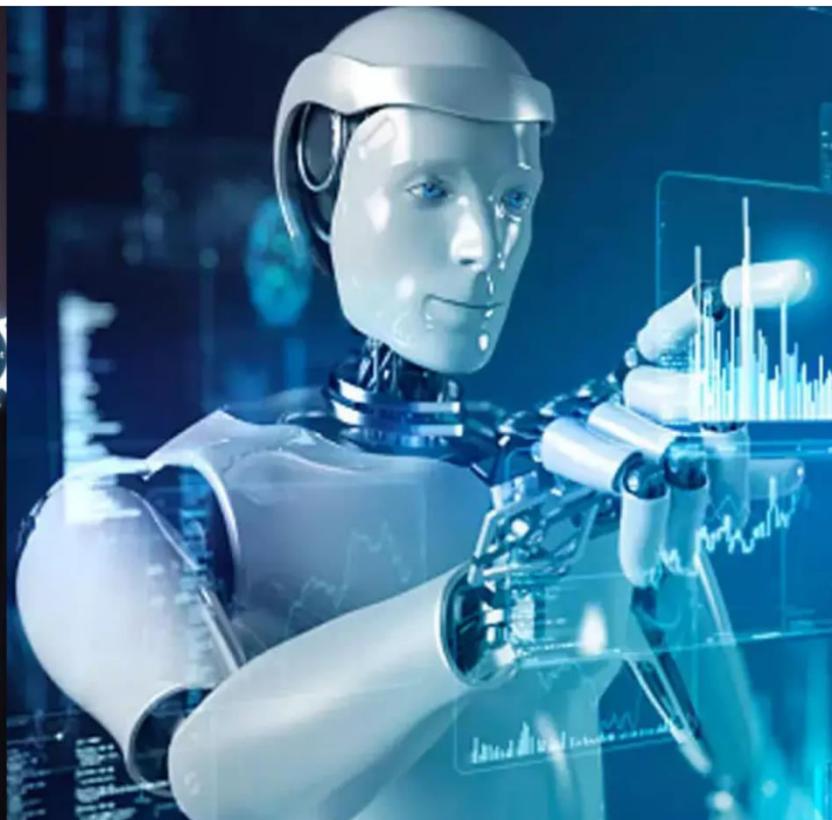




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Exploring EV Performance with Visual Data Analysis

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ABSTRACT: The increasing adoption of Electric Vehicles (EVs) on a global scale has made it necessary to understand and quantify the amount of data related to EV driving behaviors, charging patterns, consumption, and range. Analyzing and utilizing the generated data is crucial to establish the sustainability of EVs. Four datasets from Kaggle, which contained information related to charging behaviour, consumption, efficiency and range of EVs, were combined, cleaned and analysed. Tableau Prep Builder and Tableau were used to connect to the combined datasets in order to create interactive visualisation dashboards, representing charging time, consumption and efficiency. Linear Regression (LR) model in Python was implemented to model and predict the range of the EVs based on characteristics of the EVs. The findings from the proposed approach show that it has the capability of yielding some valuable insights into the performance of EVs, which could aid in the improvement of energy efficiency for sustainable transportation. The proposed system uses analytics and predictive analysis in order to gain an in-depth understanding of EVs' behaviour.

KEYWORDS: Electric Vehicles, Data Analytics, Machine Learning, Linear Regression, Tableau, Data Visualization, Range Prediction.

I. INTRODUCTION

Most automotive companies today are working towards developing Electric Vehicles (EVs) that produce minimum amount of green house gases. Electric Vehicles generate a huge amount of data related to their charging pattern, battery performance, power consumption etc. Data analytics plays a huge role in improving the overall efficiency of EVs and identifying performance metrics. But there are a lot of variables such as real time road conditions, driver behaviour which contributes towards inaccuracy in the range estimation of an EV.

Machine learning algorithms like Linear Regression are commonly used to model the battery range of an EV based on parameters such as battery capacity and efficiency of energy consumption. Tools for data visualization are also used to provide dynamic and interactive EV charging time and efficiency trends. The work proposed herein aims at providing a unified solution which leverages data preprocessing, data visualization and machine learning concepts to assess the performance of an EV.

