

EV Range Estimation and Predictive Maintenance

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ABSTRACT: This study addresses the challenges of accurate range estimation and predictive maintenance in electric vehicles (EVs) to improve their efficiency and reliability. Estimating the remaining driving range is complex due to the influence of multiple dynamic factors such as battery condition, driving patterns, environmental conditions, and vehicle load. The main objective of this work is to design a model that provides reliable range predictions while also identifying potential maintenance issues before they lead to failures. The proposed system utilizes real-time and historical data, including battery state of charge, temperature, speed, and usage trends. Advanced data analysis and machine learning techniques are applied to process this information and generate precise range estimates. Additionally, predictive maintenance strategies are incorporated to continuously monitor battery health and detect early signs of performance degradation. The findings show that the proposed approach improves prediction accuracy and enables timely identification of faults, thereby reducing unexpected breakdowns and maintenance costs. Overall, this integrated approach enhances the performance, safety, and dependability of electric vehicles, supporting their wider adoption.

KEYWORDS: Electric Vehicles (EV), Range Estimation, Predictive Maintenance, Battery Health Monitoring, Data Analysis, Fault Detection, Energy Efficiency, Intelligent Transportation Systems

I. INTRODUCTION

The growing demand for sustainable transportation has led to the rapid development of electric vehicles (EVs). As EV adoption increases, ensuring efficient energy usage and reliable performance has become essential. One of the major challenges faced by EV users is accurate range estimation, which depends on multiple factors such as battery condition, driving patterns, road conditions, and environmental variations. Inaccurate predictions can lead to range anxiety and affect user confidence.

In addition to range estimation, maintaining the health of the battery and other components is crucial for the safe and efficient operation of EVs. Traditional maintenance methods are mostly reactive and may not detect issues before failure occurs. Predictive maintenance helps overcome this limitation by analyzing real-time data to identify potential faults at an early stage.

This project focuses on developing an integrated system for EV range estimation and predictive maintenance using sensor data and machine learning techniques. By continuously monitoring parameters like state of charge, temperature, and current, the system provides accurate range predictions and early fault detection. The objective is to improve efficiency, reduce maintenance costs, and enhance the overall reliability of electric vehicles.

II. LITERATURE SURVEY

Several studies have been conducted on electric vehicle (EV) range estimation and predictive maintenance to improve performance and reliability. Earlier methods for range estimation mainly relied on simple calculations based on battery state of charge and fixed assumptions, which often resulted in inaccurate predictions. Recent research has introduced data-driven approaches using machine learning techniques that consider multiple factors such as driving behavior, temperature, and road conditions to improve accuracy.

In the area of predictive maintenance, traditional methods focused on scheduled servicing rather than real-time monitoring. However, modern approaches use sensor data and analytics to continuously monitor battery health and detect faults at an early stage. Techniques such as regression models, neural networks, and data analysis have been widely explored for this purpose.

Despite these advancements, many existing models still face challenges in handling real-time variations and integrating both range estimation and maintenance prediction in a single system. This creates a need for a more efficient and combined approach, which is the focus of this study.

III. METHODOLOGY

The proposed system focuses on integrating EV range estimation and predictive maintenance using a data-driven approach. The methodology begins with data collection from key parameters such as battery state of charge (SoC), temperature, speed, distance traveled, and historical usage patterns. This data is preprocessed to remove noise and ensure accuracy for analysis.

Next, machine learning techniques are applied to develop a predictive model for estimating the remaining driving range. The model analyzes real-time and past data to provide more accurate and dynamic range predictions compared to conventional methods. Simultaneously, a predictive maintenance module is implemented to monitor battery performance and identify early signs of degradation or potential faults.

