SPRING 2023 NUVVE TEAM

What does Nuvve do?

Nuvve Holding Corp. is a global leader in vehicle-to-grid (V2G) technology that delivers new value to electric vehicle owners through high-power charging and grid services.

What are their goals?

Through V2G technology, Nuvve aims to make the grid more resilient, enhance sustainable transportation, reduce ownership costs of electric vehicles, and support energy equity in an electrified world.

OUR PROJECT GOALS

ENERGY PRICES

- Develop an understanding of the factors that affect energy prices using tools like time-series decomposition.
- Research and build various machine learning models to forecast energy prices and optimize the bidding strategies.

DATA EXPLORATION

- Daily, Monthly, and Quarterly analyses of the price of energy and various energy sources
- Time Series decomposition and analysis on energy prices
- Explored relationship between weather, holidays, and energy prices

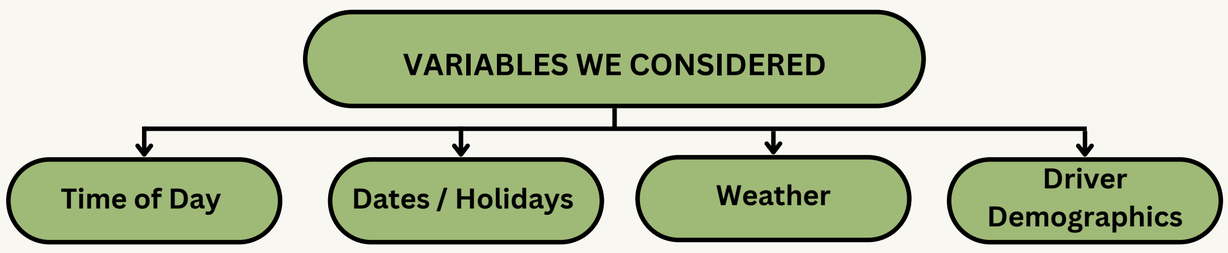
RESEARCH

- Read research papers and repositories with implementations of Single Layer, RNN, DNN, and LSTM neural networks.
- Researched different techniques and steps in hyperparameter tuning to reduce MSE and MAE.

DRIVER PROFILING

Develop an unsupervised model to profile drivers in a way to yield useful data applicable to forecasting and other future endeavors.

DATA EXPLORATION

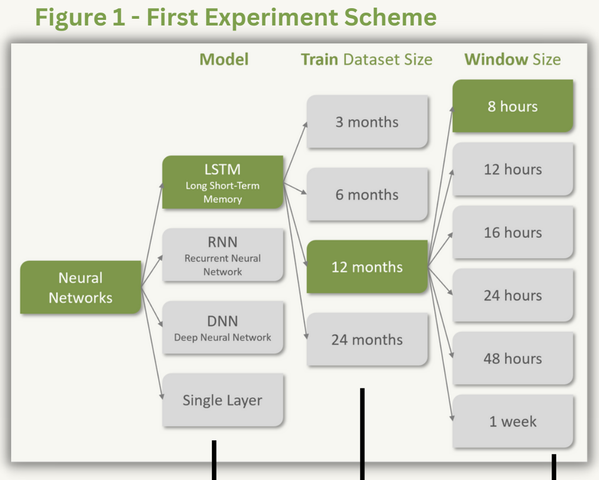


RESEARCH

- Conducted exploratory research into Nuvve, Vehicle-To-Grid technology (V2G), and factors that influence driving behavior patterns.
- Researched the influence of weather, holidays, driver demographics, and bicycle presence on driving.
- Researched numerous unsupervised machine learning models including neural networks, random forest, hierarchical clustering, and k-means.
- Concluded to use k-means clustering and utilized online tutorials to create our k-means unsupervised machine learning model.

MODELING

Figure 1 - First Experiment Scheme



First Experiment Goal - Determine:

- Best model for our data (fig. 2).
- Optimal training dataset size (fig. 3).
- Optimal window size (# of hours needed to predict the next one) (fig. 4).

Results:

LSTM (Long Short-term Memory) with a training dataset of 12 months and window size of 8 hours had the best result overall (fig. 1).

