Master Thesis Proposal:

On Remaining Useful Life Prediction of Lithium-Ion Batteries

Thesis Background

Energy storage system (ESS) based on lithium-ion batteries is one of the most important but expensive and safety-critical components in the electrified powertrain. These batteries have complex nonlinear dynamics and need a battery management system (BMS) with advanced estimation and control algorithms to ensure their optimal performance and long lifetime. In this regard, the systems and control community have shown a lot of research interest in recent years. The overall goal is to develop a knowledgebase to design battery health-conscious BMS for optimal utilization of currently available cells to guarantee their long lifetime. . One of the core BMS function is to estimate battery internal state (state-of-charge [SOC], dynamic polarization, state-of-health [SoH] etc.) and parameters (impedance, capacity etc.) using voltage, current, and temperature measurements. These estimates are used to provide critical predictions about maximum available battery energy and power (so-called state-of-energy [SoE] and state-of-power [SoP]) during driving or charging. These predictions are then used to decide maximum battery load to guarantee optimal, reliable, and safe operation.

Description of Thesis Work

To enable higher uptime, predictive maintenance, better warranty tracking, and lean inventory management, the prognosis of battery's health [so-called Remaining Useful Life (RUL) prediction] is a highly desired feature of the next generation BMS. The RUL function predicts expected lifetime (i.e., expected number of cycles, electric range, or energy throughput before end-of-life) of battery along with the uncertainty bound for a given application. The main design challenge arise due to intertwined effects of battery operating conditions and ageing process. In particular, the abrupt nonlinear ageing of batteries in later part of their lifetime makes RUL prediction a daunting task. This thesis deals with the design of RUL function using hybrid modelling approach i.e., data-driven and physics-based (or semi-empirical) models. The main tasks are the following:

1. **Propose a functional architecture** that uses on-board SoH estimates, battery usage patterns, and predictive ageing models for RUL predictions
2. **Develop adaptive estimation algorithm** for online tuning of predictive ageing model. In this regard, the use of machine learning and statistical modelling methods may also be promising for early detection of ageing patterns and prediction of RUL using fleet level battery diagnostic data.
3. **Analyze and verify** the performance of the proposed scheme thoroughly using lifetime ageing data for couple of lithium-ion chemistries under different load cycles and operating conditions.

Thesis Title: On Remaining-Useful-Life Prediction of Lithium-Ion Batteries

Thesis Level: Master

Language: English

Starting date: March/April 2020

Number of students: 2

Qualifications and Required Documents

- Must have strong educational background in electrical engineering, mechatronics, computer science, or engineering physics with very good grades in master level courses related to nonlinear filtering/estimation, machine learning, data science, linear control systems etc.
- Must have high proficiency in Matlab, Simulink, and Python.
- You must be self-motivated and meticulous in your problem solving approach.
- Familiarity with electro-thermal and ageing dynamics of lithium-ion batteries will be considered meritorious

Please send your application including **CV**, **Cover Letter**, and **Transcript of grades**.

Contact [Supervisor]:

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