RAINFALL-RUNOFF MODELING IN A LARGE TROPICAL CATCHMENT BY ADAPTIVE NETWORK-BASED FUZZY INFERENCE SYSTEM (ANFIS)

Nadeem Nawaz *[1], Sobri Harun[2] and Amin Talei[3]

[1, 2] Department of Hydraulics and Hydrology, Faculty of Civil Engineering, Universiti Teknologi Malaysia, 81310 UTM Skudai Johor Bahru, Malaysia.
(E-mail: nn.engr96@yahoo.com, sobri@fka.utm.my)
[3] School of Engineering, Monash University Malaysia, Bandar Sunway, Selangor Darul Ehsan, Malaysia.
(E-mail: amin.talei@monash.edu)

INTRODUCTION

Modeling the rainfall-runoff process is a significant hydrological task as it can be helpful in decreasing the damages of flooding and also managing the water resources [1]. This could be very important for a tropical country such as Malaysia with approximately 2500 mm annual rainfall. To date, several models are developed to capture the rainfall-runoff relationship including physically-based models and system theoretic ones. Despite many uncertainties and complexities involved in physical models the system theoretic modeling techniques lately found applicants in a variety of hydrological problems including rainfall–runoff modeling. Among different types of system theoretic models Artificial Neural Networks (ANN) and Neuro-Fuzzy Systems (NFS) have been commonly used in hydrological modelling [2]. Although ANNs have shown reasonably good performance in rainfall-runoff modelling they are suffering from several issues including long training time, non-transparent internal process, and requiring trial and error procedure to find an optimum structure. However, NFS which combine human-inspired reasoning style of fuzzy systems with learning and connectionist structure of neural networks have the significant advantage of reduced training time in comparison with ANNs. Moreover, NFS is not completely a black-box model as it can give an insight about its internal process in terms of IF-THEN rules.

The well-known Adaptive Network-based Fuzzy Inference System (ANFIS) has been successfully employed in many engineering modelling applications including hydrological modelling. In ANFIS, the global parameter tuning has been considered by means of minimization of the global error of the model. Therefore, ANFIS has been found to be an appropriate tool in non-linear mapping problems between input and output such as rainfall-runoff modelling. The present study is an application of ANFIS in rainfall-runoff modeling in a large catchment (with area of 350 Km^2) of Bekok River in the state of Johor, Malaysia. Approximately 85% of its area consists of agriculture fields, roads, utility reserves and the remaining 15% is in domestic use. Thirty years daily rainfall and runoff data was used in this study. The data was split into the training and testing datasets i.e. 80% for training and

20% for testing. The catchment has two rainfall stations; therefore, an input selection process based on correlation analysis was done to find the most appropriate rainfall and discharge antecedents for developing the model. Using 2 triangular membership functions and number of epoch of 30 were found to be appropriate for developing the ANFIS model.

MAIN RESULTS

The performance of the ANFIS model in training and testing phases were evaluated by different statistical parameters including Coefficient of Efficiency (CE), Coefficient of Determination (r^2), Root Mean Square Error (RMSE), Mean Absolute Error (MAE), and Relative Peak Error (RPE). The results obtained from ANFIS model were compared with the ones obtained from autoregressive model with exogenous inputs (ARX). ANFIS significantly outperformed ARX model in terms of all statistics. Comparison between the simulated hydrograph by ANFIS and the observed one as shown in (Figure 1) revealed that ANFIS is able to predict both low and high flows reasonably well. This study demonstrates the promising potential of neuro-fuzzy systems in rainfall-runoff modelling.

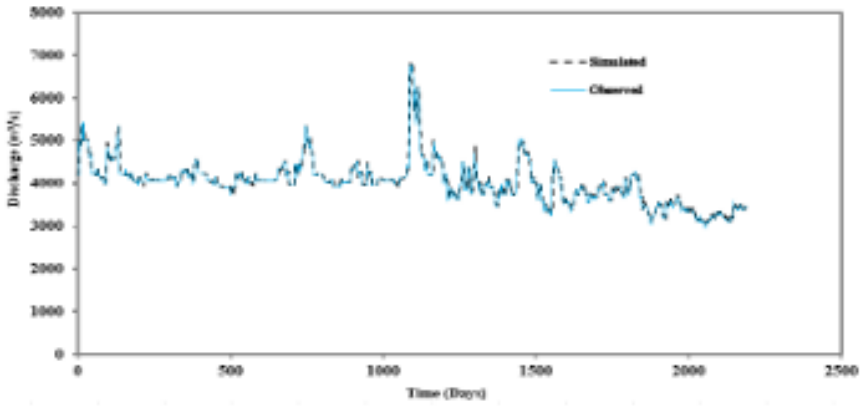

Figure 1. Observed and simulated hydrograph by ANFIS model for testing dataset for Bekok River Catchment.

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