
Unlocking Insights in Battery Research with Digital Twin-driven Data Augmentation

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Résumé

The technique of data augmentation through a digital twin has emerged as a promising approach in different sectors, such as the automotive industry, manufacturing, and energy storage. The proposed methodology relies on the creation of a digital twin that is forced to agree with all available experimental data – in our case the observed geometric deformations that occur while cycling a battery cell. In this way, the digital twin provides complementary information on certain quantities of interest, including the pressure and temperature distribution, all the while remaining consistent with the experimental observations. In this study, synthetic images identical - in terms of greyscale - to the real Li-Li solid electrolyte battery cell subjected to cycling were generated for model development and testing. The images corresponding to the initial state of the battery were automatically segmented and used as a basis to construct the digital twin. All physical properties corresponding to the battery components (electrode and electrolyte) and the surrounding environment were taken from the literature. The governing equations are those of thermo-elasticity, as the charging and discharging of a battery is associated with local temperature variations which cause dimensional variations of the cell. Computations were carried out for different heat absorption or release rates, image resolutions and image quality. In all cases an iterative optimization method was applied for computing the unknown heat source that expresses the electrochemical processes during the charging and discharging cycle of the battery cell. The sensitivity studies demonstrated the robustness of the model, including for images with low resolution, together with its limits of application. In addition, the results highlighted the ability to estimate the unknown heat source with a high degree of accuracy, regardless of the resolution. Current work involves applying the method to real datasets, further advancing battery research, and thereby contributing to progress in the field of battery research and imaging.

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