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Research paper

Flood prediction of Sungai Bedup, Serian, Sarawak, Malaysia using deep learning

Abdulrazak Yahya Saleh Al-Hababi[1]*, Roselind Tei[1]

[1]FSKPM Faculty, University Malaysia Sarawak (UNIMAS), Kota Samarahan, 94300 Sarawak, Malaysia
**Corresponding author E-mail: ysahabdulrazak@unimas.my*

Abstract

This paper aims to evaluate the performance of the Long Short Term Memory (LSTM) model for flood forecasting. Seven data sets provided by the Drainage and Irrigation Department (DID) for Sungai Bedup, Serian, Sarawak, Malaysia are used for evaluating the performance of LSTM algorithm. Distinctive network was trained and tested using daily data obtained from the DID with the year range from 2014 to 2017. The performance of the algorithm was evaluated based on (Training Error Rate, Testing Error Rate, Loss, Accuracy, Validate Loss and Validate Accuracy) and compared with the Backpropagation Network (BP). Among the seven data sets, Sungai Bedup showed small testing error rate which is (0.08), followed by Bukit Matuh (0.11), Sungai Teb (0.14), Sungai Merang (0.15), Sungai Meringgu (0.12), Semuja Nonok (0.14) and lastly Sungai Busit is (0.13). Moreover, the developed model performance is evaluated by comparing with BP model. Results from this research evidently proved LSTM models is reliable to forecasting flood with the lowest testing error rate which is (0.08) and highest validate accuracy (92.61%) compared to BP with testing error rate (0.711) and validate accuracy (85.00%). Discussion is provided to prove the effectiveness of the model in forecasting flood problems.

Keywords: Artificial Neural Network (ANNs); Backpropagation (BP); Deep Learning; Flood Forecasting; Long Short Term Memory Network (LSTM)

1. Introduction

Flood is one of the natural calamities that Malaysia faces almost every year in varying degree of magnitude. Throughout Malaysia, including Sabah and Sarawak, an estimated of 9% total area of Malaysia is vulnerable to flood and approximately almost 4.82 million people are affected by flood [1]. Over the past decade, different kinds of modelling and data types emerged to forecast the flood events [2]. Excessive rainfall can cause flooding, especially in rural and urban areas, which may undergo demographic changes from time to time. [3], data from 50 years ago reveal that 41% of all natural disasters are related to severe weather conditions or water event phenomenon such as flood. The historical record of the catchments is important to display the information and investigate the time series of flash floods occurring hourly [4]. An early accurate prediction of the occurrences is considered to overcome and reduce the impacts of flood events.

One of the previous methods selected to reduce the flood is by implementing the Artificial Neural Network (ANNs) to forecast the hourly water level. ANNs have been extensively used in different kinds of research, especially for forecasting purposes [5]. ANNs learns by tracking examples; with the specific training and learning process, it can process a set of given data. ANNs can minimise the forecasting error by implementing various algorithms in order to get the best algorithm that will yield the closest result with the actual values given, and it is a non-structural countermeasure [5].

ANNs have been developed to resemble the human biological neural network. However, the difference is that a human only processes certain information at certain times, but Deep Learning, which are developed with the same concept as human neurons can process thousands of pieces of information in a much shorter time [6].

Different principles have been used to forecast floods, such as computer simulations based on the watershed demographic model, principle of hydrological, hydraulic components and groundwater flow model [7]. However, these methods only can predict certain catchment or basin based on certain water-level value. The target in this research is a big pool of historical flood data employed to predict an accurate output; the results will then be utilized to reduce the impacts of floods not only on the society but also on the environment. The remaining parts of this paper are organized as follows: methodology is presented in section 2, empirical studies are presented in section 3, section 4 discusses the results and finally section 5 concludes the paper future works.

2. Methodology

Recently, DL has attracted a growing research interest, and the method has shown certain advantages of learning [8]. DL is able to learn from the past data to solve complex problems and has been widely used in the field of forecasting. It allows the computational models that contain numerous processing layers to learn the data given with multiple levels of abstraction [9]. The results of the DL method are compared with the standards of other neural networks. This comparison is to analyse the effectiveness of the DL algorithms in this study. This research focuses on flood forecasting in the region of Bedup River Basin. The catchment is part of the Sadong Basin, and it is located 80 km away from Kuching. [10], the area of the whole Sadong Basin is about 3550 square km2 while the total length of the main river is 150 km, as shown in Figure 1. The data sets has been collected from the DID for the years of 2014 to 2017. Forecasting has been conducted on seven