Centre for Systems Informatics Engineering

CSIE

CityU 香港城市大學 City University of Hong Kong

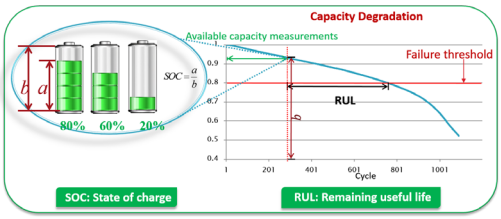
Prognostics and Health Management of Lithium-ion Batteries

Objectives

Lithium-ion batteries have been used extensively as a main energy source for electronics (e.g., cameras, laptops, and cellular phones) and electric transportation (e.g., electric vehicles and hybrid electric vehicles). Nevertheless, as with most battery systems, lithium-ion batteries suffer from capacity and power fade issues during the repeated charge-discharge process. As the performance of batteries deteriorates, battery-related breakdowns become more frequent, which becomes a disturbing nuisance. To guarantee safe and reliable battery operation, a battery prognostics and health management system is required to monitor and control lithium-ion batteries to provide good battery performance. In this system, we shall:

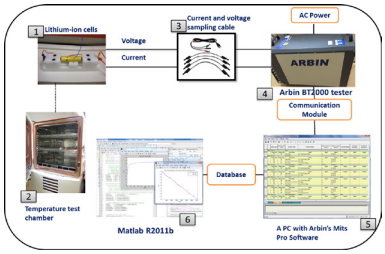
- Develop a sophisticated system that provides accurate estimation for SOC of rechargeable battery, particularly in dynamic ambient environment;
- Develop degradation models and estimation methods for effective RUL prediction of rechargeable battery;
- Evaluate and test the proposed methods using both experimental and filed data, and compare its performance with the state of art.

Battery Performance Indicators

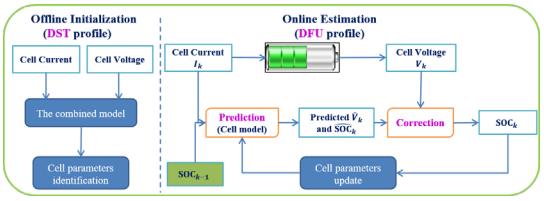


Battery Applications

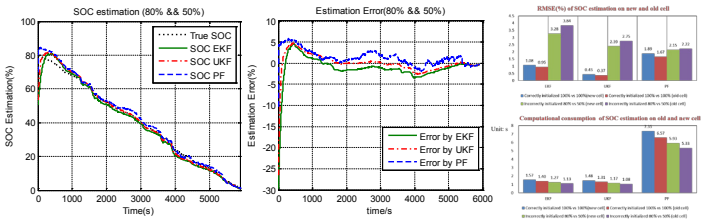
Battery Test Bench



SOC Estimation



Block Diagram

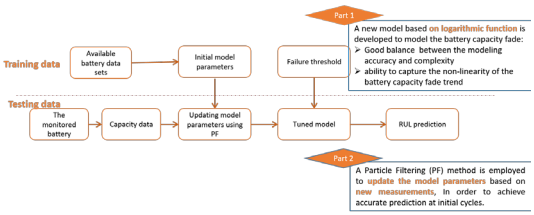


Contributions:

-Three different model-based filtering algorithms for SOC estimation are compared.
- A combined dynamic loading profile is proposed to evaluate the three algorithms.
- Robustness against uncertainty of initial states are investigated.

RUL Prediction

Framework:

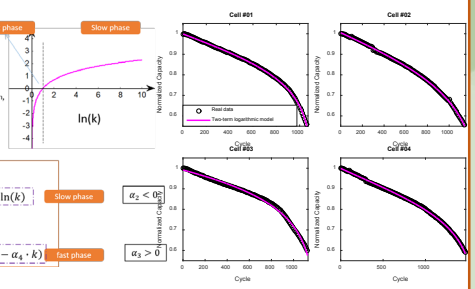


Modelling:

- Expression:

$$C = \alpha_1 + \alpha_2 \cdot \ln(k) + \alpha_3 \cdot \ln(1 - \alpha_4 \cdot k)$$

- Mechanism:
  - α_4 maps the fast degradation in battery into the fast phase in log function, and $0 < \alpha_4 \ll 1$.
  - α_2, α_3 are the scaling factors, varies between different cells.
  - α_1 relates to the initial capacity



When $k \ll k_0$,

$$\ln(1 - \alpha_4 \cdot k) \approx \ln(1) \approx 0 \qquad C \approx \alpha_1 + \alpha_2 \cdot \ln(k)$$ Slow phase $\alpha_2 < 0$

When $k \geq k_0$,

$$\frac{d\ln(k)}{dk} \approx 0 \qquad C \approx \alpha_1 + \alpha_2 \cdot \ln(k_0) + \alpha_3 \cdot \ln(1 - \alpha_4 \cdot k)$$ fast phase $\alpha_3 > 0$

Predicting: