LSTM-Based Temperature Prediction for Lithium-Ion Battery Modules with Liquid Cooling System

Yung-Jen Cheng
Graduate Student, Institute and Undergraduate Program of Vehicle and Energy Engineering, National Taiwan Normal University, Taiwan

Chun-Hsin Chang
Institute and Undergraduate Program of Vehicle and Energy Engineering, National Taiwan Normal University, Taiwan

Abstract:
This study investigates the thermal behavior of lithium-ion battery modules during the discharge process and develops a temperature prediction model by integrating a liquid-cooled thermal management system with a Long Short-Term Memory (LSTM) network. An experimental platform is established to collect time-series data of temperature and current under various discharge rates, providing a reliable dataset for model training and validation. A multi-input, single-output LSTM architecture is adopted, where historical temperature and operating current are used as input features to predict future temperature evolution. The model is trained using the Mean Squared Error (MSE) as the loss function and optimized through backpropagation, achieving stable and consistent convergence in both training and testing phases. The results demonstrate that the proposed model can effectively capture the nonlinear thermal dynamics of the battery system, with predicted temperatures closely matching experimental measurements. The average prediction error is maintained below 3%, and the MSE converges to the order of 10^{-3}, indicating high prediction accuracy and strong generalization capability under varying operating conditions. Furthermore, the developed model supports predictive control strategies for battery thermal management systems by enabling proactive thermal regulation prior to temperature rise, thereby enhancing thermal stability, system efficiency, and overall operational safety.

Keywords:
Battery thermal management system (BTMS), Electric Vehicles, Lithium-ion battery, Long short-term memory (LSTM), Temperature prediction.