VEHICLE RANGE PREDICTION

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INTRODUCTION

Electra Vehicles, Inc. is an innovative Boston-based startup developing and designing intelligent control software for energy storage systems. What sets Electra Vehicles apart is the ability to design and control dual chemistry systems through our AI-based control algorithms. Electra was one of the top-26 teams at the MassChallenge startup incubator in 2016 and is a part of the Massachusetts Clean Energy Center's AccelerateMass program to support the adoption of innovative clean technology in Massachusetts. In this project, we are working with Electra Vehicles on predicting electric vehicle range from provided system specifications. The vehicle range is defined as how far can you drive on a full charge. However, there are uncertainties that make this difficult.

OBJECTIVES

Considering the specifications of the energy storage system, the vehicle modeling parameters, and the simulated vehicle operating conditions, our goal is to project the resultant simulated vehicle range without performing a detailed cycle analysis. The resulting models will be generated for each of the supplied EPA driving cycles and will account for any possible simulated vehicle or energy storage system.

METHODS

Data preparation

The raw dataset is collected from Amazon S3 Buckets in JSON format provided by Electra Vehicles. We transformed 20,000 JSON files to Pandas DataFrame and split the dataset into 13,400 training examples and 6,600 test examples to train and evaluate our model.

METHODS

Model Construction and Evaluation

We approach the solution by using Random Forest, Decision Tree, K-Nearest Neighbors Regression, and Ordinary Least Squares algorithms to train 4 different regression models. The trained models are used to predict the vehicle range given the specific input, and we compared them using commonly used regression evaluation metrics: MAE (Mean Absolute Error), MSE (Mean Squared Error) and R-Squared Score.

RESULTS

Models	MAE	MSE	R-Squared
Random Forest	0.552	1.541	0.999
K-Nearest Neighbors Regression	1.605	29.333	0.993
Decision Tree Regression	2.231	12.435	0.997
Ordinary Least Squares	3.850	89.398	0.980

Table 1: Model Performance Comparison

The performances of all models are shown in Table 1. Considering the MAE, MSE and R-Squared value, the Random Forest model is the best regressor for our problem.

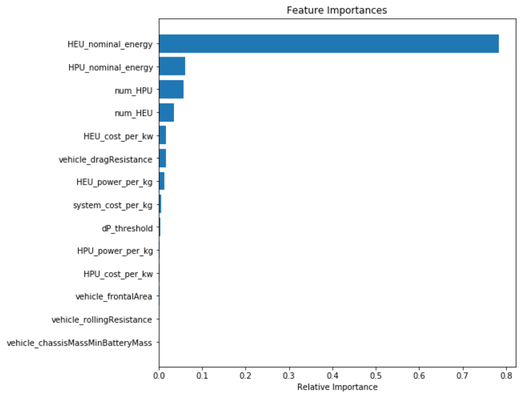


Figure 1: The feature importances

By using statistical methods, we compared the importance of each feature as shown in Figure 1, we found that the top 5 important features are HEU nominal energy, HPU nominal energy, num HPU, num HEU and HEU cost per kw. We also presented the top 12 feature distributions respects to system range in Figure 2.

Figure 2: The top 12 feature distributions

Using the Ordinary Least Squares method, we achieved the following mathematical model for our problem:

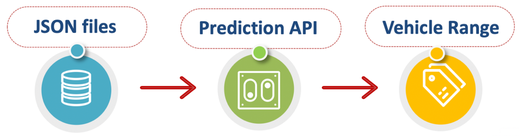
$$SystemRange = A \cdot X$$

where A is 1x14 Linear Regression model coefficient vector and X is 14x1 input feature vector.

RESULTS(CONTINUED)

We developed an easy-to-use vehicle range prediction API including 5 different models which can be used to predict the electrical vehicle range for Electra Vehicles. To use the created API, it is possible to follow three simple steps:

- Input your JSON file as input.
- Select the model you would like to use.
- Get the prediction result.



CONCLUSION

Our major results of this project can be summarized as follows:

- 14 Important features which including the system level, HPU, HEU specifications, and vehicle parameters are found to simulate the vehicle range.
- Best regression model reaches 0.999 R-squared value without overfitting.
- Easy-to-use API for Electra Vehicles to simulate vehicle or energy storage system or develop other products.

FUTURE WORK

We may try some other state-of-art technique such as Neural Network or Deep Learning in the further since they did an outstanding work in most practical problems. Also, more data can be added to train more robust models.

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