Figure 2

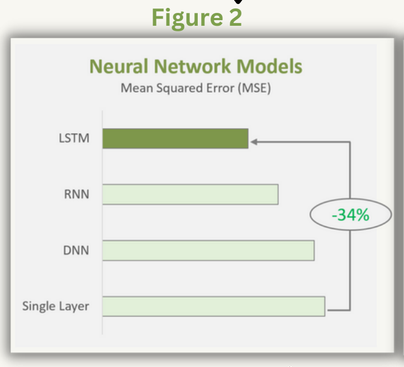


Figure 3

Figure 4

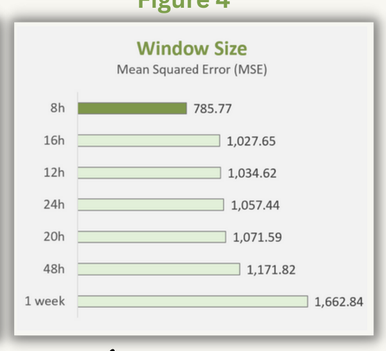
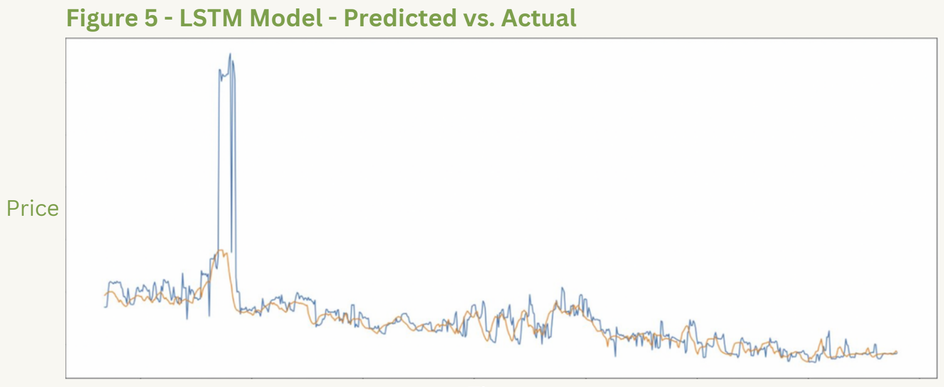


Figure 5 - LSTM Model - Predicted vs. Actual



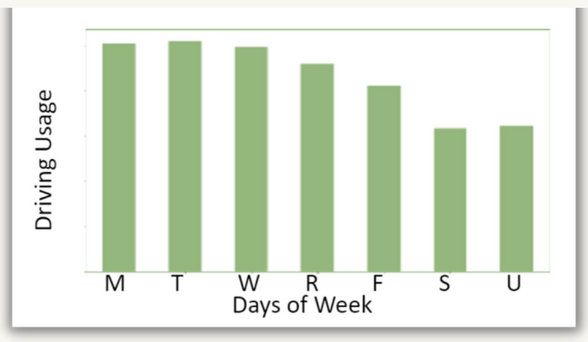


Figure 1 - Driver usage over week
Not all drivers go regularly over week

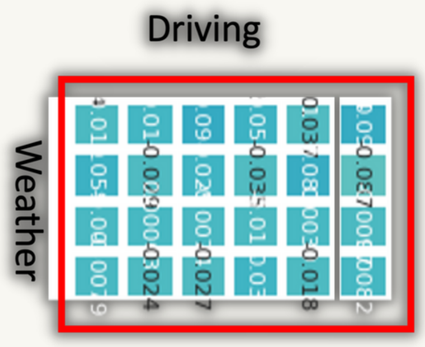


Figure 2 - Driving & Weather Heat Map
Linear correlation not significant

MODELING

- Extracted meaningful statistics for each car into a master data by computing different features together in the given data.
- Applied data preprocessing techniques: imputation methods, scaling, etc.
- Constructed heatmaps from the k-means clustered master data to understand the impact of each variable on the clustering decision (Fig. 3).

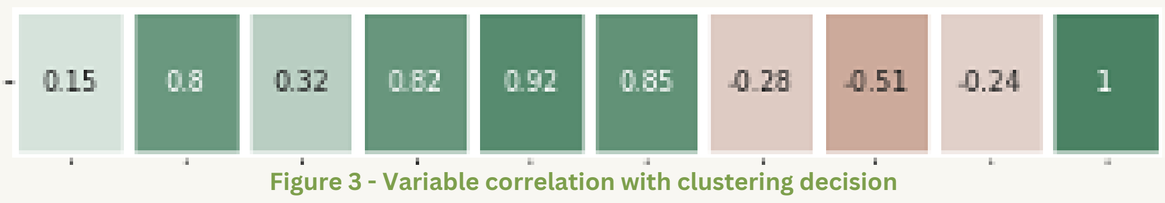


Figure 3 - Variable correlation with clustering decision

- Divided master data into categories of statistics for each car relating to energy, weather, holidays, days, and time.
- Clustering on the categories above would answer, e.g., "which drivers:
  - "drain entire battery before charging car?"
  - "plug in/out the car more times in a day?"
  - "drive similarly on weekends and weekdays?"
  - "charge the car for short periods?"

FUTURE GOALS

- Create multivariate DataFrame and integrate into predictive model.
- Achieve long term accuracy within model and streamline processes for integration of new data.
- Explore more advanced models like transformer.

FUTURE GOALS

- Improve clustering by comparing decisions across multiple categories
- Create new data frame to put back into K-Means cluster
- Create a user-end interface to allow client to interact with data

We would like to acknowledge our Nuvve mentors Ted Smith and Hamza Lemsaddek, the Data Mine faculty and staff for their help, and our TA, Mihika Ghaisas, for her guidance.