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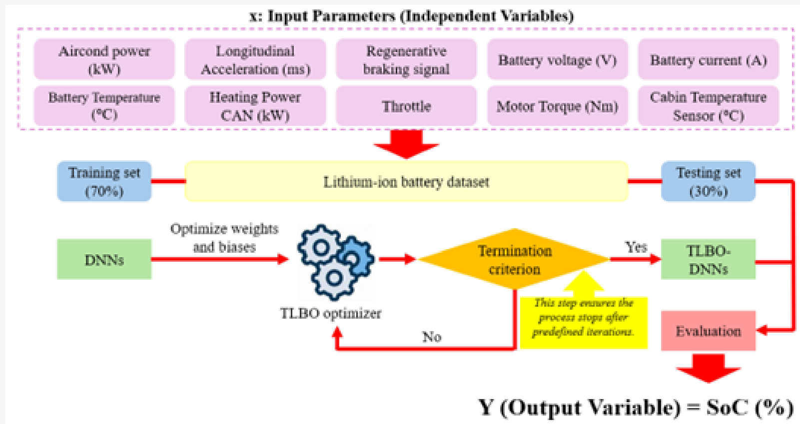
Teaching-learning algorithm boosts accuracy in EV battery monitoring



TLBO-DNNs framework SoC estimation.

GA, UNITED STATES, March 6, 2025 /EINPresswire.com/ -- Accurate estimation of the State of Charge (SoC) in lithium-ion batteries is a pivotal factor for optimizing the performance, safety, and longevity of electric vehicles (EVs). Traditional methods often fail to capture the dynamic, nonlinear nature of battery behavior, resulting in inaccuracies that undermine battery management systems (BMS). A new hybrid model that combines deep neural networks (DNNs) with a teaching-learning based optimization (TLBO) algorithm is set to revolutionize SoC estimation, offering a much-needed solution to enhance the efficiency and reliability of EVs.

As EVs emerge as a sustainable alternative to conventional transportation, the ability to monitor battery health and charge status accurately becomes increasingly important. SoC estimation indicates how much charge remains in a battery, which directly affects EV performance and safety. Traditional methods like Coulomb counting and model-based techniques, while widely used, struggle to account for the complex, nonlinear dynamics of battery systems. These limitations have spurred the development of more advanced SoC estimation techniques to enhance vehicle reliability and optimize energy consumption.

Researchers from Universiti Malaysia Pahang Al-Sultan Abdullah and the Federal University of Kashere have developed a cutting-edge hybrid model to address these challenges. The model combines the power of deep neural networks (DNNs) with the efficiency of the teaching-learning based optimization (TLBO) algorithm to improve SoC estimation in lithium-ion batteries. Published (DOI: 10.1016/j.enss.2025.01.002) in Energy Storage and Saving on February 16, 2025, the study reveals that this TLBO-DNNs hybrid outperforms traditional and other hybrid methods in terms of precision and reliability, offering a game-changing approach for EV battery management systems (BMS).

The TLBO-DNNs model optimizes the weights and biases of DNNs through the TLBO algorithm, effectively capturing the nonlinear relationships present in battery data. Tested on a massive dataset of 1,064,000 samples from BMW i3 EVs, the model achieved a mean absolute error (MAE) of 3.4480 and a root mean square error (RMSE) of 4.6487—significantly outperforming other hybrid models such as barnacle mating optimizer–DNNs (BMO-DNNs), evolutionary mating algorithm-DNNs (EMA-DNNs), and particle swarm optimization–DNNs (PSO-DNNs). Furthermore, it showed superior performance when compared to standalone models like autoregressive integrated moving average (ARIMA) and support vector machine (SVM). With optimal configuration using 21 neurons, this model strikes a perfect balance between computational efficiency and high prediction accuracy, making it ideal for real-world BMS applications.

Dr. Zuriani Mustaffa, the lead author of the study, emphasized the significance of the hybrid model: “Integrating TLBO with DNNs marks a crucial milestone in the evolution of BMS. This novel approach not only refines the accuracy of SoC estimation but also boosts the overall dependability of EVs. It represents a major step forward in the quest for more sustainable transportation solutions.”

The TLBO-DNNs model holds immense promise for the future of EVs. By providing more accurate SoC estimations, it can significantly enhance battery performance, extend battery life, and improve driver safety. As the global electric vehicle market continues to expand, breakthroughs like this will be essential in overcoming one of the most critical challenges in battery management, ultimately fostering more efficient, reliable, and sustainable transportation systems. With the continuous evolution of SoC estimation technologies, the future of EVs looks brighter than ever.

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