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Battery degradation model for mission assignment in a fleet of electric vehicles

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Battery prognostics and health management has recently become a very important and strategic topic specially with the rise of electric vehicles and electric mobility in general, which is seen as a key tool to reduce the impact of global warming. In order for battery health management to be viable, it is necessary to quantify and understand battery state of health (SOH) and its degradation mechanisms. A lot of research has been developed to understand the different degradation processes in a battery [1], to identify and understand the impacts of stress factors [2], and to quantify tendencies of degradation and predict remaining useful life [3]. In this presentation, an overview on battery degradation modelling and prognostics is given, exploring the definitions of the main stress factors, and covering the most common degradation models in the literature. Particular attention is given to an empirical model based on stress cycle decomposition linking the degradation to the history of charge and discharge cycles, which is flexible and accurate [4]. This model can be used to estimate the SoH variation of the battery based on the way the vehicle is driven. A three-step method is thus proposed to develop a comprehensive model for degradation induced by driving conditions, combining the aforementioned degradation model, with battery and vehicle dynamics models, as well as information on road topography and vehicle parameters. The first step of this overall degradation model consists in using the available information topography, speed limits and crossroads to estimate the electrical power required to carry on a given displacement. In the second step, the required electrical power is used to infer a state of charge (SoC) trajectory. Finally, in the last step, the SoC profile is decomposed into stress cycles that serve as input for the degradation model. Such a comprehensive SOH evolution model linking route profiles and driving conditions to battery degradation is suitable for decision-making problems related to the optimal management of electric vehicles. The use of this degradation model is illustrated on a use-case of a fleet of electric vehicles that must perform a set of missions: it is shown how the order of those missions can be decided by optimizing not only energy consumption but also battery degradation.

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[4] Xu ,B., Oudalov, A., Ulbig, A., Andersson, G., and Kirschen, D.S. (2018). Modeling of lithium-ion battery degradation for cell life assessment. IEEE Transactions on Smart Grid, 9(2), 1131–1140. doi:10.1109/TSG.2016.2578950

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