Precise State of Health Estimation

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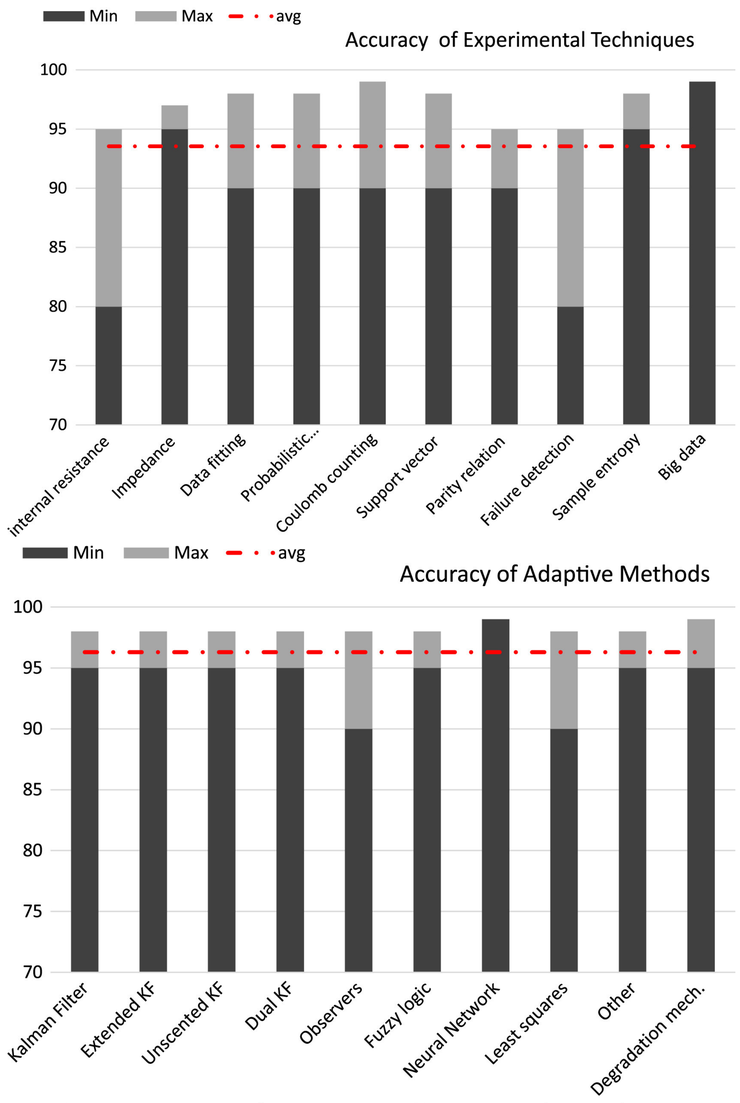
INTRODUCTION

Batteries offer a solution to the increasing demand for robust, long-term energy storage resulting from the ongoing global electrification.

- Constant discharging and charging (cycling) of a battery while in use will degrade the battery over time.
- This degradation can be quantified using the State of Health (SoH) of the battery.
- Proper tracking of the SoH is needed so that the battery can be replaced before "sudden death" occurs.



Accuracy of current SoH estimation methods[1].

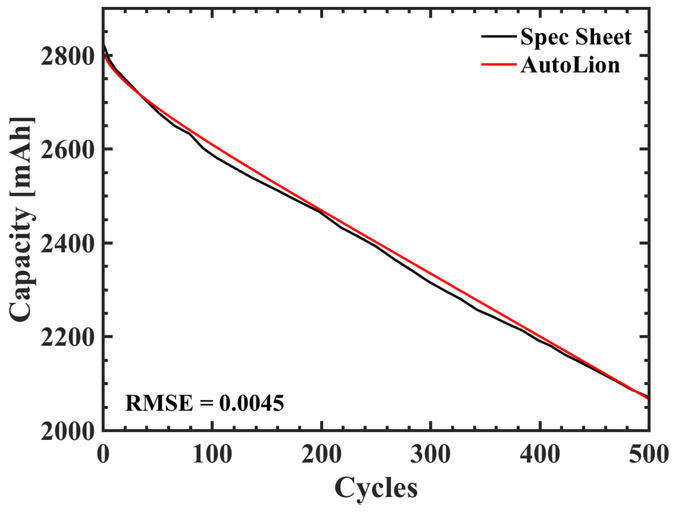
Experimental Methods:

- Computationally inexpensive
- Fit to the data set after testing

Adaptive Methods:

- Computationally expensive
- Constantly updates tuning parameters to provide accurate fit

METHODS



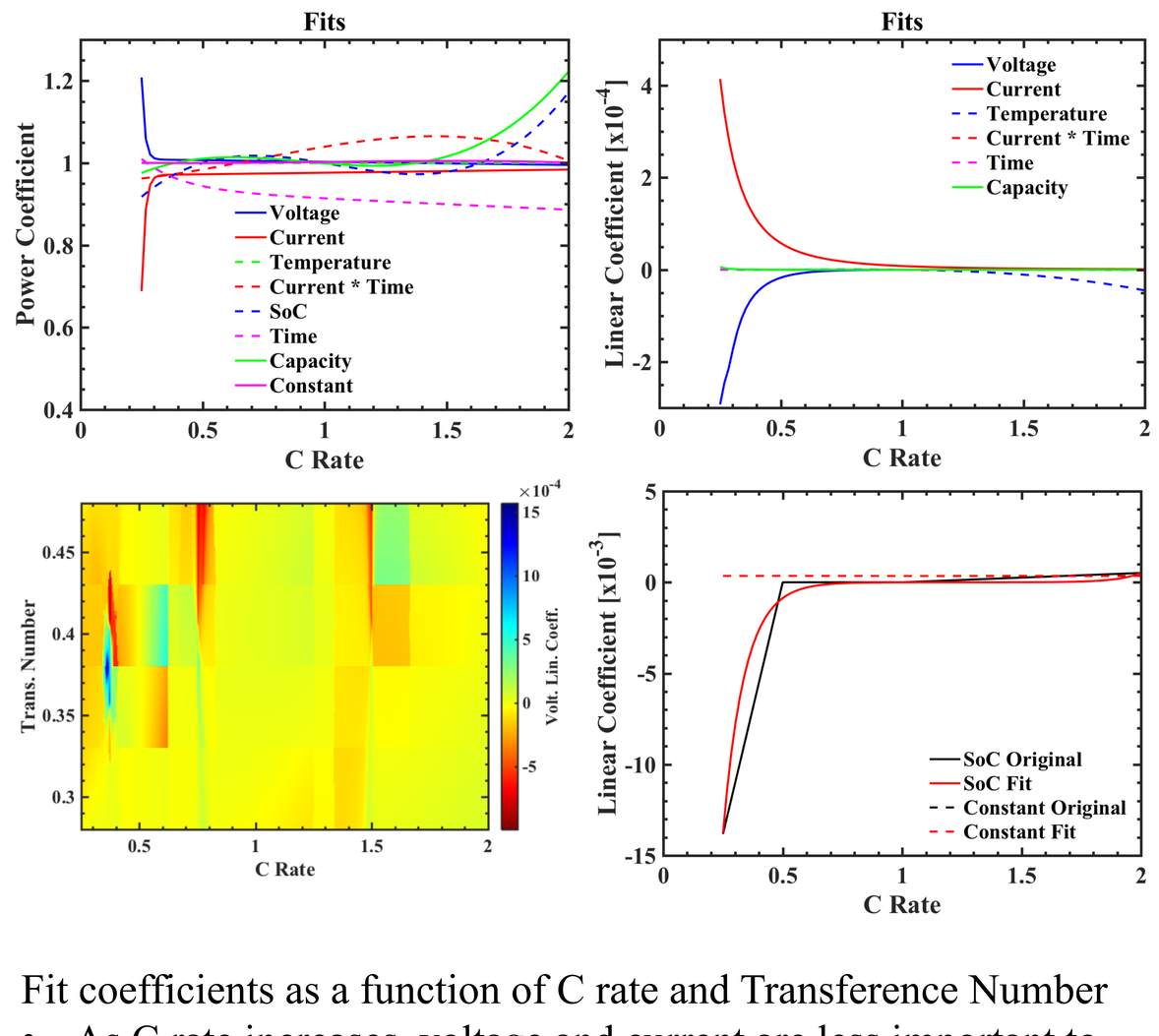
Use AutoLion ST[2] to simulate a Panasonic NCR18650F[3].