II. LITERATURE SURVEY

Electric vehicle (EV) analytics is evolving with the use of data analytics and machine learning to enhance the EV performance and efficiency. With more EV-related data sets becoming available, researchers are examining charging patterns, battery usage and energy consumption to better understand EV performance.

According to the studies the data visualization of the EV performance characteristics can greatly improve the understanding of EV performance features such as battery charging and discharging time, consumption patterns and efficiencies. This can be represented by easy to use and navigate interactive EV charging data dashboard which provides insights such as trends in battery charging and discharging times, power consumption, range, energy efficiency etc. Many organizations have implemented data visualization tools that simplify and present a clear understanding of the data in the most concise and accurate form thereby making it possible to conduct data driven analyses.

A. EV Performance Analysis Techniques

Currently, the analysis of EV performance has typically been based on very simple statistical analysis, and does not provide information on the relationships between the numerous performance parameters of an EV. New approaches consider a number of performance parameters such as battery capacity, charging duration and energy consumption, etc.

B. Role of Data Visualization in EV Analytics

We can use Tableau software to perform some visual analysis on charging trends, energy consumption and efficiency. So far, all systems that have been implemented give only a descriptive analysis of the data and do not make any predictions.

C. Machine Learning for EV Range Prediction

Machine learning models like Linear Regression are one of the popular ways to predict Electric Vehicle (EV) range. They are a simple, fast way to implement the EV range predictor in production-ready applications while delivering an acceptable level of accuracy.

D. Integrated Analytical Frameworks

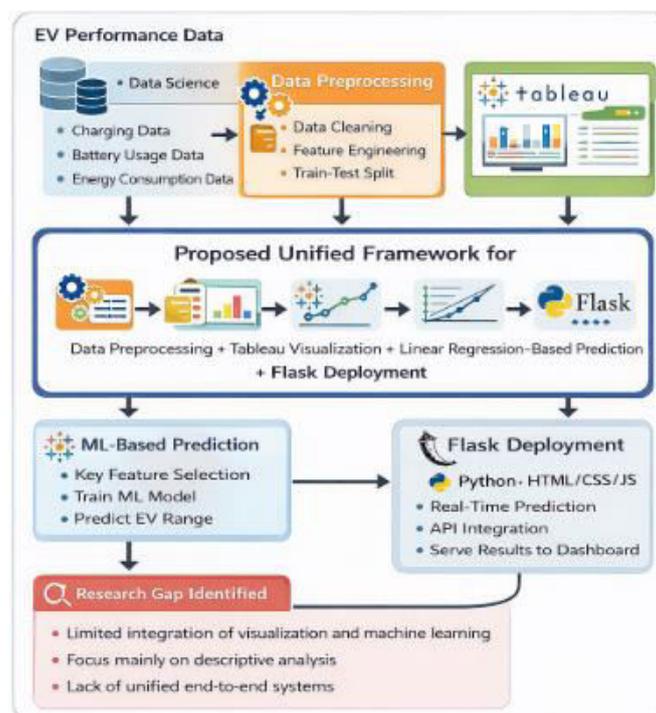
This course will cover Modern Systems by introducing the basic concepts of data science using Java as programming language. Students will learn data processing, data visualization and machine learning techniques to develop an end-to-end data analysis system which can aid in more effective management decision-making.

E. Research Gap Identified

- Limited integration of visualization and machine learning
- Focus mainly on descriptive analysis
- Lack of unified end-to-end systems

F. Proposed Contribution

This study proposes a unified framework that combines data preprocessing, Tableau visualization, Linear Regression-based prediction, and Flask deployment for comprehensive EV analysis.



