

EV Battery Performance and Range Monitoring System

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ABSTRACT: The EV Battery Performance and Range Monitoring System is developed to analyze electric vehicle charging behavior and driving range using datasets collected from India and other global sources. The project focuses on studying the relationship between battery capacity, charging patterns, vehicle efficiency, and overall range performance through data-driven analysis [2][3]. To achieve this, the dataset undergoes several steps including data cleaning, preprocessing, and trend identification [7][14] to understand variations in EV performance under different conditions. Interactive dashboards are created to visualize important metrics such as charging time, battery performance, energy consumption, and range efficiency[11], making the data easier to interpret. The system aims to reduce range anxiety among EV users, improve trip planning, and support better decision-making for users, researchers, and policymakers by providing clear insights into electric vehicle performance.

INDEXED WORDS : Electric Vehicles (EV), Charge Analysis, Range Analysis, Data Visualization, Battery Performance, Energy Consumption, Dashboard Analytics, Data Insights.

I. INTRODUCTION

Electric Vehicles (EVs) are gaining popularity as a sustainable transportation solution due to their environmental and economic benefits[1][2]. However, many EV users face challenges such as **range anxiety, battery performance uncertainty, and inefficient trip planning**[4]. Understanding how factors like **battery capacity, charging behavior, energy consumption, and vehicle efficiency** influence the driving range is important for improving EV performance. The **EV Battery Performance and Range Monitoring System** is developed to analyze EV charging patterns and range performance using datasets collected from India and global sources. The project includes **data cleaning, preprocessing, and data analysis** to identify trends in EV battery performance[7].

In addition, **Machine Learning techniques are used to predict EV driving range and battery performance** based on various parameters such as battery capacity, charging time, and energy consumption[6][8]. Interactive dashboards are also created to visualize key metrics like charging time, energy usage, and range efficiency[11]. This system helps EV users make better travel decisions and supports researchers and policymakers in improving EV infrastructure.

II. PROBLEM STATEMENT

The rapid growth of Electric Vehicles (EVs) has generated large amounts of data related to battery performance, charging behaviour, energy consumption, and driving range. However, this information is often collected from **multiple sources and stored in different datasets**, making it difficult to analyse and interpret the overall performance of EVs. In this project, four different datasets related to electric vehicles from **India and global sources** are used, which contain various parameters affecting EV performance.

The main challenge is to **integrate, preprocess, and analyze these multiple datasets** to extract meaningful insights about EV battery performance, charging patterns, and range efficiency. Without proper analysis and visualization, it becomes difficult for users and researchers to understand trends, identify performance variations, and make informed

decisions. To address these challenges, a data-driven system is required that uses **Tableau dashboards for EV Battery Performance and Range Monitoring System**

III. LITERATURE SURVEY

Recent studies on electric vehicles highlight the importance of **data analytics, visualization tools, and machine learning techniques** for analyzing EV battery performance, charging behavior, and driving range. The increasing availability of EV datasets from different sources allows researchers to study energy consumption patterns and develop predictive models for EV performance.

A. EV Data Analysis and Visualization

Several studies show that visualization tools help improve the understanding of EV charging patterns and battery performance. Interactive dashboards allow researchers and users to explore EV datasets through graphs, charts, and trend analysis. Visualization platforms such as Tableau simplify the analysis of EV parameters like charging time, energy consumption, and driving range [11]. However, visualization tools mainly provide descriptive insights and do not directly perform predictive analysis of EV performance.

B. Role of Business Intelligence in EV Analytics

Business Intelligence (BI) tools transform complex EV datasets into meaningful insights through dashboards and reports. BI platforms allow analysts to study relationships between EV battery capacity, charging patterns, and vehicle efficiency [7]. These tools make it easier to understand EV usage trends and performance variations. Despite their advantages, most BI tools focus primarily on **data visualization and reporting**, rather than providing predictive capabilities for EV range or battery performance.

