunctions or tire wear. This approach minimizes unexpected breakdowns, reduces repair costs, and improves vehicle longevity. It allows fleet operators or individual vehicle owners to schedule maintenance at optimal times, enhancing safety and reliability. By shifting from reactive to proactive maintenance, predictive systems help save time and resources, leading to more efficient and very much cost-effective vehicle management

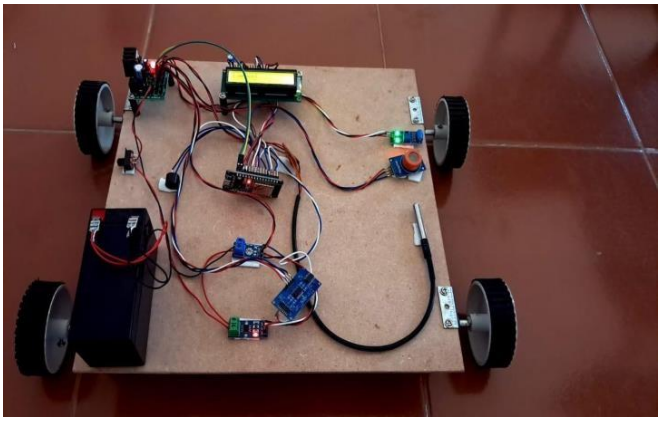

Fig 3: Outcome of the Project

IV. DISCUSSIONS

1. The system successfully monitors critical parameters such as engine temperature, battery health, oil levels, and vibrations.
2. ML algorithms provide accurate predictions vehicle condition, with alerts reducing maintenance delays.
3. Wireless data transmission using Zigbee is reliable within a specified range.
4. Telegram notifications ensure real-time updates for vehicle owners.
5. The system's performance demonstrate feasibility for large-scale implementation.

V. CONCLUSIONS

This predictive maintenance system effectively monitors vehicle health and alerts users about necessary maintenance. By combining IoT sensors, ESP32 modules, and machine learning, it ensures cost- effective and proactive vehicle management.

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