Battpulse: An AI-Powered Electric Car Battery Health Analyzer

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Abstract: *Electric cars are rapidly gaining adoption as an eco-friendly alternative to traditional cars, making battery health a key factor for performance and reliability. Over time, battery efficiency decreases due to repeated charging cycles, continuous usage, and varying environmental conditions. Monitoring battery health is essential to maintain optimal performance and extend battery life. This project presents a web-based system for predicting battery health using machine learning techniques. Users can provide simple inputs such as battery age, charge cycles, daily usage, and charging type through an interactive interface. The backend, developed using Flask, processes the data and communicates with a trained Random Forest model. The model analyzes the inputs and predicts battery health as a percentage. The results are displayed using visual elements like charts and battery indicators for better understanding. The system also provides insights into future battery degradation trends. This helps users make informed decisions about battery maintenance and usage. Overall, the solution offers a practical, efficient, and user-friendly approach for battery health monitoring in electric cars.*

Keywords: *Electric Cars, Battery Health Prediction, Machine Learning, Random Forest, Web Application*

I. INTRODUCTION

Electric cars are gaining popularity as an eco-friendly alternative to traditional fuel-based vehicles, helping reduce pollution and carbon emissions. The performance of electric cars mainly depends on battery health, which affects driving range, efficiency, and reliability. However, factors like repeated charging, continuous usage, and environmental conditions lead to battery degradation over time, making it important to monitor its State of Health (SOH). Traditional methods of battery analysis are time-consuming and not practical for regular use. To overcome this, machine learning offers a smarter way to predict battery condition using data such as battery age, charge cycles, and usage patterns. This project presents a web-based application that collects user inputs and processes them using a Random Forest model through a Flask backend. The system provides instant battery health predictions along with visual outputs, helping users easily understand battery performance. Overall, it offers a simple and efficient solution for better battery monitoring and maintenance.

II. LITERATURE SURVEY

M. A. Hannan, M. S. H. Lipu, A. Hussain(2023) This paper studies the use of machine learning to predict battery State of Health (SOH) in electric vehicles. It shows that battery degradation depends on factors like charge cycles, temperature, and usage patterns. Different models are compared, with Random Forest giving better accuracy and handling complex data effectively. The study also highlights the importance of selecting key features such as battery age and usage behavior. Overall, it supports using machine learning, especially Random Forest, for reliable battery health prediction.

Kun Li, Xinling Chen(2025) This paper studies advanced machine learning models like LSTM, CNN, and SVR for predicting battery State of Health (SOH). It uses Particle Swarm Optimization (PSO) to improve accuracy, with PSO-LSTM giving the best results. The study highlights the importance of long-term data and introduces sensorless monitoring to reduce cost. Overall, it supports using optimized ML models for accurate and efficient battery health prediction.

Z. Chen, Y. Wang, H. Li(2024) This paper presents a data-driven approach for estimating battery State of Health (SOH) using ensemble machine learning techniques. It explains that single models may not capture the complex degradation patterns of batteries, so combining models like Random Forest, Gradient Boosting, and SVR improves accuracy. The study uses real-world EV battery data, including voltage, temperature, and charge cycles, making the results practical and reliable. It highlights the importance of data preprocessing and feature selection to enhance model performance. Key factors such as charge cycles, depth of discharge, and temperature are identified as major influences on battery health. The ensemble model shows better prediction accuracy and adaptability across different battery conditions. It also supports integration with Battery Management Systems for real-time monitoring. Overall, the research strengthens the use of ensemble learning for efficient battery health prediction.

R. Kumar, S. Sharma, P. Singh(2025) This paper presents a real-time battery health monitoring system for electric vehicles using Edge AI. It explains that cloud-based systems can face delays and privacy issues, so processing data on edge devices improves speed and efficiency. The system collects real-time battery data such as voltage, current, temperature, and charging patterns. Machine learning models are used locally to predict battery State of Health (SOH) and Remaining Useful Life (RUL). Among the models tested, Random Forest provides a good balance between accuracy and performance. The study also highlights the need for optimization techniques to handle limited device resources. It supports real-time user monitoring through dashboards and alerts. Overall, the research emphasizes fast, reliable, and user-friendly battery health prediction systems.

