AN INTERNSHIP REPORT

ON

Visualization Tool for Electric Vehicle Charge and Range Analysis

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Team Size : 4

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1. INTRODUCTION

1.1 Project Overview:

This project introduces a web-based data visualization platform specifically developed to analyze Electric Vehicle (EV) charging patterns and driving range estimates. The platform integrates interactive dashboards built using Tableau, powered by MySQL databases to handle real-time and historical data. The visualization tool allows users—such as EV manufacturers, fleet managers, policy makers, and individual EV owners—to gain actionable insights through intuitive interfaces. Users can explore trends such as charging frequency, duration, energy consumption, and efficiency across different regions and vehicle models.

The tool not only visualizes data but also supports data-driven decision-making by enabling comparative analysis of charging infrastructure performance, peak usage times, and range variability under different environmental and driving conditions.

1.2 Purpose:

The purpose of this tool is to fill the existing gap in real-time analytics and forecasting tools available for the EV ecosystem. Most current solutions provide only basic reporting, lacking the ability to uncover deeper insights into energy usage patterns, range prediction accuracy, and location-specific charging behaviour. This project aims to:

- Empower EV users to optimize their driving and charging habits based on data-driven suggestions.
- Assist manufacturers and urban planners in improving charging station placement, battery design, and vehicle efficiency.
- Provide environmental and regulatory bodies with tools to monitor EV adoption trends and infrastructure needs.

By providing accessible, visual analytics, the project helps bridge the gap between raw data and strategic planning, promoting sustainable transportation and smarter energy use.

2. IDEATION PHASE

2.1 Problem Statement:

Electric vehicle users and analysts face difficulties in estimating real-time charge data, understanding range behavior across locations, and optimizing routes or performance. This project solves the problem by providing visual insights from raw datasets using interactive dashboards.

2.2 Empathy Map Canvas:
- Thinks: "I need meaningful insights from EV usage data."
- Feels: "Frustrated with static or outdated data visuals."
- Says: "I wish there was a dashboard showing real-time analytics." - Does: Uploads data, explores dashboards.
- Pain Points: Inaccessible live metrics, confusing raw data.
- Gains: Interactive visuals, location-based range prediction, optimized insights.

2.3 Brainstorming:
- Use Tableau for dashboard creation
- Store and query data using MySQL
- Support user-uploaded datasets - Display location-integrated analytics

3. REQUIREMENT ANALYSIS

3.1 Customer Journey Map:
Users visit the tool to upload EV data and receive instant insights through dashboards. They navigate various sections, visualize charging sessions, map range estimations, and make data-driven decisions.

3.2 Solution Requirement:
Functional Requirements:
- Upload EV data in standard formats
- View visual reports on charge/range trends
- Analyze map-based behaviour

Non-Functional Requirements:
- Quick load time for dashboards
- Responsive and accessible UI
- Secure data handling

3.3 Data Flow Diagram:
Data Upload ➞ Data Stored in MySQL ➞ Visualized via Tableau ➞ Insights Displayed

3.4 Technology Stack:
- Frontend: HTML
- Backend: Tableau
- Data Visualization: Tableau - Database: MySQL

4. PROJECT DESIGN

4.1 Problem–Solution Fit:

Electric Vehicle (EV) ecosystems are rapidly evolving, yet there is a noticeable gap in tools that convert vast amounts of raw vehicle telemetry and charging data into actionable insights. Most users and manufacturers struggle with fragmented data sources, lack of visualization, and inadequate predictive capabilities. This tool addresses these challenges by offering a real-time, user-friendly dashboard interface that transforms complex EV data into comprehensible patterns and trends. It empowers users to make informed decisions regarding energy usage, charging behaviour, and driving efficiency.

4.2 Proposed Solution:

The proposed web-based solution integrates data ingestion, processing, and interactive visualization into a unified platform. Data is sourced from user uploads or live feeds, and then processed to ensure consistency, completeness, and accuracy. Cleaned data is fed into a MySQL relational database, where it is structured for optimal querying and performance. Using Tableau dashboards, the processed data is rendered into a variety of interactive visual formats such as:

- Geospatial maps showing charging station utilization
- Time-series graphs tracking energy consumption trends
- Comparative bar and pie charts analyzing EV performance across models or regions
- Dynamic filters allowing users to customize views by time, location, or vehicle type

This intuitive interface enables users to uncover correlations and make data-driven decisions without requiring deep technical knowledge.

4.3 Solution Architecture:

The overall architecture is designed for scalability, modularity, and performance. It comprises three interconnected modules:

1. Data Input Layer
    - A simple and secure HTML-based front end allows users to upload CSV or Excel files containing EV charge and usage data.
    - Input validation ensures correct data formatting and structure before processing.
2. Storage and Processing Layer
    - A MySQL database is used to store the cleaned and structured EV data, enabling efficient querying and real-time updates.
    - ETL (Extract, Transform, Load) routines are either triggered manually or run automatically to maintain data integrity and freshness
3. Visualization Layer
    - Tableau dashboards connect directly to the MySQL database using live or extract connections.
    - Dashboards are hosted on Tableau Public or Server, embedded into the web interface for seamless user experience.

  - Real-time interaction capabilities allow filtering, zooming, and exporting of visual insights.

Optional enhancements such as role-based access control, automated alerts, or AI-powered range forecasting can be incorporated in future iterations of the system.

5. PROJECT PLANNING & SCHEDULING

To ensure systematic development and timely delivery, the project was divided into five key phases, each with specific objectives and deliverables. The following breakdown outlines the planning and execution steps followed during the development of the EV data visualization tool.

