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Research Article

Daily Rainfall Forecasting Using Meteorology Data with Long Short-Term Memory (LSTM) Network

Soo See Chai [a,*], Kok Luong Goh [b]

[a] *Faculty of Computer Science and Information Technology, University of Malaysia Sarawak (UNIMAS), 94300, Kota Samarahan, Sarawak, Malaysia*

[b] *International College of Advanced Technology Sarawak (i-CATS), Kuching, Sarawak, Malaysia*

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Abstract

Rainfall is a natural climatic phenomenon and prediction of its value is crucial for weather forecasting. For time series data forecasting, the Long Short-Term Memory (LSTM) network is shown to be superior as compared to other machine learning algorithms. Therefore, in this research work, a LSTM network is developed to predict daily average rainfall values using meteorological data obtained from the Malaysian Meteorological Department for Kuching, Sarawak, Malaysia. Six daily meteorology data, namely, minimum temperature (°C), maximum temperature (°C), mean temperature (°C), mean wind speed (m/s), mean sea level pressure (hPa) and mean relative humidity (%) from the year 2009 to 2013 were used as the input of the LSTM prediction model. The accuracy of the predicted daily average rainfall was assessed using coefficient determinant (R2) and Root Mean Square Error (RMSE). Contrary to the common practice of dividing the whole available data set into training, validation and testing sub-sets, the developed LSTM model in this study was applied to forecast the daily average rainfall for the month December 2013 while training was done using the data prior of this month. An analysis on the testing data showed that, the data is more spread out in the testing set as compared to the training data. As LSTM requires the right setting of hyper-parameters, an analysis on the effects of the number of maximum epochs and the mini-batch size on the rainfall prediction accuracy were carried out in this study. From the experiments, a five layers LSTM model with number of maximum epoch of 10 and mini-batch size of 100 managed to achieve the best prediction at an average RMSE of 20.67 mm and R2 = 0.82.

Keywords:*Rainfall; LSTM; Prediction; Meteorology; Time-Series Data*

1. Introduction

Accurate forecasting of rainfall is still remaining as a demanding issue in the field of meteorological services. Rainfall contributes significantly in hydrological cycle and its value is critical for water resource planning and management, flood risk prevention and reservoir operation which affects our community (Kumar and et all, 2019; Hernández and et all., 2016).

For some parts of the world, rainfall is the only source of freshwater. Therefore, predicting future rainfall events is very important to help human in planning and adapting strategies (Tran Anh, Duc Dang, & Pham Van, 2019). However, as the rainfall is resulting from various meteorological circumstances which are complex and the mathematical modelling for rainfall prediction is nonlinear (Kashiwao, 2017), the design of an effective rainfall prediction system is still remaining as a difficult task for researchers. Traditionally, rainfall prediction methods were mainly focusing on the Numerical Weather Prediction (NWP) and statistical model (Liu and et all., 2019). Yet, it was reported that, serious constraints had been noticed in these two models when there is a dynamic change and linear shift of rainfall (Darji, Dabhi, & Prajapati, 2015).

In recent years, data-driven models have gained popularity in the field of hydrological variables prediction problems (Mandal & Jothiprakash, 2012). Data-driven models are basically methods that use computational intelligence and machine learning algorithms with the existence of enormous volume of data accounting the modelled phenomena (Solomatine, 2006). There has been a lot of machine learning algorithms that are proposed for time series analysis. Among these various machine learning algorithms, deep-learning, which is rooted from conventional neural network, has shown to outperform its predecessors (Pouyanfar , 2018). This is due to the expansion and accessibility of data as well as the significant improvement in hardware technologies which had driven the advancement of deep learning studies. Deep learning uses graph theories with transformation between neurons to develop learning models with multiple layers. One of the major advantages of deep learning as compared to conventional neural network is that, the feature extraction in deep learning algorithms are performed automatically while the efficiency of the conventional neural network models relies on the goodness of the representation of the input data. In addition, features extraction is domain particular and involves tremendous amount of human work.

Recurrent neural network (RNN) is a unique kind of deep learning model which has the ability to explicitly

*Corresponding author Email address: rai.ammish@mountsafa.com