Analysis of streamflow prediction performance by various deep learning schemes

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Abstract

Deep learning models, especially those based on long short-term memory (LSTM), have presented their superiority in addressing time series data issues recently. This study aims to comprehensively evaluate the performance of deep learning models that belong to the supervised learning category in streamflow prediction. Therefore, six deep learning models—standard LSTM, standard gated recurrent unit (GRU), stacked LSTM, bidirectional LSTM (BiLSTM), feed-forward neural network (FFNN), and convolutional neural network (CNN) models—were of interest in this study. The Red River system, one of the largest river basins in Vietnam, was adopted as a case study. In addition, deep learning models were designed to forecast flowrate for one- and two-day ahead at Son Tay hydrological station on the Red River using a series of observed flowrate data at seven hydrological stations on three major river branches of the Red River system—Thao River, Da River, and Lo River—as the input data for training, validation, and testing. The comparison results have indicated that the four LSTM-based models exhibit significantly better performance and maintain stability than the FFNN and CNN models. Moreover, LSTM-based models may reach impressive predictions even in the presence of upstream reservoirs and dams. In the case of the stacked LSTM and BiLSTM models, the complexity of these models is not accompanied by performance improvement because their respective performance is not higher than the two standard models (LSTM and GRU). As a result, we realized that in the context of hydrological forecasting problems, simple architectural models such as LSTM and GRU (with one hidden layer) are sufficient to produce highly reliable forecasts while minimizing computation time because of the sequential data nature.

Keywords: Deep learning, gated recurrent unit (GRU), long short-term memory (LSTM), streamflow prediction.

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