Phase 1 – Research & Requirement Gathering

Timeline: Week 1

Objectives:

- Identify key stakeholders and end-users (e.g., EV owners, manufacturers, city planners).
- Analyze existing solutions and gaps in EV analytics platforms.
- Finalize scope, feature list, and system requirements (functional and non-functional).
- Select tools and technologies (e.g., Tableau, MySQL, HTML/CSS).

Phase 2 – Data Cleaning and Database Setup

Timeline: Week 2

Objectives:

- Collect sample EV datasets (charging logs, range logs, GPS data, etc.).
- Perform data preprocessing, including handling missing values, formatting inconsistencies, and normalizing data fields.
- Design and implement the MySQL database schema to store structured EV data.
- Populate the database with cleaned datasets.

Phase 3 – Dashboard Design

Timeline: Week 3

Objectives:

- Design and prototype Tableau dashboards for different user perspectives (individual users, analysts, planners).
- Create visual components such as:
  - Charging frequency over time
  - Range estimates across conditions
  - Geo-maps showing charger locations and usage density
- Optimize visual layouts for clarity and performance.

Phase 4 – Integration with Frontend

Timeline: Week 4

Objectives:

- Develop a web interface using HTML, CSS, and optionally JavaScript.
- Embed Tableau dashboards into the web pages.
- Provide file upload functionality for new datasets.
- Implement UI features such as filters, tooltips, and user navigation.

Phase 5 – Testing and Feedback Collection

Timeline: Week 5

Objectives:

- Perform unit testing of individual components (data upload, dashboard loading).
- Conduct integration testing to ensure database and Tableau connectivity.
- Collect feedback from sample users to evaluate usability and performance.
- Finalize adjustments based on user suggestions and resolve any identified bugs.

6. FUNCTIONAL AND PERFORMANCE TESTING

To ensure the robustness, accuracy, and responsiveness of the EV data visualization tool, both functional and performance testing were carried out during the final stages of development.

6.1 Functional Testing:

Functional testing aimed to validate that all core features operate according to the specified requirements. The following components were tested:

Data Upload Validation:

- Verified that users can upload datasets in supported formats (CSV, XLSX).
- Ensured appropriate error messages are displayed for incorrect or corrupted files.
- Confirmed successful ingestion and storage of uploaded data in the MySQL database.

Dashboard Rendering:

- Confirmed that Tableau dashboards load correctly within the web interface.
- Validated that visual elements (charts, graphs, filters) reflect uploaded data accurately.
- Ensured that filters and interactive elements respond correctly to user input.

Data Consistency Checks:

- Checked for alignment between uploaded data and dashboard outputs (e.g., energy consumption trends, charging frequency).
- Validated correctness of calculations used in KPIs and summaries.

6.2 Performance Testing:

Performance testing was conducted to measure the system's ability to handle data efficiently and provide a smooth user experience under expected load conditions.

Dashboard Load Times:

- Tableau dashboards were tested with various dataset sizes (small, medium, large).
- Load times remained within acceptable limits (typically under 3 seconds for medium datasets).

Interactive Responsiveness:

- Filters, sliders, and zoom actions on dashboards responded with minimal latency.
- Drill-downs and map navigation features were tested for real-time performance.

Scalability Checks:

- Simulated concurrent users accessing the dashboards to assess system responsiveness.
- Observed consistent performance for up to 10 simultaneous users without degradation.

Database Query Performance:

- Monitored SQL query execution times during dashboard refreshes.
- Indexed key fields to improve query speed and reduce load on the server.

7. RESULTS

The final implementation of the EV data visualization tool successfully meets the project objectives and delivers a seamless, insightful user experience. The tool transforms raw EV data into interactive, visual formats that support both individual and organizational decision-making.

Key Outcomes:

- **Visualization of EV Charge Cycles**
  Users can clearly observe charging frequency, duration, and energy consumption trends over time. Time-series graphs and bar charts display daily, weekly, and monthly charging behavior, aiding in usage pattern analysis.
- **Mapping of EV Range Patterns**
  Interactive maps provide geographic insights into vehicle range estimates and charging station usage. Users can explore location-based efficiency, helping manufacturers and planners identify regions requiring infrastructure improvements.
- **Insights Across Time/Location Filters**
  Dynamic filters allow users to slice data by time range, region, vehicle model, and more. This flexibility empowers users to conduct comparative analysis and spot correlations in real-time.
- **Dynamic, User-Friendly Analytics**
  Dashboards are designed to be intuitive, responsive, and visually engaging. Even non-technical users can interact with complex datasets without needing to understand backend processes or query languages.

Additional Benefits:

- Enhanced data interpretation for stakeholders (EV owners, planners, and analysts).
- Centralized platform for real-time monitoring and trend discovery.
- Foundation for future expansion (e.g., predictive analytics, AI integration)

8. ADVANTAGES & DISADVANTAGES

Advantages:

- Real-time analytics
- Map-based insights
- Intuitive dashboards

Disadvantages:

- Requires Tableau license for deployment
- Data quality depends on user input

9. CONCLUSION

This project demonstrates how Tableau and MySQL can be used to deliver valuable insights for EV data analytics. It empowers users with real-time, location-aware decision-making tools.

10. FUTURE SCOPE

- Expand to predictive analytics (battery health, long-term range)
- Add mobile app integration
- Include real-time telematics feed
- Multi-user data comparison dashboard

11. APPENDIX

Source Code & Resources:

- **GitHub:** https://github.com/tarun5408/Visualization-Tool-for-Electric-Vehicle-Chargeand-Range-Analysis
- **Dataset:** https://github.com/tarun5408/Visualization-Tool-for-Electric-Vehicle-Chargeand-Range-Analysis/tree/main/Dataset
- **Demo:** https://github.com/tarun5408/Visualization-Tool-for-Electric-Vehicle-Chargeand-Range-Analysis/tree/main/video%20demo