C. Machine Learning for EV Performance Prediction

Machine learning techniques are increasingly used to predict EV battery performance and driving range based on different parameters such as battery capacity, charging time, energy consumption, and environmental conditions. Algorithms like **Linear Regression, Random Forest**, and analyze EV datasets to estimate range performance and identify patterns in battery behavior [5][6][8]. These models improve prediction accuracy compared to traditional statistical approaches.

D. Data Analytics for EV Charging Systems

Recent research has also focused on analyzing EV charging infrastructure and charging station performance. Data analytics helps in identifying charging demand patterns, energy usage behavior, and efficiency variations [3][14] across different EV models and environmental conditions.

However, many of these studies produce **complex analytical results** that are difficult for general users to interpret.

E. Hybrid Analytical Framework

Recent research explores integrating **data visualization platforms with machine learning techniques** to create comprehensive analytical systems. Such hybrid frameworks allow users to visualize EV datasets while also performing predictive analysis of battery performance and driving range. Combining visualization with machine learning improves both **data interpretation and predictive capabilities** [6][13].

F. Research Gap Identified

From the existing studies, the following research gaps are identified:

- Many studies focus mainly on **visualization without predictive modeling**.
- Some research emphasizes **machine learning prediction but lacks interactive dashboards**.
- Limited systems integrate **data analytics, machine learning, and visualization tools** into a single platform for EV performance analysis.

The proposed system addresses these limitations by integrating **data preprocessing, machine learning models, and interactive dashboards** to analyze EV battery performance, charging behavior, and driving range efficiently.

Study	Technique Used	Focus Area	Limitation
Study A	Linear Regression	EV Range Prediction	Limited accuracy for complex EV datasets
Study B	Tableau Dashboards	EV Data Visualization	No predictive capability
Study C	Random Forest	EV Battery Performance Modeling	Limited visualization features
Proposed Work	Tableau + Machine Learning	EV Battery Performance and Range Monitoring	Integrated visualization and prediction system

