Lehrstuhl Steuerung, Regelung und Systemdynamik

Bachelor Thesis

Practical, Programming, Theory

Lithium-ion Battery lifetime prognosis

Keywords: Python, Battery, Prognosis

Conditions:

Duration:	3 months
Requirements:	Programming skills in Python
Language:	English
Target group:	Bachelor students

Contents:

Lithium-ion batteries (LIBs) are used in many applications for storing and providing energy such as electric vehicles, consumer electronics, and electrical grids. The usage of LIBs has gained interest over the years in these applications due to its long cycle lifetime, high energy density, and light weight. However, constant usage of the batteries causes material aging and capacity fade over time, leading to battery degradation and ultimately the end of life of a battery. Thus, this would cause the malfunction of an electrical system (thermal runway, explosion, etc.). The degradation of battery is a complex electrochemical process which includes many electrochemical side reactions, such as solid electrolyte interphase, electrolyte oxidation, salt decomposition, particle fracture, and active material dissolution. Further research shows that different stress factors contribute to the degradation, such as temperature of the battery, ambient temperature, current, cycling depth etc.

Thus, the understanding of the battery's aging mechanism is important for performance as well as safety reliability of a system. The prognostic of the battery stipulates its health by predicting the remaining useful lifetime (RUL) and the end of life (EoL) of the battery. This is needed to reduce the risks of a sudden failure in a system by providing fault diagnosis (scheduling maintaining at the appropriate time). It also aims to avoid unnecessary costs by only scheduling maintenance when needed. RUL predictions assess the extent of degradation from its expected state of health in its expected usage conditions. Hence, lifetime models based on different prognostic models can be utilized to predict the RUL and EoL.

Prognostic models are based on three categories: model-based, data-driven, or hybrid-based models. Prior to developing these models, an integral part is to analyze the different stages of aging as well as how different varying stress factors affect the aging process (capacity fade). Prognostics is performed using State Estimators and Predictors. State Estimators are responsible for estimating the current state of the modeled system using sensor data and a prognostics model. The state estimator then produces an estimate of the system state with uncertainty in the form of an uncertain data object. This state estimate is used by the predictor to predict when events will occur (EoL of the battery) as well as RUL of the battery.

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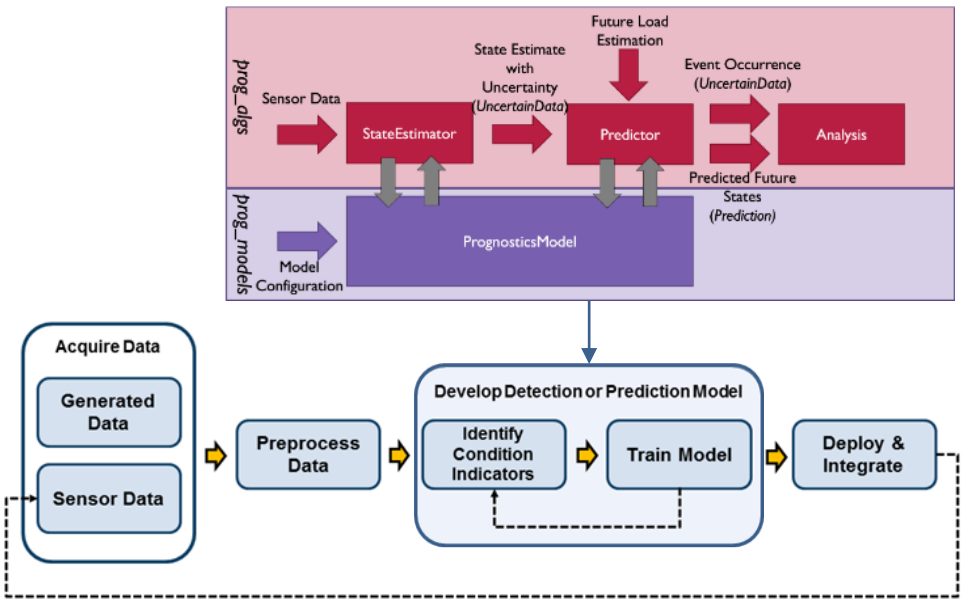
The NASA Prognostics Python Packages (ProgPy) are providing a framework that focuses on developing models for prognostics and health management (such as the state estimation and prediction of RUL). Three packages are included in this framework, the prog_models, prog_algs, and prog_server. Thus, the aim of this work is to use existing LIBs data from the NASA Ames Prognostic Centre of Excellence (PcoE) in combination with the packages for state estimations and RUL predictions.



Thus, the goals of this work are:

- Review of documentation/literature related to degradation of LIBs (types of LIBs, types of LIBs degradation, modes of degradation, stress factors influencing the degradation)
- Review of documentation/literature related to prognostics of LIBs (state estimations, RUL predictions)
- Implementation of lifetime prediction models (for predictions of RUL and EoL) using ProgPy with the provided datasets
- Analysis of capacity fade to develop the RUL, EOL
- Complete and detailed documentation/presentation of the research results

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