METAHEURISTIC ALGORITHMS AND NEURAL NETWORKS IN HYDROLOGY

Edited by
Kuok King Kuok and
Md Rezaur Rahman

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This book first published 2024

Cambridge Scholars Publishing

Lady Stephenson Library, Newcastle upon Tyne, NE6 2PA, UK

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN: 978-1-0364-0804-6
ISBN (Ebook): 978-1-0364-0805-3

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CHAPTER 2

PARTICLE SWARM OPTIMIZATION IN FEEDFORWARD NEURAL NETWORKS FOR RAINFALL-RUNOFF SIMULATION

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Abstract

Backpropagation neural networks have been used effectively by hydrologists in recent years to model various nonlinear hydrological processes due to their capacity to generalize patterns in vague, noisy, ambiguous, and incomplete input and output data sets. However, the solutions may be stuck at a local minima due to the slow convergence rate during the training process. To overcome these problems, Particle Swarm Optimisation (PSO) is adopted in this study to train the feedforward neural network to model the rainfall-runoff for Sungai Bedup Basin in Sarawak, Malaysia. Nash-Sutcliffe coefficient and correlation coefficient are used to measure the model performance. Current runoff is the model's output, and the model's inputs are current rainfall, antecedent rainfall, and antecedent runoff. Results revealed that the current runoff was accurately

reproduced by a particle swarm optimization feedforward neural network (PSONN), with R = 0.872 and E^2 = 0.775 for the training data set and R = 0.900 and E2 = 0.807 for the testing data set. The results are comparable with conventional Multilayer Perceptron and Recurrent Neural Networks. Therefore, PSONN has successfully modeled the rainfall-runoff relationship and can be adapted to solve optimization problems in other domains.

Keywords: Particle swarm optimization feedforward neural network (PSONN), Multilayer Perceptron (MLP), Recurrent (REC); Coefficient of correlation (R), Nash-Sutcliffe coefficient (E^2)

1. Introduction

Due to the enormous geographical and temporal diversity of catchment characteristics and rainfall patterns, rainfall-runoff correlations are among the most difficult hydrological phenomena to comprehend (Jehanzaib et al., 2022; Aqnouy et al., 2023). Hydrologists continue to find the most suitable and simplest method of converting rainfall to runoff for streamflow forecasting, raw water supply, flood control, irrigation, drainage, water quality, hydropower production, recreation, and aquatic and wildlife protection. Numerous intricate elements play a role in this transition, such as interception, depression storage, infiltration, overland flow, interflow, percolation, evaporation, and catchment meteorological conditions. These data are only sometimes readily available and are typically difficult to get. With all these non-stationary and typically nonlinear factors, it is challenging to estimate runoff accurately.

Recent advancements in artificial intelligence (AI) have led to the proposal of artificial neural network (ANN) for implementation. With the application of ANN, information such as watershed topography, river network structure, river cross-sections, soil properties, and antecedent moisture contents are no longer needed to input into a model for accurate simulation of surface runoff (Kuok et al., 2019; Lai et al., 2023).

Furthermore, antecedent moisture levels are dynamic and dependent on a wealth of historical and contemporary hydrological complicated processes and data. Specifically, real-time, non-stationary, and nonlinear natural events can be effectively handled by a backpropagation neural network (BPNN) (Chen et al., 2020; Zhang & Qu, 2021). BPNN can be applied to rainfall-runoff systems because of their inherent behavior. Water resources have seen numerous BPNN applications over the past twenty years. O'Reilly et al. (2018) adopted BPNN for effective drinking water quality management