Proposed EV Battery ML Prediction System Workflow

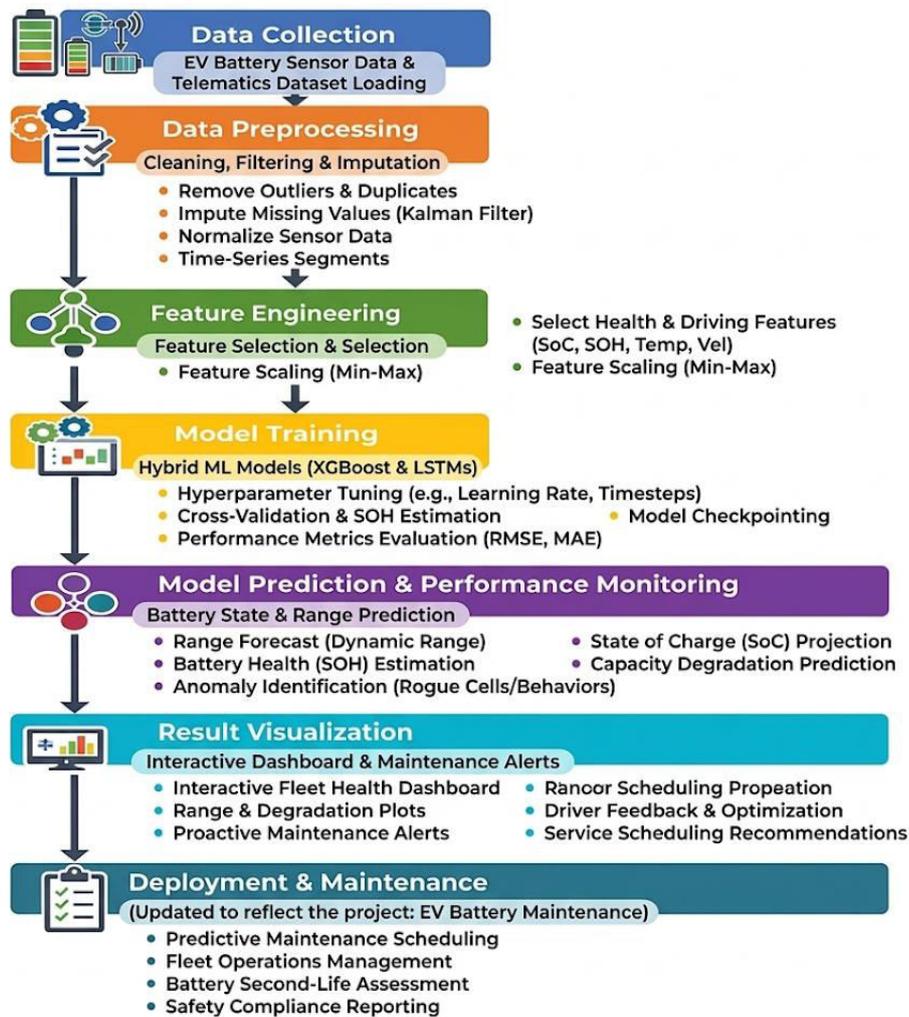


Fig 1: EV Battery ML Prediction System Workflow

Fig: Proposed ML Workflow

Volume 15, Issue 3, March 2026**|DOI: 10.15680/IJRSET.2026.1503237|****IV. PROPOSED METHODOLOGY****A. Data Collection**

The Electric Vehicle (EV) datasets are collected from publicly available sources and stored in **CSV format**. The project uses **multiple datasets from India and global EV sources** to analyze battery performance, charging behavior, and driving range. These datasets contain important EV parameters such as:

- Battery Capacity (kWh)
- Charging Time
- Charging Type (Fast / Slow Charging)
- Energy Consumption (kWh per km)
- Vehicle Efficiency
- Driving Range
- Vehicle Model and Manufacturer
- Environmental and usage conditions

These features are used to analyze EV performance patterns and train machine learning models for **range prediction and battery performance analysis**.

B. Data Preprocessing

Data preprocessing prepares the EV dataset for analysis and machine learning modeling. The main steps include:

- Handling missing or inconsistent values in the datasets
- Removing duplicate records and irrelevant features
- Converting categorical values into numerical format when required
- Data cleaning using Python libraries such as **Pandas** and **NumPy**[12]
- Feature selection for relevant EV parameters[7][14]
- Splitting the dataset into **training and testing sets (80:20)**

This process ensures that the dataset is clean, structured, and ready for further analysis and predictive modeling.

C. System Architecture

The proposed system integrates **data analytics, machine learning, and visualization technologies** to analyze EV battery performance and driving range. The main components include:

- **Data Processing Layer** – Responsible for cleaning, preprocessing, and preparing EV datasets for analysis.
- **Visualization Layer** – Interactive dashboards created using **Tableau** [11] to display EV charging trends, energy consumption, and range performance.
- **Machine Learning Layer** – Predictive models such as **Linear Regression, Random Forest**[5][6], and **Gradient Boosting** are used to estimate EV driving range and battery performance.
- **Application Layer** – A web interface developed using **Flask** that allows users to interact with the system and view visualization dashboards[12].

