Electric Vehicle Charging Demand Forecasting

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Introduction

The increasing adoption of electric vehicles (EVs) brings a significant challenge in managing the energy demand at charging stations. Accurate forecasting of charging demand is essential to optimize energy distribution, avoid overloading infrastructure, and enhance the user experience. This project aims to forecast EV charging demand using time-series modeling techniques, enabling better planning and operational efficiency.

Abstract

This project presents a comprehensive approach to forecasting electric vehicle charging demand using real-world historical data. The workflow involved data preprocessing, exploratory data analysis (EDA), stationarity checks, and time-series forecasting using ARIMA and Prophet models. Evaluation metrics such as MAE, RMSE, and MAPE were used to assess model performance. Finally, a visualization dashboard was created in Tableau to present insights and support decision-making.

Tools Used

- Python (Pandas, NumPy, Matplotlib, Seaborn, Statsmodels, Prophet)
- Jupyter Notebook
- Tableau for visualization
- Excel for initial data review

Steps Involved in Building the Project

1. Data Collection & Preprocessing
   - Imported and cleaned the dataset.
   - Handled missing values and converted time columns to datetime format.
   - Extracted time-based features (hour, day, month).

2. Exploratory Data Analysis (EDA)
   - Visualized charging patterns across different timeframes.
   - Performed correlation and seasonality checks.
   - Conducted seasonal decomposition to observe trend, seasonality, and residuals.

3. Stationarity Testing
   - Used Augmented Dickey-Fuller (ADF) test.

- Differenced non-stationary series to make them suitable for ARIMA.

4. Modeling
   - Built and tuned ARIMA models for univariate forecasting.
   - Used Facebook Prophet for modeling trends and seasonality with high flexibility.

5. Model Evaluation
   - Evaluated models using MAE, RMSE, and MAPE metrics.
   - Compared ARIMA and Prophet performance.

6. Visualization & Insights
   - Built a Tableau dashboard showing daily/weekly trends, peak usage hours, and demand forecasts.
   - Insights included time-of-day patterns and recommended station upgrades.

Conclusion

The forecasting models developed in this project provide valuable insights into EV charging behavior and help anticipate demand spikes. By integrating these forecasts into operational planning, energy providers can ensure better resource allocation and improved service efficiency. Future work may involve integrating weather data or user behavior for multi-variate forecasting to further enhance accuracy.