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CALTRANS DIVISION OF RESEARCH, INNOVATION AND SYSTEM INFORMATION
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Research Notes

Design

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Remote DCFC Reliability and Downtime Detection Tool

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Remote DCFC Reliability and Downtime Detection Tool

New anomaly detection models are being developed to detect electrical vehicle (EV) charger failures that standard monitoring systems can miss.

WHAT IS THE NEED?

The California Department of Transportation (Caltrans) operates a growing network of public EV charging stations across California. Keeping these chargers consistently available and working is essential for building public trust and supporting the state's EV adoption goals.

Current monitoring systems rely mainly on backend data, like network connectivity or payment processing, which often miss problems that directly affect users, such as blocked access, damaged cables, or unresponsive units. Remote locations mean that physical site visits can be inconvenient, costly, and delayed.

This research project is developing a tool to fill that gap. By analyzing charger usage data, the tool will help detect real-time failures that users experience, even when backend systems show the charger as operational. Remote detection can allow for more rapid repairs when needed.

WHAT ARE WE DOING?

This project aims to enhance Caltrans' EV charging infrastructure reliability by developing an anomaly detection tool that identifies failures not captured by standard network monitoring, such as blocked access, damaged connectors, or other on-site issues. The tool leverages real-world charger usage patterns and consists of two complementary models: a probability-based model for detecting statistically unusual gaps in usage and a Long Short-Term Memory (LSTM) neural network for identifying more complex temporal anomalies. Initial work focused on historical ZEV 30-30 data due to early delays in accessing live Caltrans charger data, allowing for early model validation while resolving data access challenges.

The project has completed or is progressing through three

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key research tasks. Model conceptualization involved reviewing literature and evaluating relevant anomaly detection techniques. Data collection and processing included preparing historical datasets, incorporating new Caltrans data, and performing time-series transformations and descriptive analyses to guide model design. The naive probability model and LSTM model have been built and validated, with a technical report submitted to Caltrans detailing datasets, model architecture, and validation results.

As the project transitions toward integration testing and field validation, challenges have arisen in engaging Caltrans' maintenance staff. To address this, alternative validation strategies are being developed using publicly available live charger status information from networks and Google Maps as proxies. A limited three-month dataset will be scraped to construct utilization-over-time feeds, and student testers will verify charger availability at select sites. Preliminary tests have confirmed this approach is feasible, providing a practical path forward if direct field support from Caltrans is not available by year-end.

WHAT IS OUR GOAL?

The project's goal is to deliver a robust, scalable tool that enables Caltrans to detect real-world EV charger failures more quickly and accurately. By supplementing existing monitoring protocols, this tool can support proactive maintenance, improve reliability reporting, and ultimately enhance the EV charging experience for the public.

WHAT IS THE BENEFIT?

This tool provides Caltrans with a new method for identifying EV charger reliability issues by analyzing actual usage patterns. It is capable of detecting "silent failures," such as chargers that appear online but go unused due to blocked access or malfunctioning equipment.

By uncovering these issues, the tool can help reduce charger downtime through faster failure detection, support compliance with state reliability reporting requirements, increase public confidence in EV infrastructure, and prioritize maintenance efforts based on real-world usage data.

WHAT IS THE PROGRESS TO DATE?

The project has advanced through its initial technical tasks, moving from model development toward validation and integration. A comparative literature review of anomaly detection methods—including statistical, machine learning, and deep learning techniques—helped establish the modeling framework. Historical ZEV 30-30 data were processed, transformed into hourly time series, and analyzed to identify temporal and spatial usage patterns. Meanwhile, newer Caltrans datasets are now being incorporated to refine the models. Two anomaly detection models have been developed: a naive probability model for identifying unusually long usage gaps, and an LSTM-based model for detecting more complex temporal disruptions. Both models were initially validated with historical data and are now being tested with current Caltrans data.

The next steps are focused on field testing and operational integration. Engaging Caltrans' maintenance staff for on-site evaluation has been challenging, so alternative validation methods are being pursued. Publicly available live charger status data from networks and Google Maps will be scraped over three months to generate utilization-over-time feeds, enabling the models to demonstrate anomaly detection in real-world conditions.

Additionally, student testers will verify a small subset of chargers marked as "down" on these platforms, providing targeted ground-truthing despite limited resources. Preliminary scraping tests confirm the feasibility of this approach. If Caltrans cannot provide field-testing support by year-end, this alternative plan will ensure continued progress and keep the project on schedule.