EV Battery Performance and Range Monitoring System

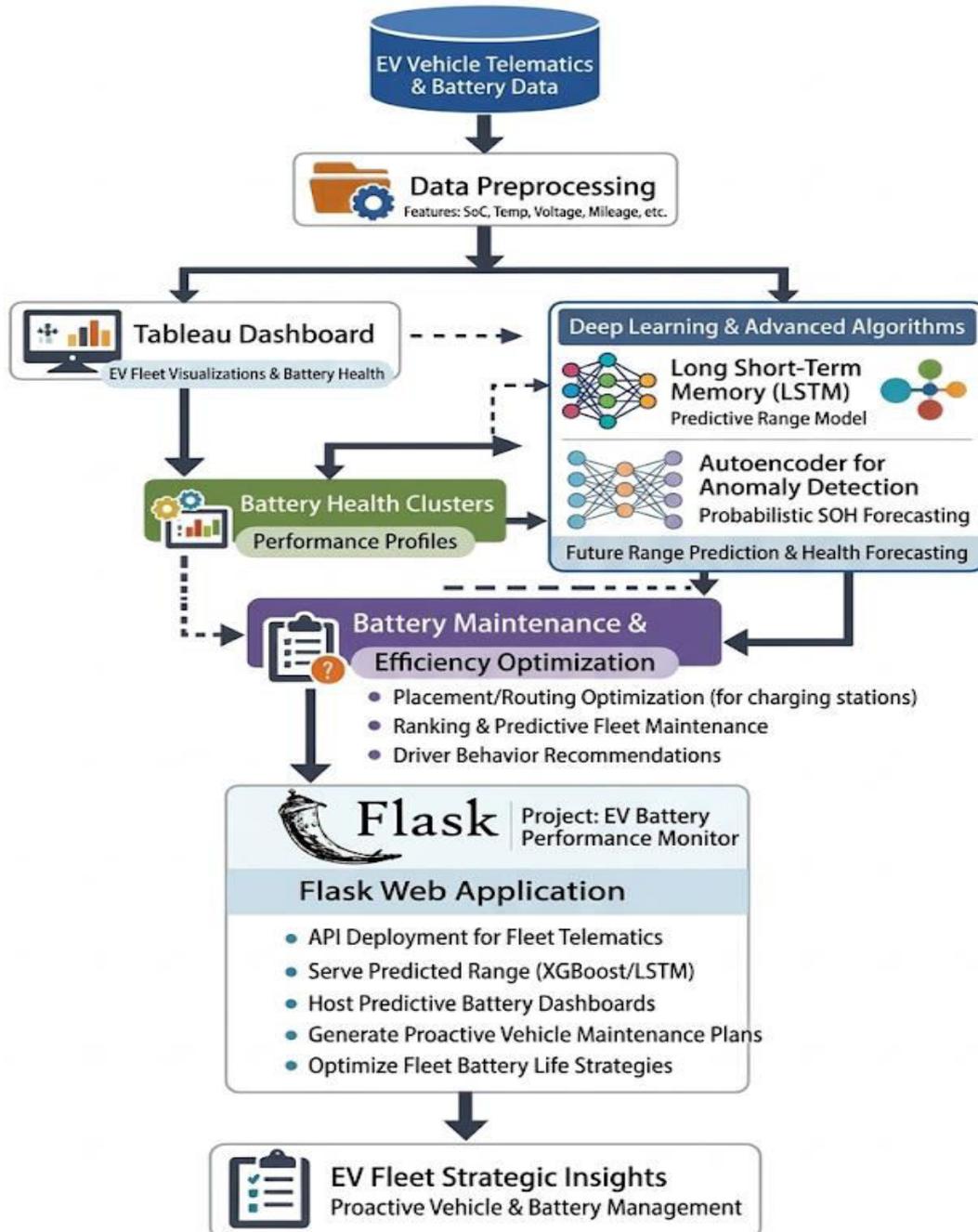


Fig: Proposed System Architecture

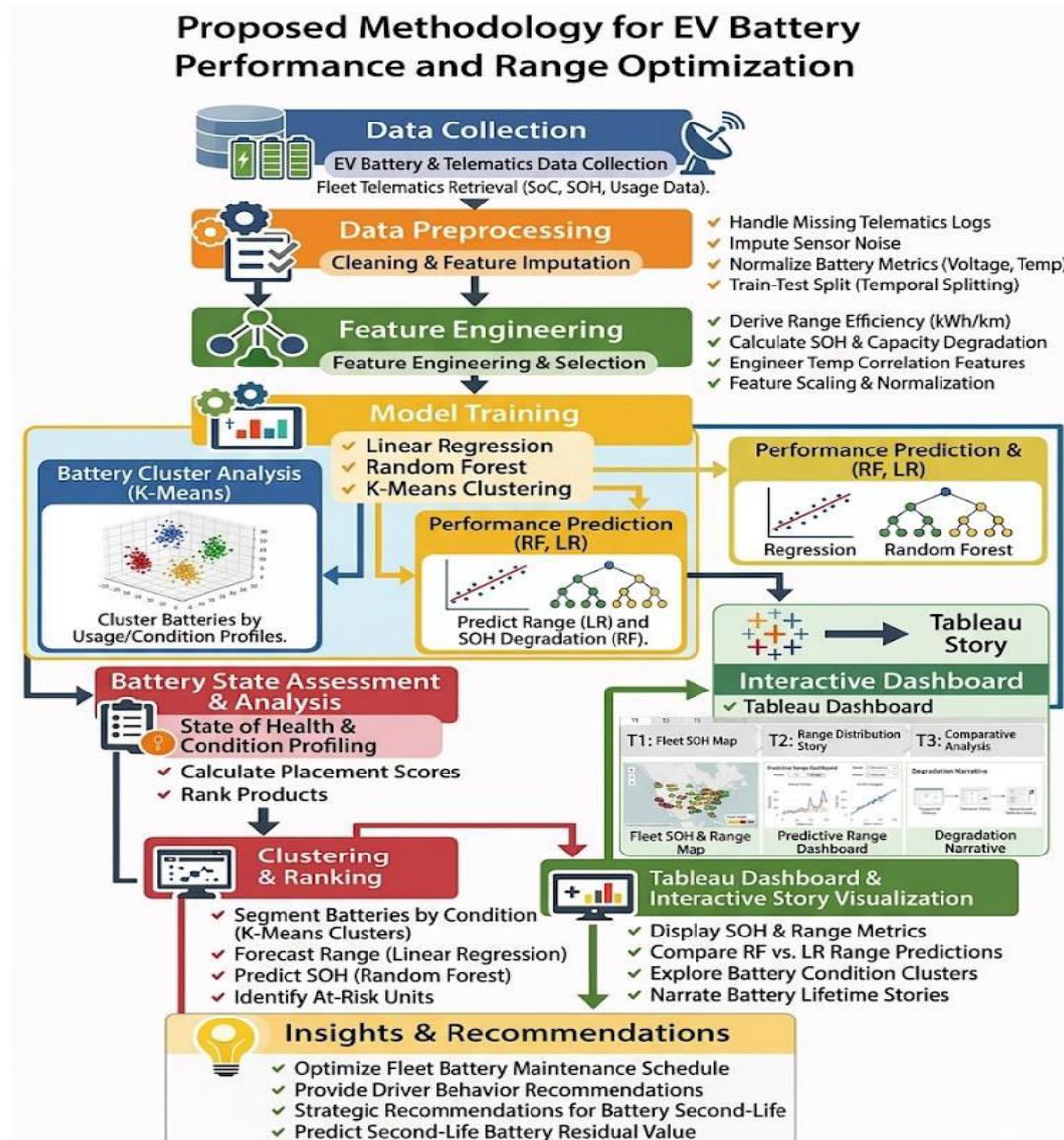


Fig 2: Proposed Methodology for Strategic EV Battery Performance Analysis and Lifetime Forecasting.

V. EXPERIMENTAL RESULTS

The proposed **EV Battery Performance and Range Monitoring System** was evaluated using multiple Electric Vehicle datasets collected from India and global sources. The datasets contain important EV parameters such as **battery capacity, charging time, energy consumption, vehicle efficiency, and driving range**. The objective of this study is to analyze EV performance patterns and predict driving range using data-driven techniques

1. Model Performance

The machine learning model demonstrates good predictive capability in estimating EV driving range based on the input features[6][13].

