

Remaining useful life estimation with electrochemical physics-informed neural networks

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Background

Predicting battery degradation trajectories to estimate remaining useful Life (RUL) is an important practice in regards to safety, battery operation and cost. RUL is a monotonic decreasing function of a battery's decreasing State of Health (SoH), and depends on a multitude of degradation modes related to battery operation, external influences, battery chemistry and individual cell-, pack and module variations. Data-driven and physics/modelling-based methods are popular in RUL prediction, with hybrid methods gaining popularity in recent years. Physics-based neural networks (PINNs) have emerged as a promising, accurate and flexible method for RUL estimation when physical details or battery models exist, with several potential advantages over for instance convolutional- or transformer models.

Results

We have implemented a PINN for predicting RUL based on anodic solid-electrolyte interface (SEI) growth. The physics is represented by an electrochemical Butler-Volmer model for computing the SEI current, which is used to regularize the neural network. The PINN was initially trained on lab cycling data, and the parameters transferred to a long short-term memory (LSTM) model for predicting the degradation trajectory and subsequently the RUL based on SoH time series data. The work has been performed as part of the EU HORIZON Project BatMax.

Conclusions

Our results demonstrate several aspects of what makes PINN battery modelling attractive, including parameter discovery, good results with noisy data and few datapoints, and ease of implementation, running and training. Future work would include improving PINN accuracy and performance through fine-tuning, or extend the electrochemical model.