Machine learning based models for lithium ion batteries

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Motivation

- Our project aims to address whether ML can be used to model battery voltage
- We hope ML may offer an alternative to equivalent circuit and physics models

Methodology

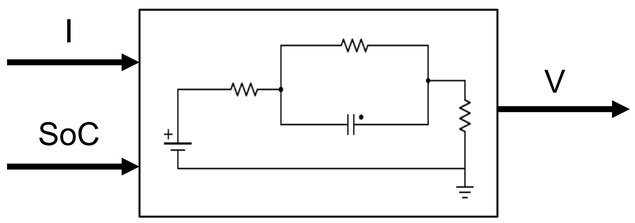

Fig 1. Circuit model architecture

Fig 2. ML model architecture

- *nn_relu* and *nn_tanh* are 3 layer NNs with the architecture above and relu / tanh activations
- *lstm* is a 2 layer NN with 20 recurrent neurons using tanh activations and sigmoid connections followed by 1 neuron FC linear layer

Data

Data were acquired from six NCR18650B cells at these temperatures and cycles

- *Temperature:* 5°C, 25°C, 35°C
- *Cycle:* Const. Curr., HPPC, US06, UDDS

Two runs were looked at using different validation sets, intending to address different questions:

Validation set 1: held out random drive cycles
Can the model generalize to data like training set?

Validation set 2: held out all US06 drive cycles
Is the learning applicable to new usage data?

Results

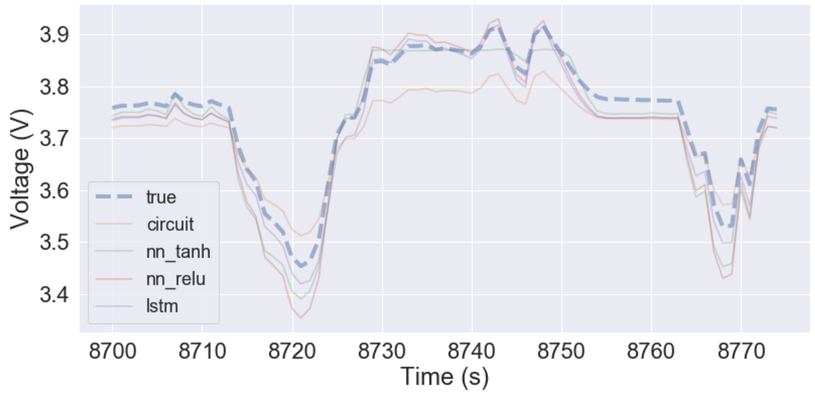

Fig 3. ML generalizes for battery voltage prediction
(Validation set 1)

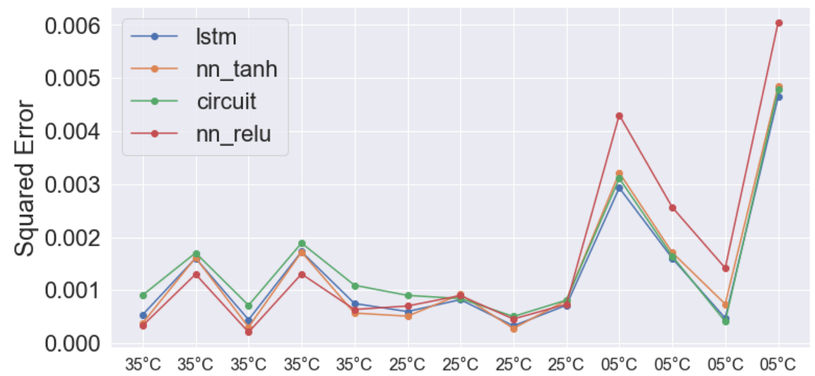

Fig 4. Predictions generalize to new drive cycles, and error and temperature appear related
(Validation set 2)

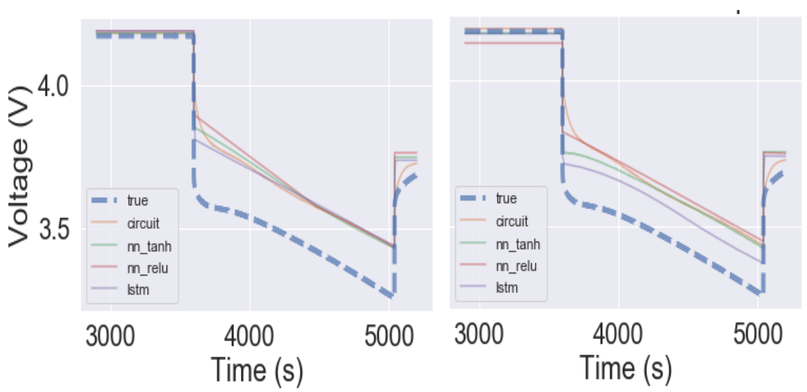

Fig 5. Including temperature allows more complex fits, fit without temperature as input on left and with on right
(Validation set 2)

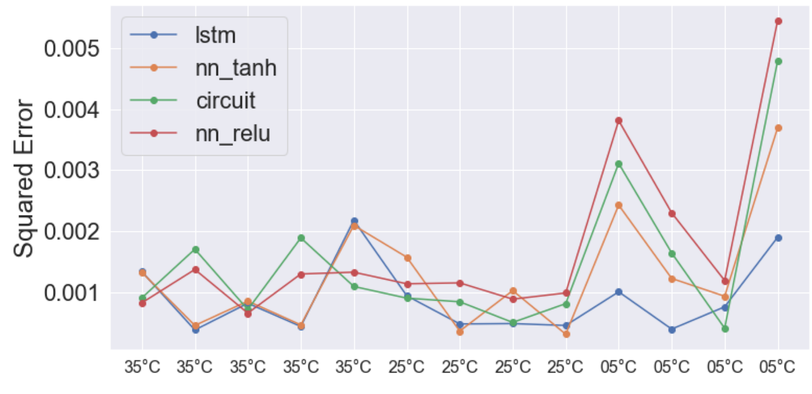

Fig 6. ML with temperature gives more robust prediction
(Validation set 2)

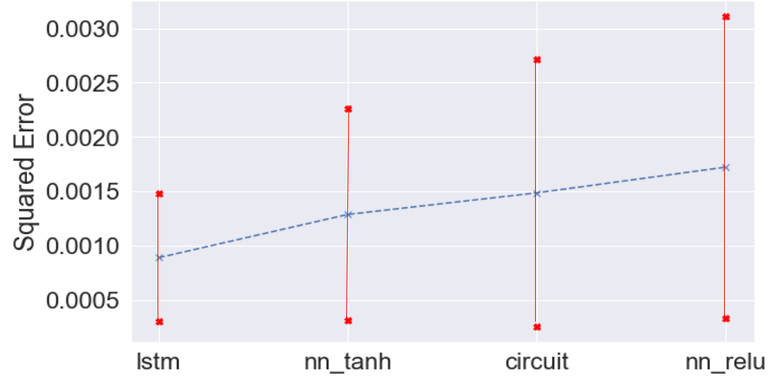

Fig 7. Average model performance on validation set with standard deviations
(Validation set 2)

Conclusions

- ML models work, generalizing well to battery voltage prediction (measured by squared error)
- ML models show promise generalizing to previously unseen drive cycles, especially after incorporating temperature

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