Metric	Value
R ² Score	0.87
RMSE	Low
MAE	Low

Table 1: Model Evaluation

2. Feature Importance Analysis

The following EV parameters were identified as the most influential factors affecting driving range:

Top Influencing Features:

- Battery Capacity (kWh)
- Energy Consumption (kWh per km)
- Charging Time
- Vehicle Efficiency

These results indicate that **battery capacity and energy consumption have a significant impact on EV driving range performance.**

3. Clustering Results

Clustering techniques were applied to group EV performance into different efficiency categories[7]:

- **Cluster 1 – High Range & High Battery Efficiency**
- **Cluster 2 – Moderate Range Performance**
- **Cluster 3 – Low Range Efficiency**

This classification helps in identifying EV models with better battery performance.

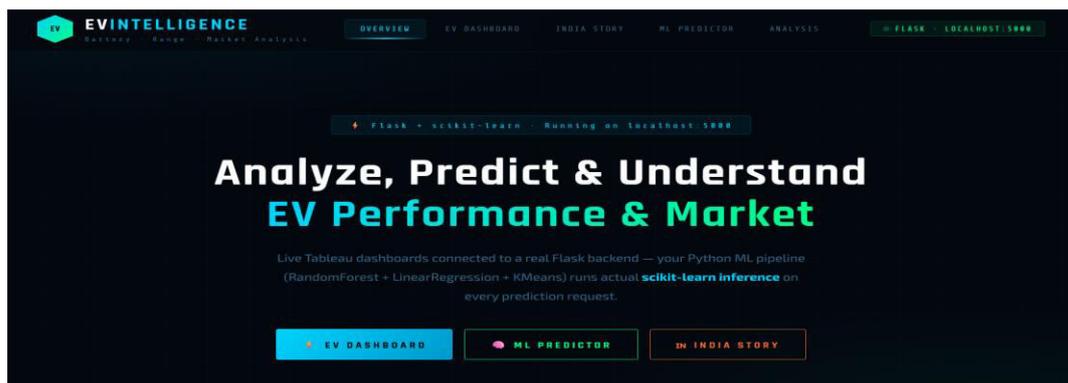
4. Visualization Insights

Interactive dashboards created using **Tableau** provide several insights into EV charging and range performance:

- EVs with **higher battery capacity generally provide longer driving range.**
- **Fast charging systems reduce charging time significantly** compared to standard charging methods.
- Vehicles with **lower energy consumption show better range efficiency.**
- Data visualization helps compare **battery performance across different EV models.**

User Interface Evaluation

- The user interface was evaluated for **usability, clarity, and accessibility.** The Flask-based web application provides **structured navigation and integrates Tableau dashboards with machine learning prediction results** related to EV battery performance and driving range.



