Abstract

The Battery State of Charge (SOC) is the parameter representing the fraction of a battery's remaining available energy to its fully charged state. The Battery SOC is one of the most important parameters of an electric vehicle's (EV) Battery Management System (BMS) as it is used for battery pack balancing, estimating available power, battery safety control, and providing users with available runtime. Electric Vehicle mostly uses lithium-ion battery because of its high energy density which comes with a cost of complex non-linear dynamic system. Lithium-ion batteries are susceptible to over-charging and undercharging because of their inherent properties. Their dynamic properties also tend to change with ambient temperature, operating current, SOC, and operating voltage. Hence requires a complex Battery Management System (BMS) to effectively manage the dynamic parameters. SOC is one of the most important intermediate parameters required for effective EV battery management. In addition, the life cycle of lithium-ion batteries is also a function of its operating SOC.

Unfortunately, EV battery SOC cannot be measured directly due to lack of parameter linearly proportional to its available energy. Hence it requires complex estimation algorithms to achieve an accurate SOC estimate. It is often the case that conventional EV SOC management system over-compensates the SOC error estimates at the cost of usable energy. Another common challenge with conventional algorithms is their inability to reconverge quickly from erroneous initialization. Quick convergence and fast SOC estimation algorithm is also required in EV for fast charging.

This research proposes a novel ensemble algorithm that uses a weighted estimate of the Central Difference Kalman Filter (CDKF) and Nonlinear Autoregressive with Exogenous Input (NARX) to estimate SOC. The major contributions of the proposed methods are:

1. To improve the accuracy of SOC estimates in comparison to convention ensemble SOC estimation methods especially at low temperature.
2. Fast convergence estimation technique which converges quickly from large erroneous initialization state, this is particularly useful in super-fast EV charging technology.
3. Provides robust and reliable SOC estimates. The robustness of the proposed method is tested under various drive cycle and temperature extremes. The estimator provides a reliability indicator in the form of a convergence covariance which indicates how close the estimate is to the true value.