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Development of a Data-Driven Method for Diagnosing the State of Health of Battery Cells, Based on the Use of an Electrochemical Aging Model, with a View to Their Use in Second Life

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Abstract : Accurate estimation of the remaining useful life of lithium-ion batteries for electronic devices is crucial. Data-driven methodologies encounter challenges related to data volume and acquisition protocols, particularly in capturing a comprehensive range of aging indicators. To address these limitations, we propose a hybrid approach that integrates an electrochemical model with state-of-the-art data analysis techniques, yielding a comprehensive database. Our methodology involves infusing an aging phenomenon into a Newman model, leading to the creation of an extensive database capturing various aging states based on non-destructive parameters. This database serves as a robust foundation for subsequent analysis. Leveraging advanced data analysis techniques, notably principal component analysis and t-Distributed Stochastic Neighbor Embedding, we extract pivotal information from the data. This information is harnessed to construct a regression function using either random forest or support vector machine algorithms. The resulting predictor demonstrates a 5% error margin in estimating remaining battery life, providing actionable insights for optimizing usage. Furthermore, the database was built from the Newman model calibrated for aging and performance using data from a European project called Teesmat. The model was then initialized numerous times with different aging values, for instance, with varying thicknesses of SEI (Solid Electrolyte Interphase). This comprehensive approach ensures a thorough exploration of battery aging dynamics, enhancing the accuracy and reliability of our predictive model. Of particular importance is our reliance on the database generated through the integration of the electrochemical model. This database serves as a crucial asset in advancing our understanding of aging states. Beyond its capability for precise remaining life predictions, this database-driven approach offers valuable insights for optimizing battery usage and adapting the predictor to various scenarios. This underscores the practical significance of our method in facilitating better decision-making regarding lithium-ion battery management.

Keywords : Li-ion battery, aging, diagnostics, data analysis, prediction, machine learning, electrochemical model, regression
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