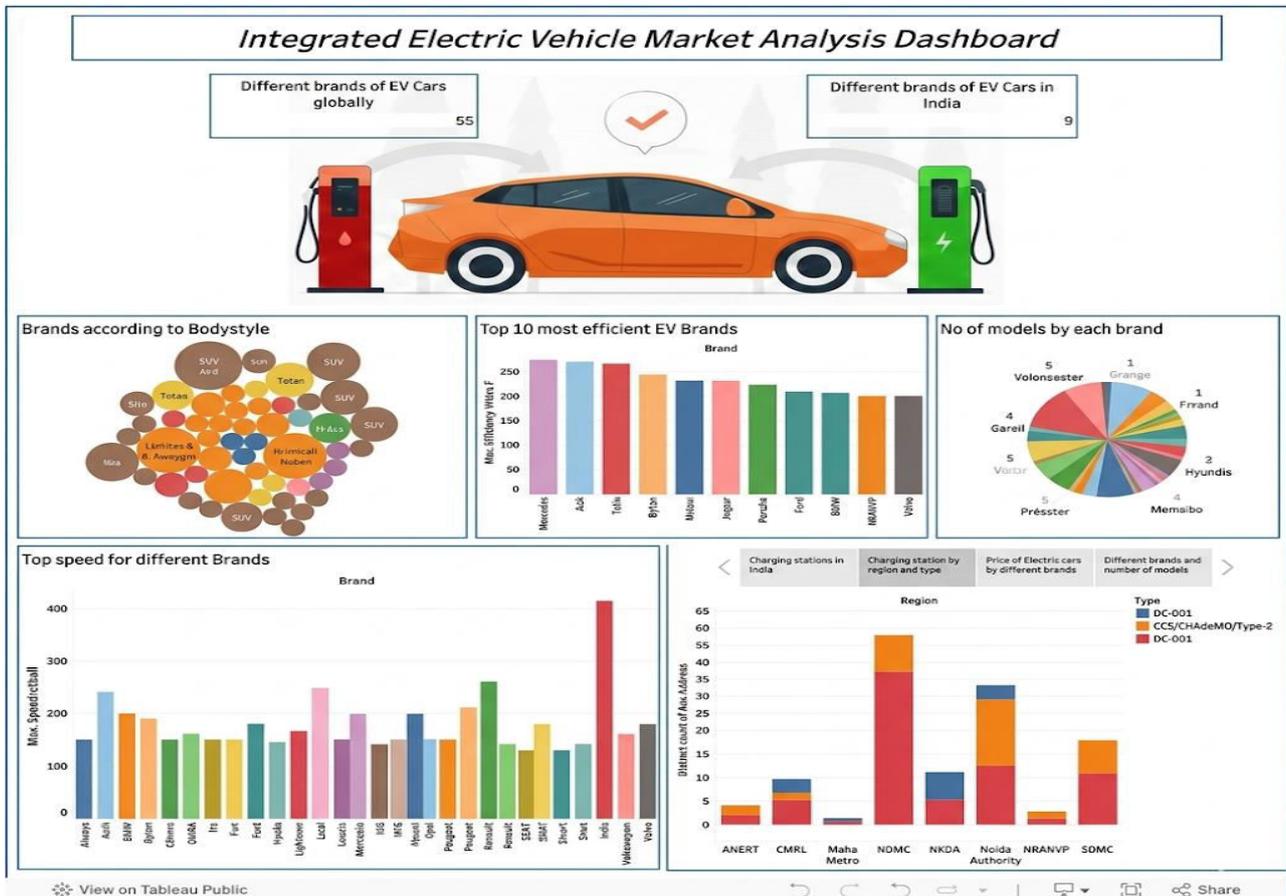
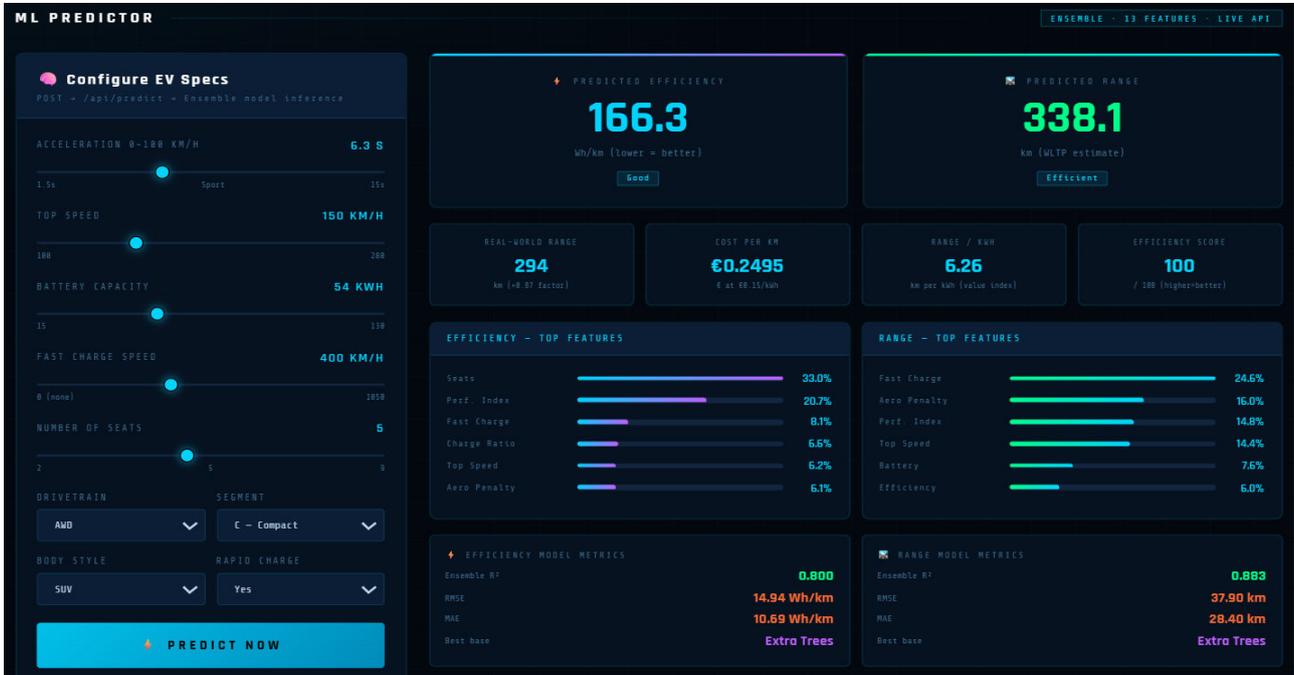


