Optimizing Routes and Locations for EV Charging Points

Technical Report

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Prepared from: 'Optimizing-routes-and-locations-for-EV-charging-points.ipynb'

Executive Summary

August 17, 2025

This report summarizes the analysis performed on a dataset of Tesla Supercharger locations and an optimization model used to recommend new charging station placements. The goal is to improve network coverage and minimize driver travel distance between charging points, with a focus case study on California.

Objective

August 17, 2025

Analyze Tesla Supercharger locations, identify geographic and temporal trends, and recommend new station locations that minimize overall travel distance under projected demand.

Data & Preprocessing

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Source: CSV dataset of Supercharger stations with fields such as station name, address, GPS coordinates, power (kW), number of stalls, open date, and status. Key preprocessing steps: • Drop irrelevant columns and filter to U.S. entries. • Convert Open Date to datetime and fill missing dates with the dataset median. • Parse GPS string into numeric Latitude and Longitude. • Ensure ZIP codes and other fields are correctly typed.

Methodology

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• Exploratory data analysis to study spatial and temporal patterns. • Build pairwise geodesic distance matrix among candidate stations. • Formulate a binary optimization problem where each candidate site has a binary decision variable. • Objective minimizes total pairwise distances of selected stations, subject to demand-based constraints. • Solve using an LP/MIP solver (HiGHS solver reported) and extract selected 'build' sites.

Key Findings

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• California dominates the Supercharger network; most recommended expansions concentrate there. • Station openings spiked around 2019–2020 and slowed afterward. • Station attributes (power, stalls, elevation) show wide distribution with no strong simple correlations. • Optimization recommends filling coverage gaps mainly in major metro areas (e.g., Bay Area, Los Angeles, San Diego).

Optimization Results (summary)

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The optimization returned a near-optimal solution (objective ≈ 3.24e6, ~10% optimality gap reported in the notebook). Multiple sites across California were recommended; selections cluster in high-demand metros. The model output included a list of stations marked for building (examples: Richmond, San Jose, San Diego, Los Angeles, San Francisco).

Recommendations

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• Prioritize new stations in populous metro areas (Bay Area, LA, San Diego) to minimize average driver detours. • Use the model as an input to a broader decision process that includes land availability, local grid capacity, permitting, and expected local EV adoption rates. • Re-run optimization periodically as demand and fleet composition evolve; include non-Tesla networks and public data where possible.

Next Steps / Limitations

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• Incorporate traffic flow, population density, and projected EV adoption at a finer geographic resolution. • Add cost metrics (land, build, grid upgrades) and multi-objective optimization (minimize cost and distance). • Validate model recommendations with field checks and local stakeholders.

Appendix — Example Recommended Sites

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A sample of 'Build' sites extracted from the notebook's optimization output: • Richmond • San Jose • San Diego • Los Angeles • San Francisco Note: The notebook contains the full list of recommended locations and solver outputs.