Imperial College London

Generalised diagnostic framework for rapid battery degradation quantification with deep learning

Haijun Ruan, Jingyi Chen, Weilong Ai and Billy Wu*

Dyson School of Design Engineering, Imperial College London, London, SW7 2AZ, United Kingdom

Key scientific questions

- How to use deep learning to gain insight into battery degradation?
- How to rapidly quantify degradation mechanisms of batteries?
- What is a generalized battery diagnostic method?

Key results

- A generalised and rapid diagnostic approach with almost all the aging paths presented
- Deep learning shed insight into battery degradation mechanisms in 0.012 s, enabling the analysis of big datasets
- Lower training cost/time via synthetically generated aging datasets
- Validated with three leading battery chemistries aged under different conditions
- Online real-world application potential highlighted with partial (dis)charge data

Real-world applications

❑ The generalised diagnostic framework works with:

- Partial (dis)charge data
- Relatively high current (0.3C discharge/0.1C charge)

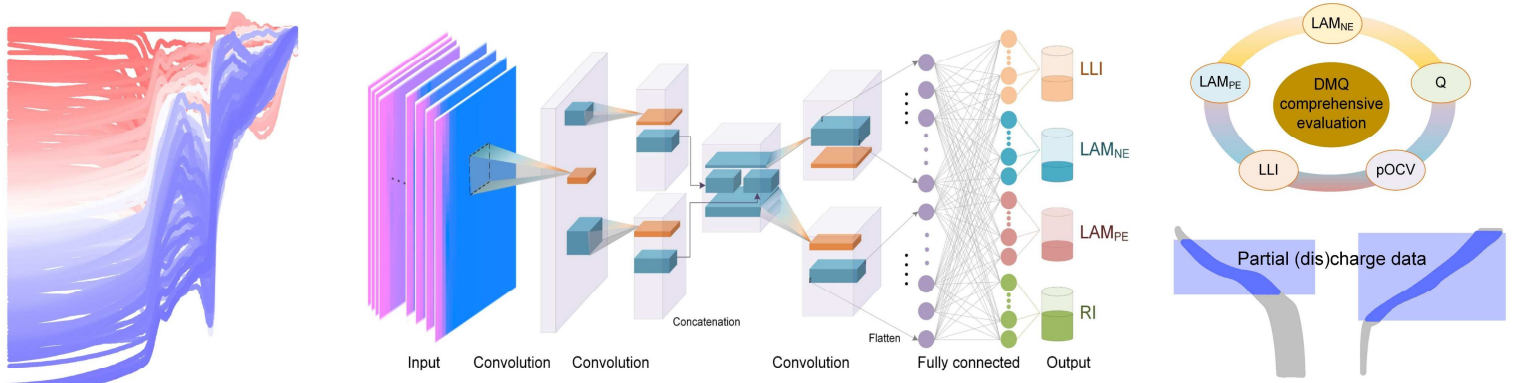
Contact: Haijun Ruan, h.ruan@imperial.ac.uk

Imperial College Electrochemical Science and Engineering (ESE) Group, https://www.imperial.ac.uk/electrochem-sci-eng/

Synthetic ΔQ (OCV) datasets

Generalised deep learning diagnostic framework

Real-world applications

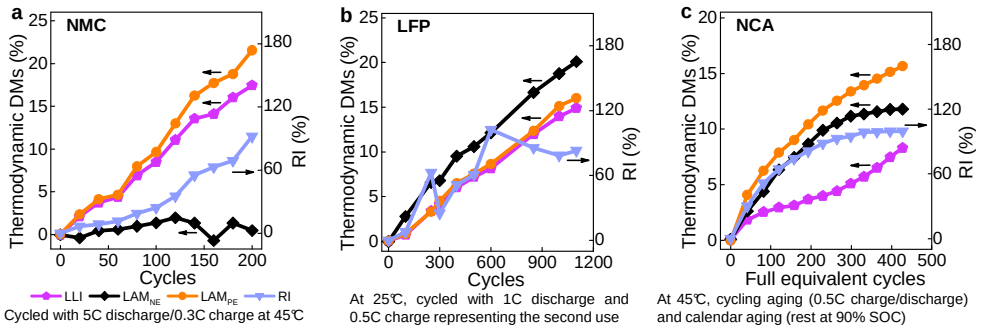


Cover almost all aging paths → Offline training → Convolutional neural network for degradation mode quantification → Rapid Diagnostic → Experimental data of aged batteries

Deep learning diagnostic framework

❑ The diagnostic time for each OCV measurement of every battery is < 0.012 s

❑ Demonstrated on multiple battery chemistry



Cycled with 5C discharge/0.3C charge at 45℃

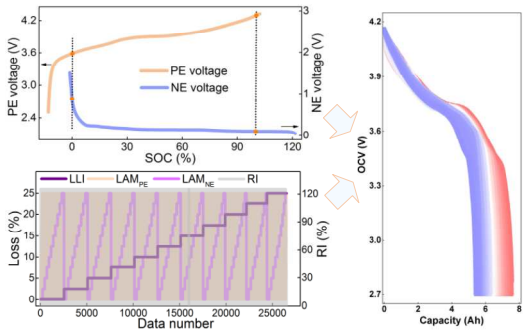
At 25℃, cycled with 1C discharge and 0.5C charge representing the second use

At 45℃, cycling aging (0.5C charge/discharge) and calendar aging (rest at 90% SOC)

Generalised feature

❑ Almost all aging paths covered in the trained CNN

❑ Suitable for any battery chemistry



CNN: Convolutional neural network;OCV: Open circuit voltage; DM: Degradation mode; LLI: Loss of lithium inventory; LAM_{NE}: LAM in negative electrode; LAM_{PE}: LAM in positive electrode; RI: Resistance increase; LAM: Loss of active material; NMC: $LiNi_xMn_yCo_{1-x-y}O_2$/Graphite; LFP: $LiFePO_4$/Graphite; NCA: $LiNi_xCo_yAl_{1-x-y}O_2$ /Graphite

Haijun Ruan, Jingyi Chen, Weilong Ai, Billy Wu. Generalised diagnostic framework for rapid battery degradation quantification with deep learning[J]. Energy and AI, 2022, 9: 100158.

EPSRC THE FARADAY INSTITUTION Innovate UK