- Analyze at CC discharge and charge at .25C, .5C, C and 2C
- Vary Transference Number to .3 and SEI resistance to .00063.

$$[A_1 \quad \dots \quad A_n]\begin{bmatrix}(x_1(t_1))^a & \dots & (x_1(t_m))^a \\ \vdots & \ddots & \vdots \\ (x_n(t_1))^n & \dots & (x_n(t_m))^n\end{bmatrix} = [SOH(t_1) \quad \dots \quad SOH(t_m)]$$

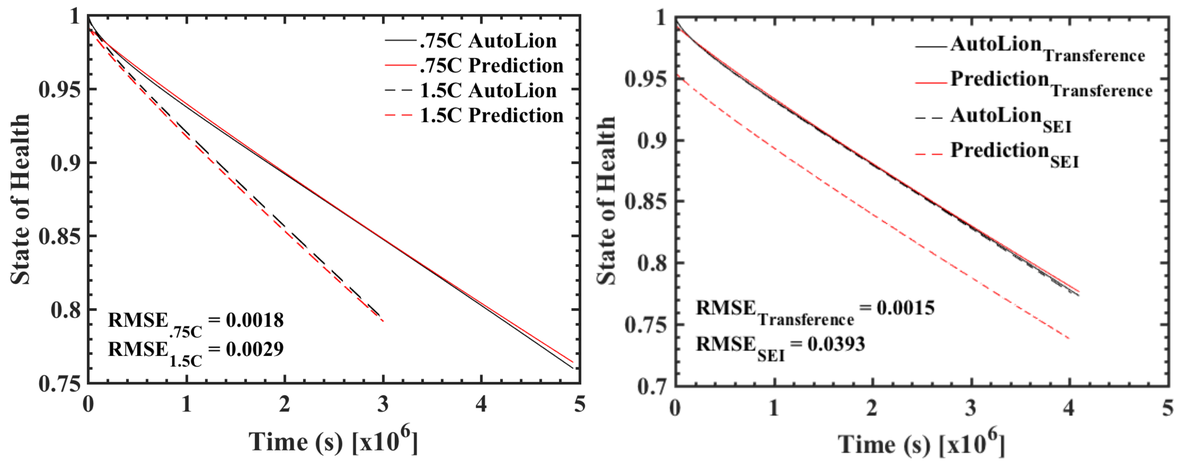
- A's – Linearly fit parameters using Least Squares Regression
- a … n – Exponents fit using non-linear Least Squares Regression
- x's – Voltage, Current, SoC, Temperature, Capacity, Time, Current * Time, and a Constant

RESULTS



Fit coefficients as a function of C rate and Transference Number

- As C rate increases, voltage and current are less important to the fit while capacity, current * time and time become more important to the fit



AutoLion SoH curves and prediction algorithm SoH curves for the specified C rates and for the given SEI resistance and Transference Number variation.

- Parameters determined using fit equations above
- Capable of accurately adapting to predict SoH

CONCLUSIONS

- Created a method that uses the computational simplicity of experimental methods but maintains adaptability and accuracy.
- Algorithm produces a function which can be computed at any time and can do so in a fraction of a second.
- Algorithm can be used for any chemistry provided enough base cases to fit against.

REFERENCES

1. Berecibar, M. et al., *Renewable and Sustainable Energy Reviews,* 56, 572-587 (2016).
2. Kalupson, J.; Luo, G.; Shaffer, C. E. AutoLion™, *SAE Tech. Pap. Ser.* 2013, DOI: 10.4271/2013-01-1522
3. Panasonic, "Lithium Ion NCR18650F," data sheet, 2012 [Version 13.11 R1]

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