III. EXISTING SYSTEM

Existing systems use machine learning and deep learning models to predict battery State of Health (SOH) based on parameters like voltage, current, and temperature. Although these models provide high accuracy, they are mainly designed for research or industrial use and require large datasets and complex processing. Most systems depend on sensor-based data or specialized hardware, making them less practical for everyday users. Additionally, they lack simple and interactive interfaces, as results are often shown in technical formats. These systems are usually offline tools and not available as web-based applications. Hence, there is a gap between advanced prediction models and user-friendly solutions for general electric car users.

Existing System Disadvantages

- Not easily accessible for general users
- Requires sensor data or complex inputs
- Lacks user-friendly interface
- Mostly offline or non-interactive systems
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Proposed System

The proposed system is a web-based platform that predicts electric car battery health using machine learning. Users can enter simple details like battery age, charge cycles, usage, and charging type through an easy-to-use interface. The backend, built with Flask, processes this data using a Random Forest model to generate battery health predictions instantly. The results are displayed using clear visual elements such as battery indicators, progress bars, and charts. This system focuses on simplicity and accessibility, making it useful even for non-technical users. Overall, it provides a practical and efficient solution for monitoring and managing battery performance.

Proposed System Advantages

- Accurate prediction using machine learning
- Easy and user-friendly interface

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- Instant results without complexity
- Clear visualizations for better understanding

IV. SYSTEM ARCHITECTURE

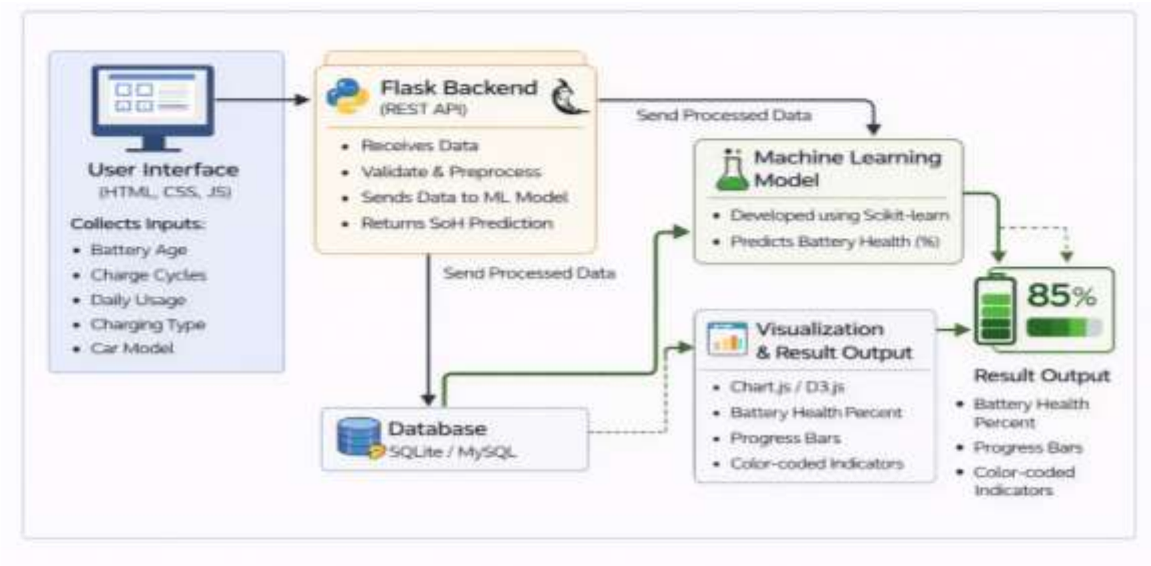

Fig 1 System Architecture

The system architecture of the *Electric Cars Battery Health Estimation System* is designed to deliver real-time predictions using machine learning. It follows a structured flow consisting of the Frontend, Backend, Machine Learning Model, and Visualization Layer. The frontend, developed using HTML, CSS, JavaScript, and Bootstrap/Tailwind, provides an interactive interface for users to enter details such as battery age, charge cycles, daily usage, charging type, and car model. These inputs are validated and sent to the backend for processing through the Flask framework, which ensures seamless communication between the user interface and the prediction model. This architecture ensures an accurate, efficient, and user-friendly system for monitoring and managing EV battery health in real time.

