Battery health prediction of lithium-ion batteries from impedance spectroscopy using machine learning

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Research question

How can Electrochemical Impedance Spectroscopy (EIS) be used to predict the state-of-health of lithium-ion batteries using Gaussian Process Regression?

Motivation

- A growing number of used lithium-ion batteries presents an opportunity for second-life use
- Electrochemical Impedance Spectroscopy is portable, rapid, and non-invasive
- Derived features capture important physical insights without direct capacity data
- This project explores whether EIS data can be used to predict battery health using machine learning

Methodology

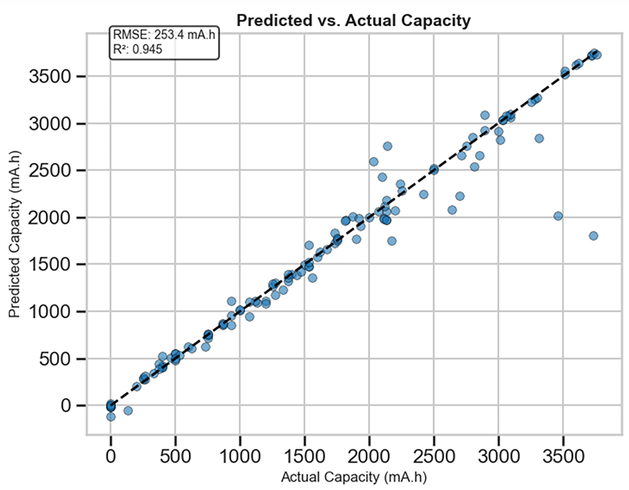
- Gathered EIS data from various battery datasets spanning different charging rates and temperatures
- Stratified the sample to ensure a balanced representation across capacity ranges
- Extracted features including impedance magnitude, resistance, phase angle, and real/imaginary impedance components
- Identified most important features using Gaussian Process with Automatic Relevance Determination
- Used gaussian process regressor with different kernels
- Evaluated model across multiple battery datasets and discovered variations in feature importance between datasets

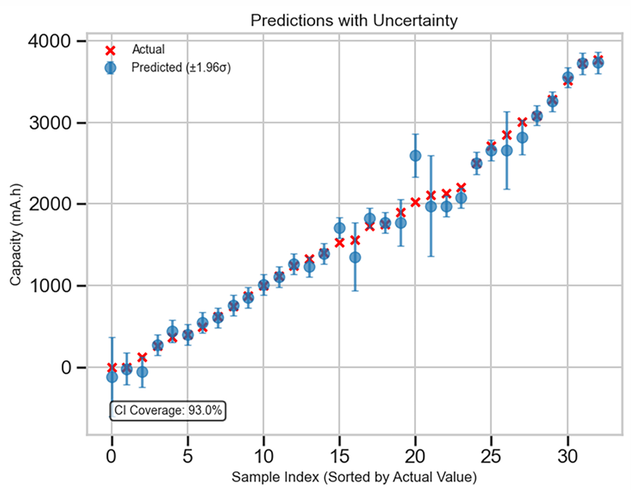
Findings and progress

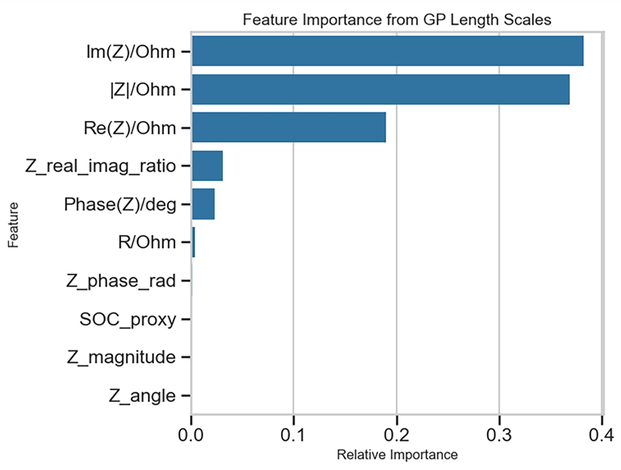
- Achieved an R^2 of 0.945 and RMSE of 253.4 mA*h
- Confidence intervals matched actual values in 93% of cases
- Impedance derived features were shown to be the dominant predictor
- A combination of kernels including RBF, matern, and whitekernel worked best

Future work

- Testing alternative kernel configurations for improved model transferability
- Investigate physical meaning of feature importance variations across datasets
- Apply model to real-time battery management systems







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