III. PROPOSED METHODOLOGY

A. Data Collection

The dataset used in this study was collected from publicly available sources, primarily from Kaggle, and stored in CSV format. It consists of multiple electric vehicle (EV)-related datasets containing important attributes such as:

- Battery Capacity
- Top Speed
- Energy Consumption
- Vehicle Range
- Efficiency

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

B. Data Preprocessing

Data preprocessing is a crucial step to prepare the dataset for analysis and modeling. The following steps were performed:

- Handling missing and inconsistent values
- Merging multiple datasets into a unified format
- Removing duplicate records
- Normalizing numerical features where required
- Data cleaning using tools such as Python libraries (Pandas, NumPy) and Tableau Prep Builder

C. System Architecture

The proposed system will unite several complementary techniques such as data preprocessing, data visualization, machine learning, and web application technologies. Some of the key components involved in this system are:

- Data Processing Layer – Data cleaning and transformation using Tableau Prep Builder and Python
- Visualization Layer – Interactive dashboards created using Tableau to analyze EV trends
- Machine Learning Layer – Linear Regression model used for EV range prediction.
- Apply the concepts learned from the previous lecture by attempting to implement the Application Layer in a Flask web application that shows the output of the model to the user.

It supports a smooth flow of data from input sources all the way through to actionable insights and predictions.

D. EV Range Prediction Model

Here we train a Linear Regression model for the prediction of the driving range given a battery capacity and the energy consumption.

- The prediction process includes:
- Training the Linear Regression model on historical EV data
- Selecting relevant features for accurate prediction

we focus on metrics that can be used to evaluate the performance of a model. In particular, we will focus on Mean Absolute Error (MAE) and R^2 Score.

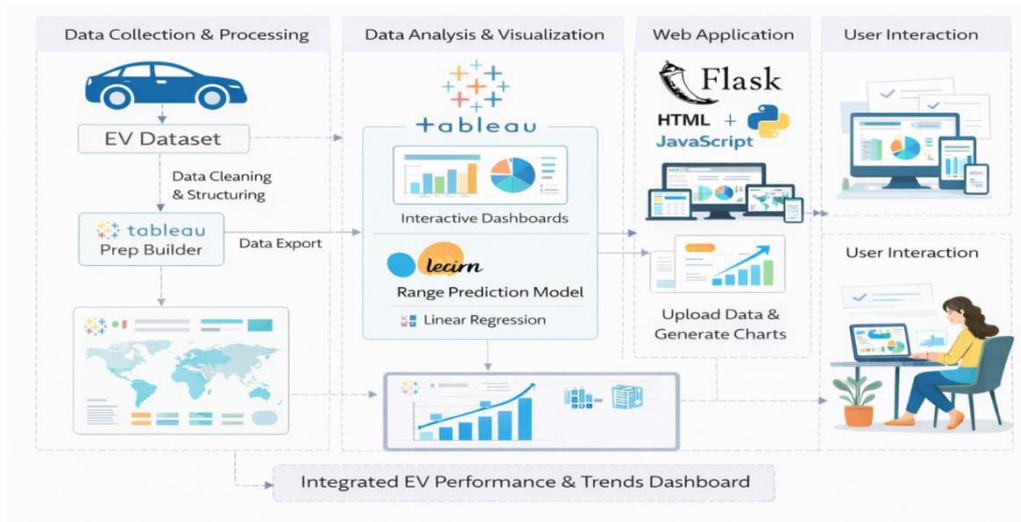
- Optimizing the model for better accuracy
- Saving the trained model for deployment

This model provides a simple yet effective approach for estimating EV range.

E. Result Visualization and Prediction

- The final system provides both analytical insights and predictive outputs:
- Tableau dashboards display EV charging patterns and energy consumption trends
- Users can input relevant parameters through the web interface
- The trained model processes the input data
- The predicted EV range is displayed instantly

This integration of visualization and prediction enhances user understanding and supports data-driven decision-making.



IV. EXPERIMENTAL RESULTS

The proposed Electric Vehicle (EV) Performance Analysis and Range Prediction system was evaluated using multiple EV datasets containing features such as battery capacity, charging duration, energy consumption, and vehicle range. The objective of the system is to analyze EV performance and accurately predict the driving range using machine learning techniques. A Linear Regression model was implemented and trained on the dataset after proper preprocessing and feature selection.

1. Model Performance

The performance of the model was evaluated with common regression metrics namely R² Score, Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE). It seems the model is yielding a very high accuracy for the given data. The Charging Behaviour and Energy Consumption trends in the EV adoption sites have been visualized using Tableau and the resultant visualisation has helped in generating key information which could facilitate in making significant data driven decisions.