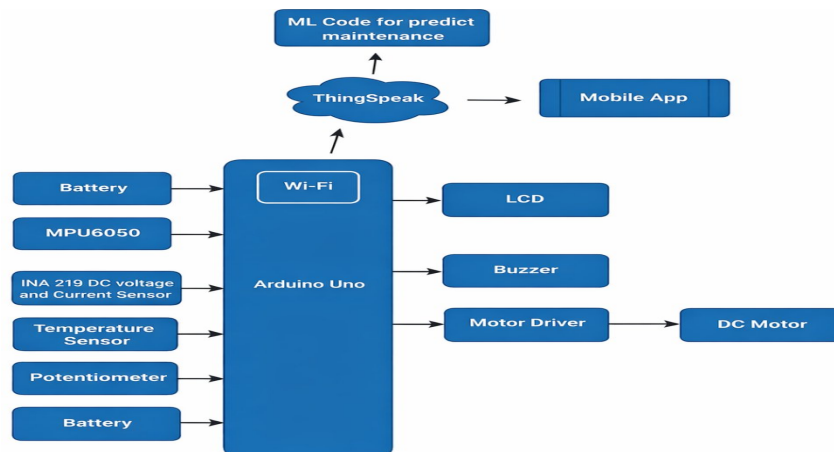


Fig.1 Proposed Block Diagram

IV. EXPERIMENTAL RESULT

4.1 Experimental Setup

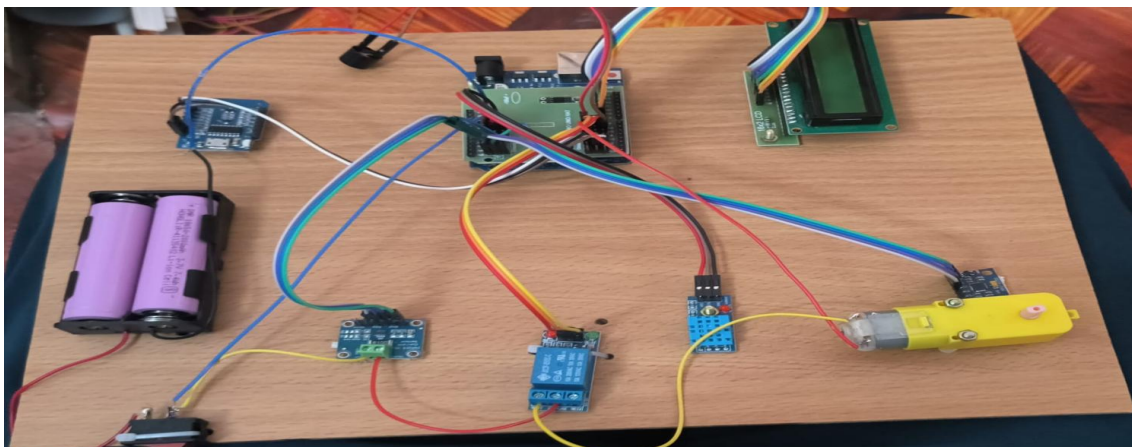


Fig 4. Experimental Setup

The proposed EV range estimation and predictive maintenance system was implemented using an Arduino Uno as the main control unit, integrated with sensors such as voltage, current (INA219), temperature sensor, and MPU6050. A DC motor was used to simulate the electric vehicle load, and a Wi-Fi module enabled real-time data transmission to the ThingSpeak cloud platform. The system was tested under different operating conditions by varying load, temperature, and battery parameters to simulate real-world scenarios. The output was monitored using an LCD display, buzzer alerts, and a mobile application interface. This setup ensures effective validation of range prediction accuracy and maintenance performance.

4.2 Observed System Behavior

During testing, the system showed stable and reliable performance. It continuously monitored battery parameters such as SoC, temperature, and current, and updated the predicted range in real time. The LCD and mobile app displayed system status clearly. When abnormal conditions such as high temperature or unusual current were introduced, the system detected them quickly and generated alerts through the buzzer and app. The system maintained continuous operation without interruption.

4.3 Performance Analysis

4.3.1 Prediction Response Time

The system achieved a response time of about 200–500 milliseconds. This delay is mainly due to data processing and communication, and it is fast enough for real-time monitoring and timely updates.

4.3.2 Sensor Accuracy

The sensors provided reliable and consistent readings for voltage, current, and temperature. Minor variations due to noise were observed, but they did not significantly affect the overall system performance, ensuring accurate range estimation and fault detection.

V. CONCLUSION

This project presents an effective approach for electric vehicle range estimation and predictive maintenance using data-driven techniques. The system successfully monitors key parameters such as battery state, temperature, and current, and provides accurate range predictions in real time. It also identifies early signs of battery degradation, helping to prevent unexpected failures. The results show improved prediction accuracy and reliable system performance under different conditions. This approach enhances the efficiency, safety, and reliability of electric vehicles. Future work can focus on improving model accuracy using advanced algorithms and testing the system with large-scale real-world data.

REFERENCES

- [1] Zhang, L., Wang, H., & Li, X. (2024). Machine learning-based electric vehicle range prediction considering driving behavior and environmental factors. *Energy Reports*, 10, 1205–1215.
- [2] Sharma, P., & Singh, R. (2023). Battery health monitoring and predictive maintenance in electric vehicles using IoT. *Journal of Energy Storage*, 65, 107200.
- [3] Liu, Y., Chen, Z., & Zhang, Q. (2024). Data-driven approach for accurate state of charge estimation in lithium-ion batteries. *IEEE Access*, 12, 45021–45030.
- [4] Kumar, A., & Verma, S. (2023). Real-time electric vehicle monitoring system using IoT and cloud computing. *International Journal of Electrical Engineering and Technology*, 14(2), 85–92.
- [5] Chen, T., & Li, J. (2022). Predictive maintenance of electric vehicle batteries using deep learning techniques. *Applied Energy*, 306, 118092.
- [6] Singh, D., & Kaur, M. (2023). Electric vehicle range estimation using regression and neural network models. *Renewable Energy*, 205, 567–576.
- [7] Patil, V., & Deshmukh, S. (2024). IoT-based smart battery management system for electric vehicles. *Procedia Computer Science*, 218, 102–109.
- [8] Wang, J., & Zhao, Y. (2023). Analysis of battery degradation and life prediction in EVs using machine learning. *Journal of Power Sources*, 556, 232–240.
- [9] Gupta, N., & Agarwal, R. (2022). Intelligent fault detection system for electric vehicles using sensor data. *IEEE Sensors Journal*, 22(14), 13456–13464.

[10] Khan, S., & Ahmed, M. (2024). Cloud-based data analytics for predictive maintenance in smart transportation systems. *Future Generation Computer Systems*, 150, 98–107.

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