Methodology

Modules Name:

- Presentation Layer
- Backend Layer
- Machine Learning Layer
- Visualization Layer
- Output Layer

1. Presentation Layer (HTML, CSS, JavaScript, Bootstrap)

This module is responsible for user interaction and is developed using HTML, CSS, JavaScript, and Bootstrap. It provides a clean and responsive interface where users can easily enter inputs such as car company, model, battery age, charge cycles, daily usage, and charging type. Dynamic elements like dropdown menus improve usability by showing relevant options based on user selection. The design focuses on simplicity so that even non-technical users can navigate and provide inputs without confusion.

2. Backend Layer (Flask + Validation)

The backend is implemented using the Flask framework, which acts as the core controller of the system. It receives user input through HTTP requests and processes the data efficiently. This module also includes validation mechanisms to ensure that inputs fall within acceptable ranges, preventing incorrect or unrealistic values. If invalid data is entered, appropriate error messages are displayed, improving system reliability and user experience.

3. Machine Learning Layer (Random Forest Model)

This is the core module where prediction takes place. A Random Forest regression model is trained using important battery-related features such as battery age, charge cycles, usage patterns, and charging type. The model learns complex relationships between these parameters and battery health. Once trained, it is integrated into the system to provide fast and accurate predictions whenever the user submits input data.

4. Visualization Layer

This module enhances the clarity of results using Chart.js. Instead of showing only numerical values, it presents data through interactive charts like bar graphs for current battery health and line charts for future degradation trends. These visual elements make it easier for users to interpret the results quickly and understand how battery performance changes over time.

5. Output Layer (Battery Health %)

The output module displays the final predicted battery health as a percentage along with visual indicators. A color-coded battery bar (green, orange, red) helps users quickly identify the condition of their battery. It may also include insights such as estimated future degradation, enabling users to plan maintenance or optimize usage. This module ensures that the final results are clear, informative, and actionable for users.

V. IMPLEMENTATION

The proposed system is implemented by integrating web technologies with machine learning techniques to create a complete end-to-end solution. The frontend is developed using HTML, CSS, JavaScript, and Bootstrap, providing a responsive and interactive interface for users to input battery-related details. Dynamic elements such as dropdowns and validation messages improve usability and ensure correct data entry. The backend is built using the Flask framework, which acts as a bridge between the user interface and the machine learning model. When the user submits input data, the backend processes the request, performs validation checks, and converts the data into a structured format using libraries like Pandas and NumPy. The trained model is loaded using the pickle library and used to generate predictions in real time. The machine learning model, developed using Scikit-learn, is trained on key parameters such as battery age, charge cycles, daily usage, and charging type. The model learns patterns from historical data and predicts battery health as a percentage. To improve performance, preprocessing techniques such as data cleaning, normalization, and feature selection are applied during training. For better user understanding, the output is visualized using Chart.js. Graphs such as bar charts and line charts are used to represent current battery health and future degradation trends. This combination of real-time prediction and visual feedback enhances user experience and makes the system practical for everyday use. Overall, the implementation focuses on accuracy, speed, and simplicity, ensuring that users can easily monitor battery health without requiring technical expertise or specialized hardware.

Algorithm Used

Existing Algorithm

Traditional systems often rely on clustering algorithms and basic statistical methods to analyze battery data. These approaches group similar data points to identify patterns but do not provide direct predictions of battery health. In some cases, deep learning models like LSTM and CNN are used, which require large datasets and high computational resources. While these methods can achieve good accuracy, they are complex, time-consuming, and not suitable for real-time or user-friendly applications.

Proposed Algorithm

The proposed system uses the Random Forest Regression algorithm to predict battery health accurately. It works by combining multiple decision trees, which improves prediction stability and reduces overfitting. The model can handle complex relationships between inputs like battery age, charge cycles, and usage patterns. It is also robust, efficient, and requires less tuning compared to other algorithms. Integrated with the Flask backend, it provides fast and reliable real-time predictions for users.