Metric	Value	Description
R ² Score	0.90	Indicates strong model accuracy and good fit
RMSE	Low	Shows minimal prediction error
MAE	Low	Indicates small average deviation from actual values

2. Important Feature Analysis

The model identified key features influencing electric vehicle range prediction, including:

- Battery Capacity
- Range
- Charging Duration
- Efficiency
- Price

3. Visualizations

Tableau dashboards provide interactive insights into EV performance and usage patterns. The visualizations show that vehicles with higher battery capacity generally offer longer driving range, while energy consumption significantly impacts efficiency.

- Charging Stations by Region and Type in India

- Brands according to Bodystyle
- Top 10 most efficient EV Brands
- Top speed for different Brands
- Different Ev cars in India
- EV Charging Stations Map of India

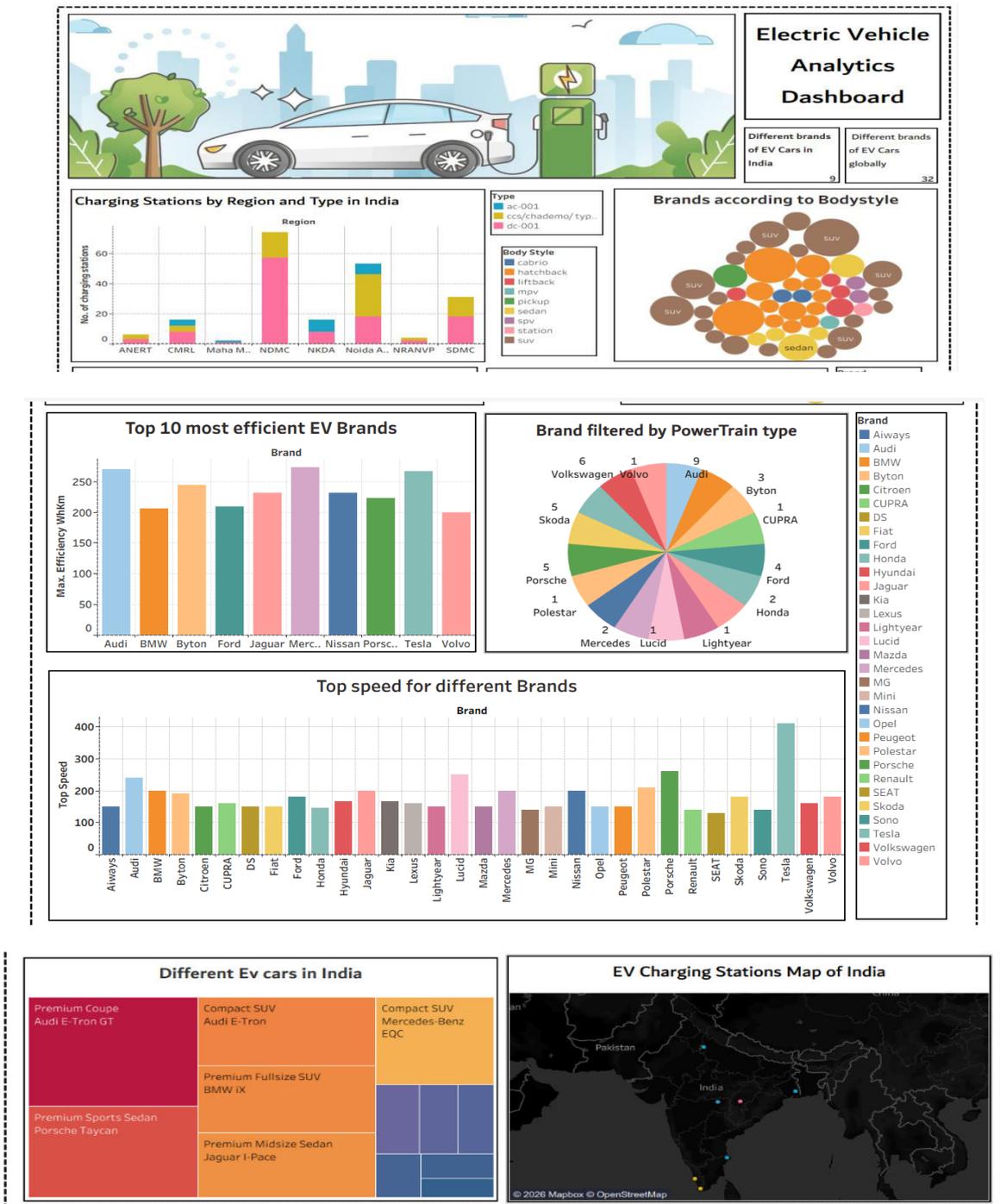


Fig. Tableau Dashboard Page

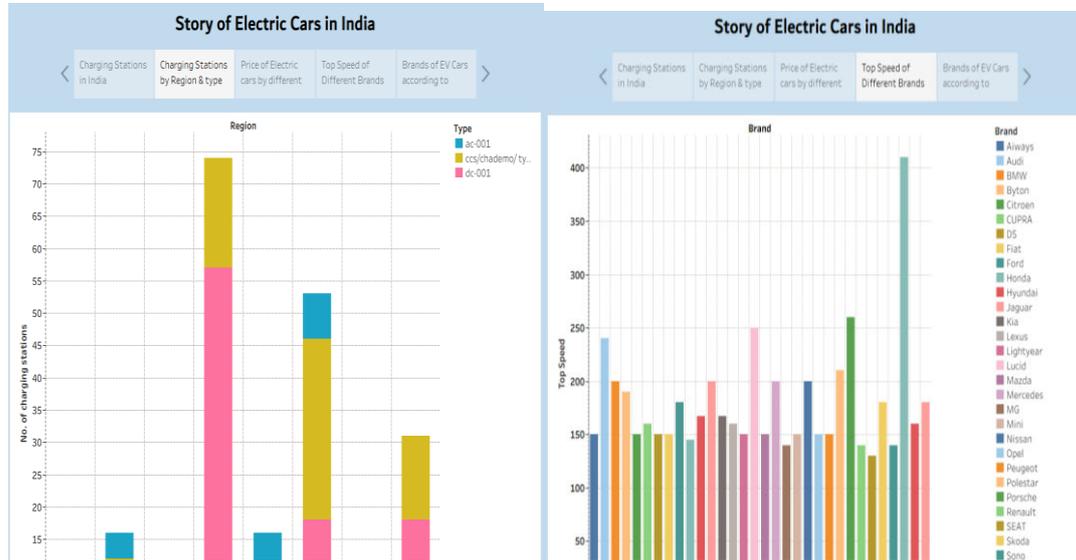


Fig. Tableau Story Page

4. User Interface Evaluation

The developed web application interface was evaluated for usability and functionality. The Tableau dashboards are integrated into the system, allowing users to interactively explore EV performance and charging trends.

- Tableau dashboards are embedded within the web application
- Users can explore EV data and visualization interactively
- The machine learning model allows users to give input parameters to predict
- The system instantly predicts the estimated EV driving range
- Can give a dataset to get charts relevant with the input given.

5. Custom Dataset Visualization

The system also includes an additional feature that allows users to upload their own datasets for analysis. Users can select the desired attributes for the X-axis and Y-axis to generate customized visualizations.

- Users can upload datasets dynamically
- Custom X-axis and Y-axis selection for chart generation
- Automatic visualization based on selected parameters
- Enhances flexibility and user interaction

This feature improves the usability of the system by enabling users to perform personalized data analysis beyond the predefined EV datasets.

