Improved Battery State of Charge Estimation Method

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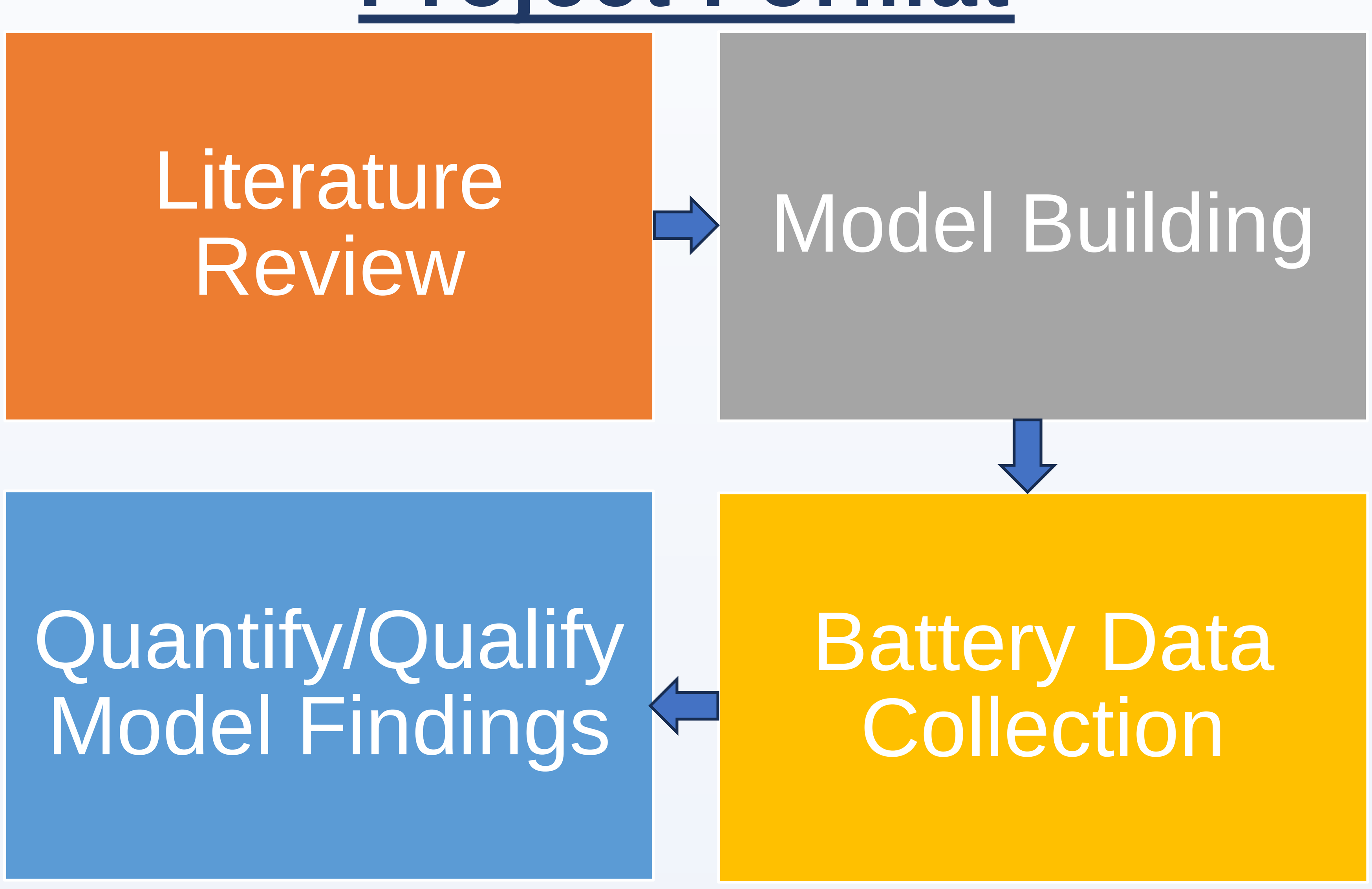
Introduction

There is a well recognized need for accurate State of Charge (SOC) estimation since battery powered devices such as EV's are being pushed in the public market. Accurate SOC estimation can be difficult to achieve for some battery chemistries, especially those involving phase transitions such as the lithium iron phosphate (LFP) chemistry. Literature shows that SOC estimation accuracy for LFP cells can be enhanced by either using higher-fidelity models for feedback estimation or by measuring additional signals such as back pressure/volume, or both. This summer I've explored a different and complementary strategy where a series-connected battery string contains cells of multiple chemistries. The idea is that such pack hybridization increases the sensitivity of overall open-circuit potential (OCV) with respect to SOC, thereby improving estimation accuracy.