VI. EXPERIMENTAL RESULTS

This paper implements features screenshots that provide visual documentation of the system development, functionality and user interface evidence. The snapshots provide a clear representation of how the application works in real-time, and illustrates main functionality during release.

Landing Page:

Fig: 2 Landing Page
The landing page acts as the entry point of the application with a clean and modern design. It displays the project title and includes a button to start the system, ensuring smooth user onboarding.

Registration Page:

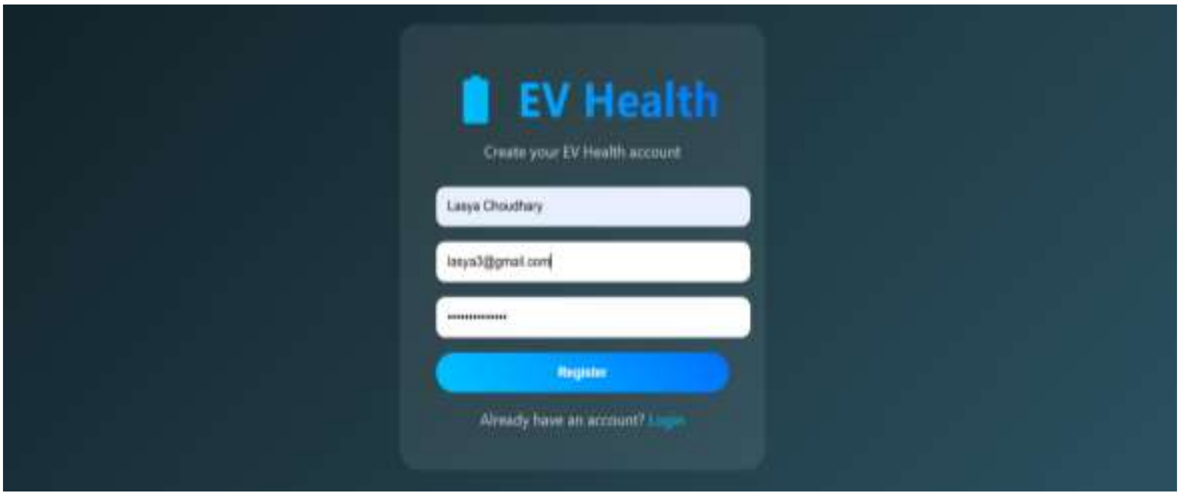

Fig: 3 Registration Page

This page allows new users to create an account by entering basic details. It ensures secure storage of data and prevents duplicate registrations.

Login Page:

Fig: 4 Login Page

The login page enables registered users to access the system using valid credentials. It ensures secure authentication and controlled access.

EV Battery Health Dashboard:

Fig: 5 EV Battery Health Dashboard

This dashboard allows users to enter battery and vehicle details such as age, usage, and charge cycles. It acts as the main input interface for prediction.

Valid Input Submission:

Fig: 6 Valid Input Submission

This step confirms that all inputs are valid and ready for processing by the machine learning model.

Battery Health Visualization:

Fig 7 Battery Health Visualization

The system displays battery health using a bar chart, making it easy for users to understand the results visually.

Battery Degradation Forecast Graph:

Fig: 8 Battery Degradation Forecast Graph

This graph shows future battery degradation over time, helping users plan maintenance and understand long-term performance.

VII. CONCLUSION

The proposed system effectively combines machine learning with a user-friendly web interface to predict electric car battery health. By using the Random Forest algorithm, it provides accurate and reliable predictions based on key inputs such as battery age, charge cycles, and usage patterns. The integration of Flask with modern web technologies ensures smooth performance and easy interaction. Visualizations using charts and indicators help users clearly understand battery condition. The system simplifies complex analysis into an accessible format for all users. It supports better decision-making for battery maintenance and usage. Overall, it offers a practical and efficient solution for battery health monitoring. The project also contributes to improving sustainability in electric vehicles.

VIII. FUTURE ENHANCEMENT

The system can be enhanced by integrating real-time data from vehicle sensors or APIs for more accurate predictions. Advanced machine learning models like XGBoost or deep learning can further improve performance. Expanding the system into a mobile application can increase accessibility for users. Cloud integration can support scalability and handle multiple users efficiently. Additional features like smart recommendations can help users maintain better battery health.

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