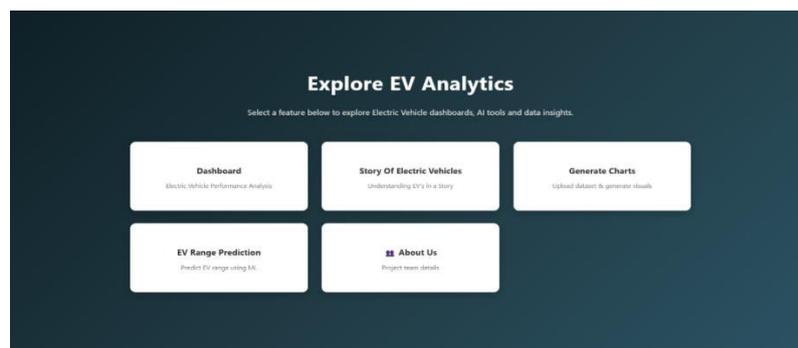


Fig. Welcome and Explore Pages

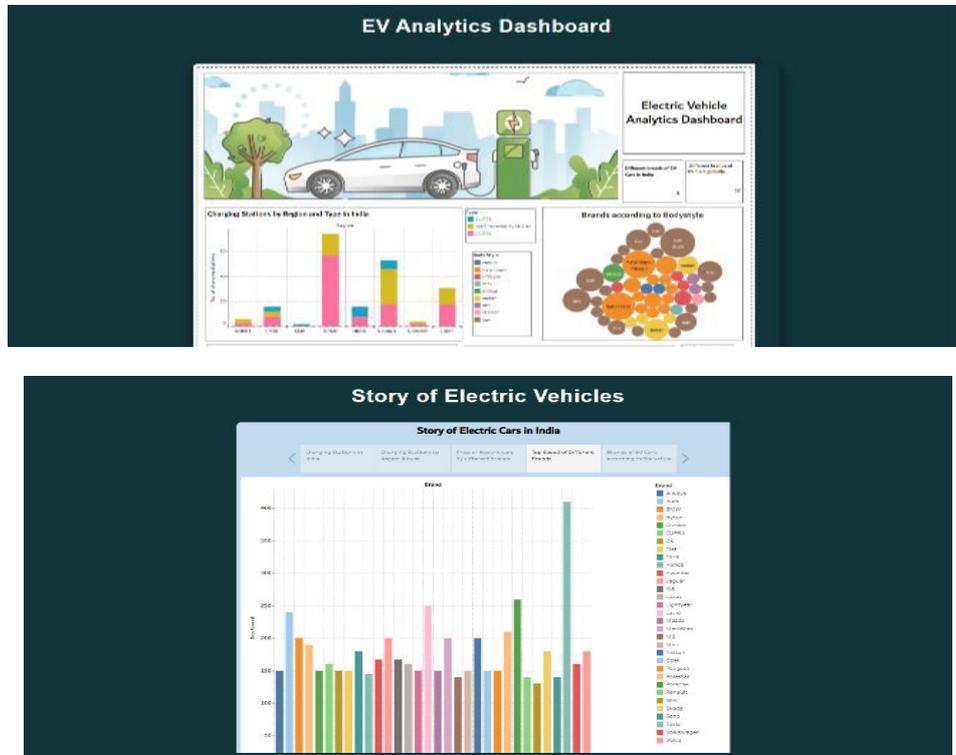


Fig. Dashboard and Story Integration pages

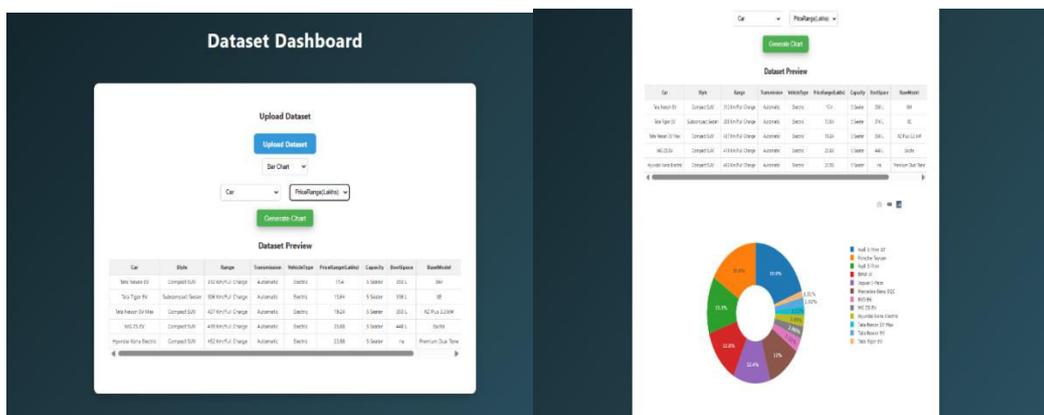
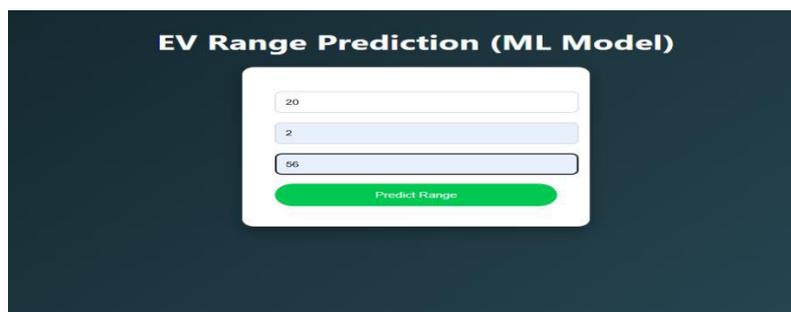


