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Enhanced State of Charge Estimation for Lithium-Ion Batteries Using xLSTM Networks

Lithium-ion batteries are central to the transition toward a sustainable energy economy, enabling reduced reliance on fossil fuels through their widespread use in electric vehicles and portable devices. Accurate estimation of the battery's state of charge (SOC) is vital not only for operational safety but also for guiding user behaviors that prolong battery lifespan and support reuse. Traditional methods for SOC estimation often rely on Long Short-Term Memory (LSTM) networks due to their capacity to model temporal sequences; however, LSTMs struggle with capturing long-range dependencies inherent in battery discharge and charging cycles. In this study, we evaluate the effectiveness of xLSTM, an enhanced variant of LSTM designed to better handle extended temporal contexts, in improving SOC prediction. We conduct experiments on two publicly available battery datasets that include various usage profiles and degradation states. Our methodology involves training and testing both LSTM and xLSTM models on these datasets, using consistent preprocessing and evaluation metrics to ensure comparability. Results show that xLSTM generally outperforms standard LSTM models in SOC estimation accuracy, particularly in sequences requiring long-term memory retention. These findings demonstrate that xLSTM offers a promising direction for more reliable battery state modeling, with implications for safer, more efficient battery management systems in practical applications.

Keywords
State of Charge Estimation, Lithium-Ion Batteries, xLSTM, Battery Management Systems, Time Series Prediction, Deep Learning

Biography
Florian Krebs is a Senior Researcher at JOANNEUM RESEARCH in Graz, Austria, specializing in machine listening and intelligent acoustic systems. He holds degrees in electrical and sound engineering from TU Graz and the University of Music and Performing Arts Graz. After earning his PhD in automatic music analysis from JKU Linz in 2017, he joined JOANNEUM RESEARCH, where he now leads national projects such as DURAICELL, focusing on acoustic monitoring of battery performance. His work combines artificial intelligence with real-time acoustic sensing to advance environmental and industrial monitoring in complex, dynamic environments.

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