Project Format



Basic SOC Literature

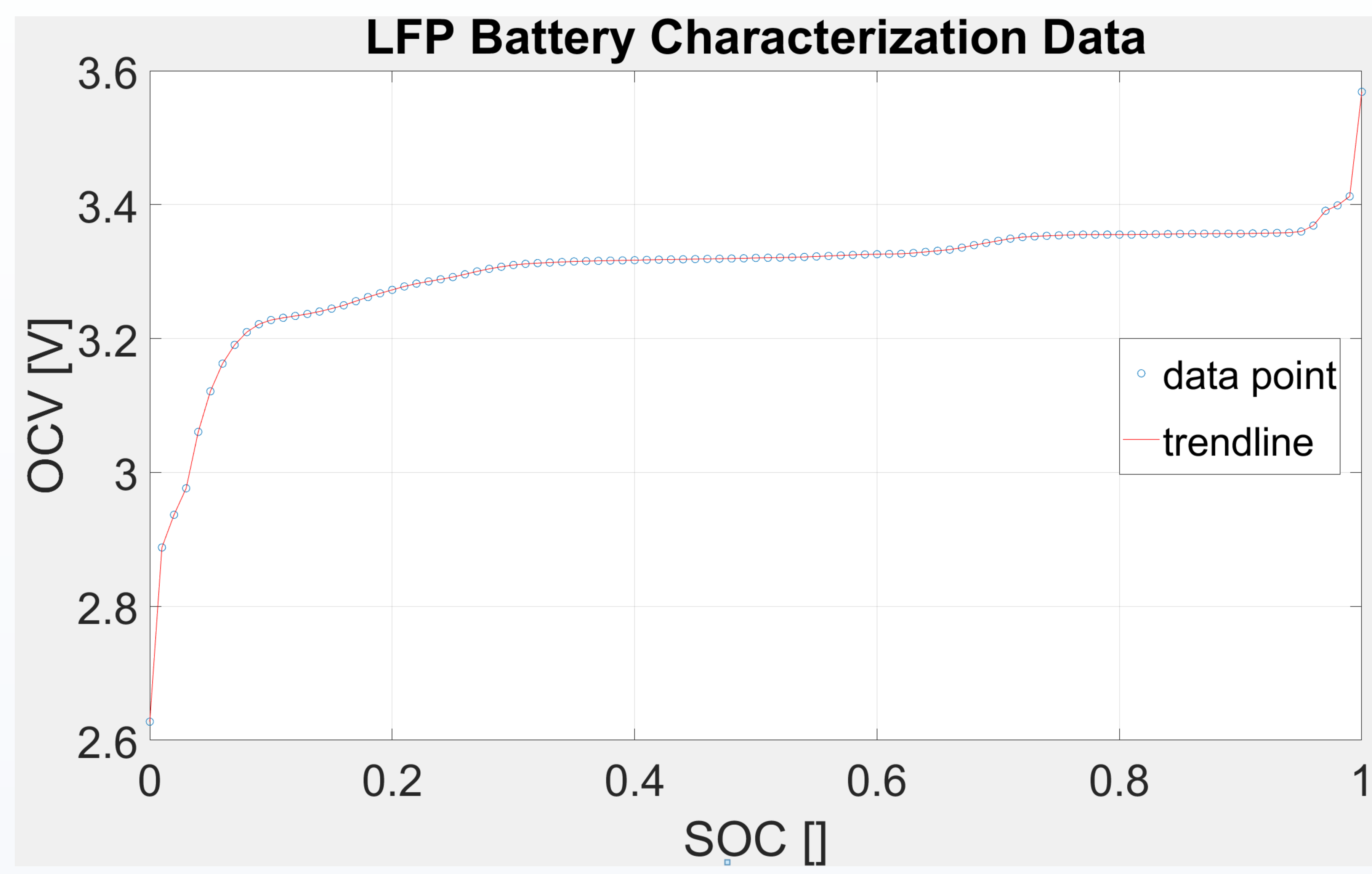
SOC is the percentage of remaining capacity in a battery that is at its maximum available capacity. It can be estimated using several different methods. Some common methods include the Ampere-Hour Integral, Model-Based, Data-driven, and Look-Up Table methods. It is common to combine several methods to provide a control system to the interface that can estimate the SOC as accurately as possible.

