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Application of Long Short-Term Memory (LSTM) Neural Network for Flood Forecasting

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Abstract: Flood forecasting is an essential requirement in integrated water resource management. This paper suggests a Long Short-Term Memory (LSTM) neural network model for flood forecasting, where the daily discharge and rainfall were used as input data. Moreover, characteristics of the data sets which may influence the model performance were also of interest. As a result, the Da River basin in Vietnam was chosen and two different combinations of input data sets from before 1985 (when the Hoa Binh dam was built) were used for one-day, two-day, and three-day flowrate forecasting ahead at Hoa Binh Station. The predictive ability of the model is quite impressive: The Nash–Sutcliffe efficiency (NSE) reached 99%, 95%, and 87% corresponding to three forecasting cases, respectively. The findings of this study suggest a viable option for flood forecasting on the Da River in Vietnam, where the river basin stretches between many countries and downstream flows (Vietnam) may fluctuate suddenly due to flood discharge from upstream hydroelectric reservoirs.

Keywords: flood forecasting; Artificial Neural Network (ANN); Recurrent Neural Network (RNN); Long Short-Term Memory (LSTM); deep neural network; Da river

1. Introduction

Flooding is a significant cause of social and economic losses, as well as the loss of human life. It poses a potential danger to densely populated areas located next to and downstream of major rivers. Accurate forecasting of flood flow is an essential requirement for reducing the risk of flooding and is important for planning and managing water resources systems. However, accurate forecasting of river discharge is a difficult problem because river flood stage analysis is a complex dynamic process characterized by spatial and temporal variations. In addition, the river flow process is nonlinear and influenced by many factors such as river basin surface mantle, the rainfall process, as well as riverbed terrain and climatic characteristics. Many predictive measures, which require an enormous amount of data for forecasting, have been proposed to mitigate or prevent the effects of floods.

Currently, there are two approaches for flow prediction. The first method consists of mathematical models that simulate the hydrodynamic process of the water's flow. This first approach is a widely used method because the mathematical models are based on concepts of hydraulics and hydrology. These models generally have a tendency to require a large amount of input data (i.e., rainfall forecasts and topography data) which may not always be available or could be difficult to obtain. In addition, the parameters of the model need to be tested and evaluated carefully as these parameters are regionally dependent, and sometimes it is difficult to estimate or calibrate the parameters that fit the model. As a result, models do not gain good performance especially in areas where available data is limited. Moreover, process-based methods have limitations regarding flood warnings because the runtime of these models is usually quite long [1]. Another drawback of conventional hydrological models is that