Merging physical domain knowledge with AI improves prediction accuracy of battery capacity

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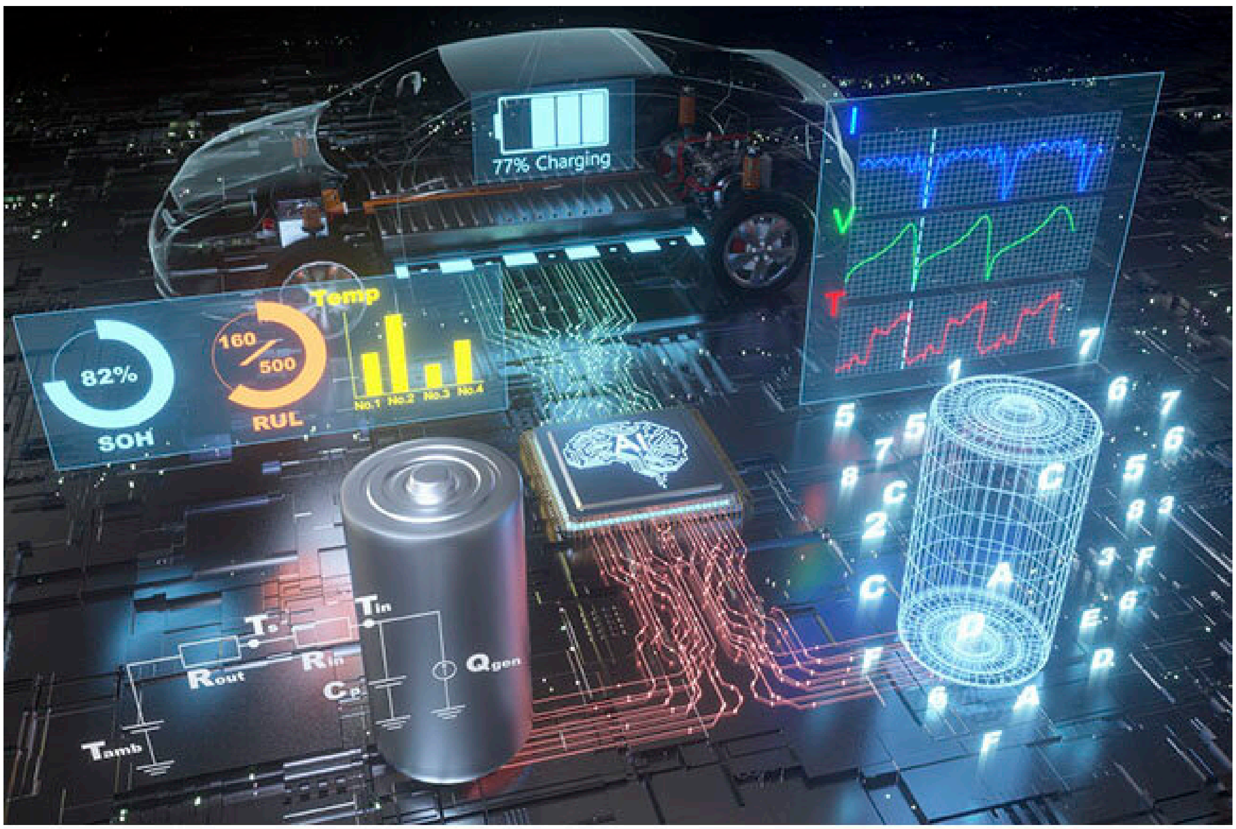

Estimation of battery capacity and remaining useful life through physical domain knowledge-based artificial neural networks.

Credit: POSTECH

Recently, electric vehicles (EVs) are seen everywhere, from passenger cars to buses to taxis. EVs have the advantage of being eco-friendly and having low maintenance costs, but their owners must remain wary of fatal accidents in case the battery runs out or reaches the end of its life. Therefore, precise capacity and lifespan predictions for the lithium-ion batteries—commonly used in EVs—are vital.

A POSTECH research team led by Professor Seungchul Lee, and Ph.D. candidate Sung Wook Kim (Department of Mechanical Engineering) collaborated with Professor Ki-Yong Oh of Hanyang University to develop a novel artificial intelligence (AI) technology that can accurately predict the capacity and lifespan of lithium-ion batteries. This research breakthrough, which considerably improved the prediction accuracy by merging physical domain knowledge with AI, has recently been published in *Applied Energy*, an international academic journal in the energy field.

There are two methods of predicting the battery capacity: a physics-based model, which simplifies the intricate internal structure of batteries, and an AI model, which uses the electrical and mechanical responses of batteries. However, the conventional AI model required large amounts of data for training. In addition, when applied to untrained data, its prediction accuracy was very low, which desperately called for the emergence of a next-generation AI technology.

To effectively predict battery capacity with less training data, the research team combined a feature extraction strategy that differs from conventional methods with physical domain knowledge–based neural networks. As a result, the battery prediction accuracy for testing batteries with various capacities and lifespan distributions improved by up to 20%. Its reliability was ensured by confirming the consistency of the results. These outcomes are anticipated to lay the foundation for applying highly dependable physical domain knowledge–based AI to various industries.

Professor Lee of POSTECH remarked, "The limitations of data-based AI have been overcome using physics knowledge. The difficulty of building big data has also been alleviated thanks to the development of the differentiated feature extraction technique."

Professor Oh of Hanyang University added, "Our research is significant in that it will contribute in propagating EVs to the public by enabling accurate predictions of remaining lifespan of batteries in next-generational EVs."

More information: Sung Wook Kim et al, Novel informed deep learning-based prognostics framework for on-board health monitoring of lithium-ion batteries, *Applied Energy* (2022). DOI: 10.1016/j.apenergy.2022.119011

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