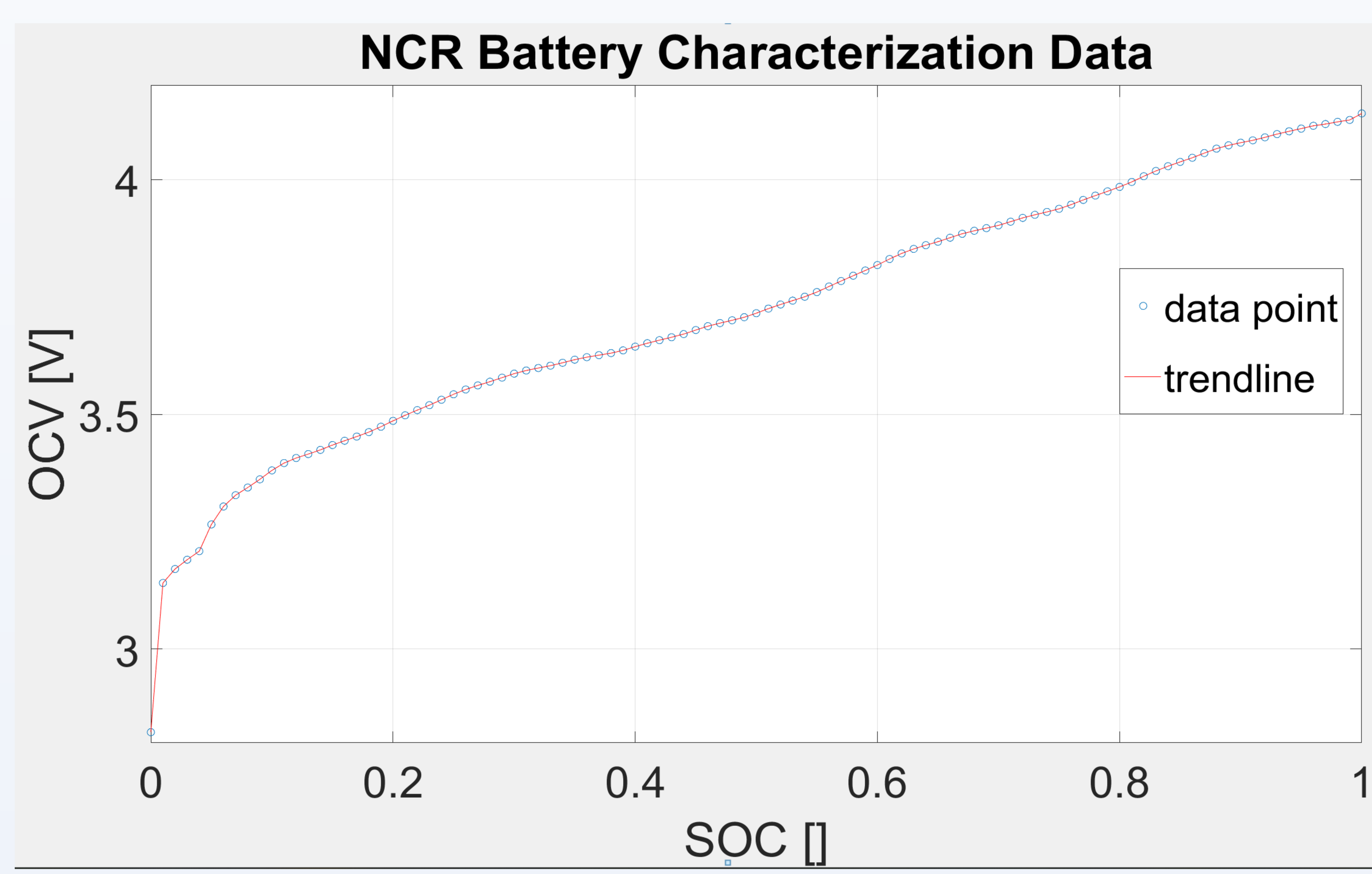
References/Affiliation

1. R. Xiong, J. Cao, Q. Yu, H. He and F. Sun, "Critical Review on the Battery State of Charge Estimation Methods for Electric Vehicles," in *IEEE Access*, vol. 6, pp. 1832-1843, 2018, doi: 10.1109/ACCESS.2017.2780258.
2. Docimo, D, Ghanaatpishe, M, & Fathy, HK. "Development and Experimental Parameterization of a Physics-Based Second-Order Lithium-Ion Battery Model. San Antonio, Texas, USA. October 22–24, 2014. V001T19A003. ASME. https://doi.org/10.1115/DSCC2014-6270
3. Cycling Data: Casey Casten Mechanical Engineering Student at University of Maryland - College Park
4. REU Summer Advisor: Hosam Fathy Mechanical Engineering Maryland Energy Innovation Institute
5. National Science Foundation
6. UMD Department of Material Science and Engineering
7. Maryland Energy Innovation Institute

Preliminary Work/Results

Cycling data from another UMD student was loaded into a simple first order battery model created in MATLAB. Inputs of current, time, and voltage were used to estimate the batteries internal resistance, raw OCV values, charge capacity, and SOC. From this linear regression was used to create a fitted curved for battery characterization. Displayed are plots of the characterizations for LFP and NCR cells.





Conclusion/Reflection

Delays and a very long literature review meant I was only able to get to the beginning of simulations and modeling. 18650 batteries were purchased, but there was not enough time to cycle them and include any data here. However, the plots above were produced from simple models I created allowing me to verify the theory and hypothesis in the introduction. Further time on this project would allow for new cycling data, Fisher information to verify this new methods impact on overall accuracy, and more validation through Monte Carlo simulation.