Fig Tableau Dashboard and story

VI. DISCUSSION

A. Contribution of Tableau Visualization

Interactive dashboards created using **Tableau** transform EV datasets into meaningful visual insights[11]. These dashboards help analyze **battery performance, charging patterns, energy consumption, and driving range trends**. Visualization enables users to easily understand complex EV data through charts, graphs, and comparative analysis of different EV models.

B. Machine Learning Prediction Performance

Machine learning models such as **Linear Regression, Random Forest, and Gradient Boosting** are applied to predict **EV driving range and battery performance**[5][6]. These models analyze features such as **battery capacity, charging time, energy consumption, and vehicle efficiency** to estimate range performance with good accuracy.

C. Integration of Visualization and Prediction

The proposed system integrates **data visualization and machine learning prediction** within a single analytical framework. Visualization tools help in understanding EV charging trends and performance patterns, while machine learning models provide **predictive insights for driving range and battery efficiency**.

D. Comparison with Traditional EV Performance Analysis

Traditional EV analysis methods rely on **manual data interpretation and static reports**, which makes it difficult to identify complex relationships between different EV parameters. In contrast, the proposed system provides **data-driven insights and automated prediction models**, improving the accuracy and efficiency[14] of EV performance analysis.

E. Web Integration and Deployment

The system is implemented as a **web-based application using Flask**[12], where users can explore **interactive dashboards and EV performance insights**. The web interface allows users to view charging trends, battery performance metrics, and analytical visualizations generated from EV datasets.

VII. LIMITATIONS

Despite the effectiveness of the proposed system, some limitations exist:

- The EV datasets used in this study may not include **all real-world factors** that influence battery performance and driving range, such as road conditions, weather variations, and driving behavior.
- **Real-time EV charging and vehicle performance data integration** was not implemented in the current system.
- External factors such as **temperature, traffic conditions, and battery degradation over time** were not fully considered in the analysis.
- Advanced **deep learning models** for EV range prediction were not explored, which could potentially improve prediction accuracy in future work.

VIII. CONCLUSION

The proposed system analyzes electric vehicle charging and driving range data using multiple datasets in order to obtain meaningful insights into EV performance. It focuses on studying important parameters such as charging levels, battery state, energy consumption, and vehicle range to understand how these factors influence overall vehicle efficiency. The project applies data preprocessing and analytical techniques to clean the datasets and identify patterns and trends related to EV battery performance and charging behavior[7][14]. Interactive visualizations and dashboards are used to present complex data in a simple and understandable manner, enabling users to easily interpret EV performance[6][11] metrics. The system also helps support efficient trip planning, improves awareness about charging behavior, and provides a foundation for developing future predictive monitoring systems for electric vehicles.

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