

METAHEURISTIC ALGORITHMS AND NEURAL NETWORKS IN HYDROLOGY

Edited by
**Kuok King Kuok and
Md Rezaur Rahman**

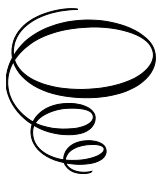
Metaheuristic Algorithms and Neural Networks in Hydrology

Metaheuristic Algorithms and Neural Networks in Hydrology

Edited by

Kuok King Kuok and Md Rezaur Rahman

**Cambridge
Scholars
Publishing**



Metaheuristic Algorithms and Neural Networks in Hydrology

Edited by Kuok King Kuok and Md Rezaur Rahman

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

Copyright © 2024 by Kuok King Kuok, Md Rezaur Rahman
and contributors

All rights for this book reserved. No part of this book may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior permission of the copyright owner.

ISBN: 978-1-0364-0804-6

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

TABLE OF CONTENTS

Chapter 1	1
Neural Network – A Black Box Model Kuok King Kuok, Chiu Po Chan, Md Rezaur Rahman, Khairul Anwar Mohamad Said, Chin Mei Yun	
Chapter 2	35
Particle Swarm Optimization in Feedforward Neural Networks for Rainfall-Runoff Simulation Kuok King Kuok, Chiu Po Chan, Md Rezaur Rahman, Chin Mei Yun, Mohd Elfy Mersal	
Chapter 3	63
Bat Optimisation Neural Networks for Rainfall Forecasting: Case Study for Kuching City Kuok King Kuok, Chiu Po Chan, Md Rezaur Rahman, Chin Mei Yun, Mohd Elfy Mersal	
Chapter 4	83
Cuckoo Search Optimization Neural Network Models for Forecasting Long-Term Precipitation Kuok King Kuok, Chiu Po Chan, Md Rezaur Rahman, Khairul Anwar Mohamad Said	
Chapter 5	105
Whale Optimization Neural Network for Daily Water Level Forecasting Considering the Changing Climate Kuok King Kuok, Chiu Po Chan, Md Rezaur Rahman, Teng Yeow Haur	
Chapter 6	129
Salp Swarm Optimization Neural Network for Daily Water Level Forecasting with the Impacts of Climate Change Kuok King Kuok, Teng Yeow Haur, Chiu Po Chan, Md Rezaur Rahman, Muhammad Khusairy Bakri	

Chapter 7	147
Missing Daily Rainfall Prediction using Grey Wolf Optimizer-based Neural Network Lai Wai Yan, Kuok King Kuok, Chiu Po Chan, Md Rezaur Rahman, Muhammad Khusairy Bakri	
Chapter 8	170
Development of Multi-Verse Optimizer in Artificial Neural Network for Enhancing the Imputation Accuracy of Daily Rainfall Observations Lai Wai Yan, Kuok King Kuok, Chiu Po Chan, Md Rezaur Rahman, Muhammad Khusairy Bakri	
Chapter 9	194
Sine Cosine Algorithm based Neural Network for Rainfall Data Imputation Po Chan Chiu, Ali Selamat, Kuok King Kuok	
Chapter 10	208
Hybrid Sine Cosine and Fitness Dependent Optimizer for Incomplete Dataset Po Chan Chiu, Ali Selamat, Kuok King Kuok	

5. Book's contents

CHAPTER 2

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

KUOK KING KUOK¹, CHIU PO CHAN²,
MD REZAUR RAHMAN³, CHIN MEI YUN¹,
MOHD ELFY MERSAL¹

¹Faculty of Engineering, Computing and Science, Swinburne University of Technology, Sarawak Campus, Jalan Simpang Tiga, 93400, Kuching, Sarawak, Malaysia.

²Faculty of Computer Science and Information Technology, Universiti Malaysia Sarawak, Jalan Datuk Mohammad Musa, 94300, Kota Samarahan, Sarawak, Malaysia

³Faculty of Engineering, Universiti Malaysia Sarawak, Jalan Datuk Mohammad Musa, 94300, Kota Samarahan, Sarawak, Malaysia

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 (PSOENN), with $R = 0.872$ and $E^2 = 0.775$ for the training data set and $R = 0.900$ and $E^2 = 0.807$ for the testing data set. The results are comparable with conventional Multilayer Perceptron and Recurrent Neural Networks. Therefore, PSOENN 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 (PSOENN), 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; Agnouy 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