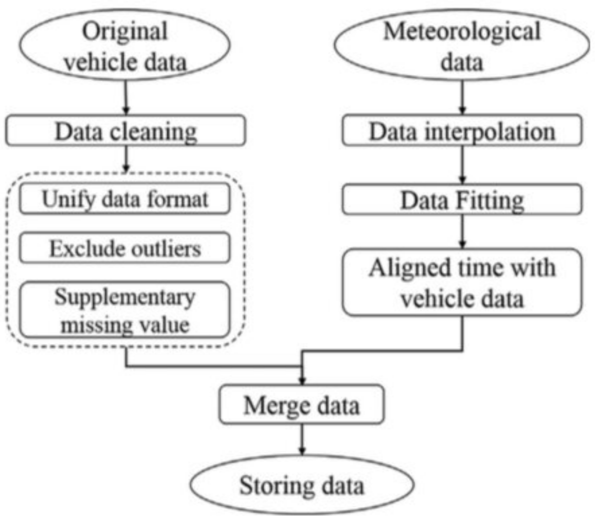
Using deep learning to predict parameters of batteries on electric vehicles

26 August 2019, by Ingrid Fadelli



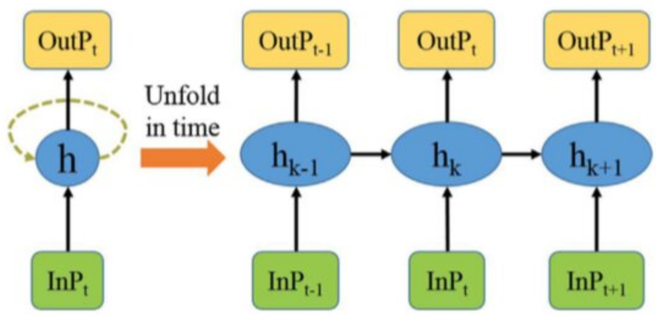
A flow chart of how the technique used by the researchers preprocesses vehicle and meteorological data. Credit: Hong et al.

The batteries used to power electric vehicles have several key characterizing parameters, including voltage, temperature, and state of change (SOC). As battery faults are associated with abnormal fluctuations in these parameters, effectively predicting them is of vital importance to ensure that electric vehicles operate safely and reliably over time.

Researchers at the Beijing Institute of Technology, the Beijing Co-Innovation Center for Electric Vehicles and Wayne State University have recently developed a new deep learning-based technique to synchronously predict multiple parameters of battery systems used for electric vehicles. The method they proposed, presented in a paper published in Elsevier's *Applied Energy* journal, is based on a long short-term memory (LSTM) recurrent neural network; a deep learning architecture that can process both single data points (e.g. images) and entire data sequences (e.g. speech recordings or video footage).

"This paper investigates a new deep-learning enabled method to perform accurate synchronous multi-parameter prediction for battery systems using a long short-term memory (LSTM) recurrent neural network," the researchers wrote in their paper.

The researchers trained and evaluated their LSTM model on a dataset collected by the Service and Management Center for electric vehicles (SMC-EV) in Beijing, which included battery-related data of an electric taxi over the course of one year. Their model considers the three main characterizing parameters for batteries used on electric vehicles, namely voltage, temperature, and SOC. Due to its structure and design, once all of the hyper-parameters considered by the model are pre-optimized, it can also be trained offline.



Architecture of the LSTM-RNN. Credit: Hong et al.

The researchers also developed a technique to carry out weather-vehicle-driver analyses. This technique considers the impact of weather and driver behaviors on a battery system's performance, ultimately enhancing their model's prediction accuracy. In addition, the researchers used a pre-dropout method that prevents the LSTM model from overfitting by identifying the most suitable parameters before training.

Evaluations and simulations testing the LSTM-based model yielded highly promising results, with the new technique outperforming other strategies for battery parameter prediction, without requiring additional time to process data. The findings gathered by the researchers suggest that their model could be used to determine a variety of battery faults, informing drivers and passengers in a timely fashion and avoiding fatal accidents.

"The stability and robustness of this method have been verified through 10-fold cross-validation and comparative analysis of multiple sets of hyperparameters," the researchers wrote. "The results show that the proposed model has powerful and precise online prediction abilities for the three target parameters."

The researchers observed that after its offline training was complete, the LSTM model could perform fast and accurate online predictions. In other words, the fact that it was trained offline did not appear to decrease the speed and accuracy of its predictions.

In the future, the battery parameter prediction model developed by this research team could help to enhance the safety and efficiency of electric vehicles. Meanwhile, the researchers plan to train the LSTM network they developed on more datasets, as this could further enhance its performance and generalizability.

More information: Jichao Hong et al. Synchronous multi-parameter prediction of battery systems on electric vehicles using long short-term memory networks, *Applied Energy* (2019). DOI: 10.1016/j.apenergy.2019.113648

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