MSc Thesis: Machine Learning for Health Prognostics of 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 knowledge-base to design adaptive-predictive BMS (i.e., battery health-conscious and application-aware control system) 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 health parameters (state-of-resistance [SoR], State-of-Capacity [SoQ] 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/adapt maximum battery load and operational windows to guarantee optimal, reliable, and safe operation.

Description of Thesis Work
To enable adaptive-predictive control functionality, higher uptime, predictive maintenance, better warranty tracking, and lean inventory management, the online 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 some uncertainty bounds for a given application. The main design challenge arises 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 prediction function using hybrid modelling approach i.e., data-driven and physics-based (or semi-empirical) models. The main tasks are the following:

- Propose a functional architecture that uses on-board SoH estimates, battery usage patterns, operating conditions, and predictive ageing models for RUL predictions
- 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 individual vehicle or fleet level battery diagnostic data
- Analyze and verify the performance of the proposed scheme thoroughly using lifetime ageing data for lithium-ion batteries under different load cycles and operating conditions

Thesis Title: On Remaining-Useful-Life Prediction of Lithium-Ion Batteries for Adaptive-Predictive BMS

Language: English
Starting date: 2021-01-18
Number of students: 2 [please see a remark below]
Qualifications and Required Documents

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

Please send your application including CV, Cover Letter, and Transcript of grades. Application will not be considered without a complete set of the required documents.

Link to application:
https://xjobs.brassring.com/TGnewUI/Search/home/HomeWithPreLoad?partnerid=25079&siteid=5171&PageType=JobDetails&jobid=707658

Remark: We would prefer if you apply as a group of two students to collaborate and work together on this thesis topic. If this is the case then please submit your applications individually with all the required documents but do write you partner name in your cover letter so that we can evaluate you as a group.

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