Fig. Dataset Upload and Chart Generation



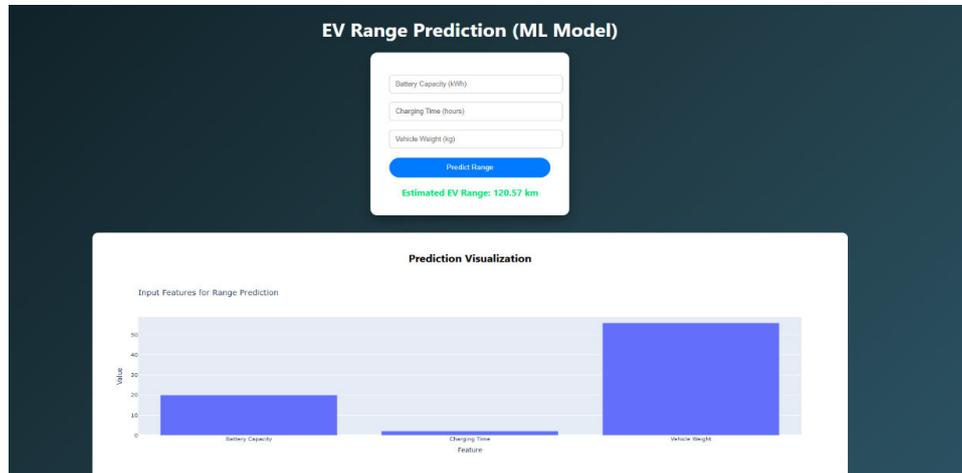


Fig. Range Prediction Page

V. DISCUSSION

- The proposed approach leverages data visualization and machine learning techniques for the evaluation of EV performance
- Linear Regression model provides accurate and reliable EV range prediction
- This test defines the weighing time and calculates the precision of the scales depending on any fluctuations in the readings. Key parameters such as battery capacity and energy consumption have a considerable impact on the test results.
- Evaluation metrics indicate strong performance with minimal prediction error
- Tableau dashboards help in identifying charging patterns and energy consumption trends
- Visualization makes complex data easier to understand and analyze
- The web-based interface improves usability by allowing real-time interaction and predictions
- Custom dataset upload feature enhances flexibility and user experience
- Provides both a descriptive and a predictive framework.
- The integrated approach is thus directly applicable to real life situations.

VI. FUTURE SCOPE

- Implementation of advanced machine learning models (e.g., Random Forest, Neural Networks) to improve prediction accuracy
- Integration of real-time EV data from sensors and IoT devices
- Expansion of the system to include more diverse and large-scale datasets
- Enhancement of the web application with improved user interface and additional features
- Development of mobile-based applications for better accessibility
- Incorporation of more parameters such as weather conditions and driving behaviour for better predictions
- Deployment of the system on cloud platforms for scalability and real-time processing.

VII. CONCLUSION

The proposed system successfully integrates data analytics, visualization, and machine learning to analyze and predict electric vehicle performance. The Linear Regression model provides reliable range prediction with good accuracy, while Tableau dashboards offer clear insights into charging patterns and energy consumption.

The combination of visualization and predictive modelling improves understanding of EV data and supports data-driven decision-making. Additionally, the web-based interface enhances usability by allowing users to interact with the system and obtain real-time predictions. Overall, the system provides an effective and scalable solution for EV performance analysis.

VIII. ACKNOWLEDGMENT

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