

METAHEURISTIC ALGORITHMS AND NEURAL NETWORKS IN HYDROLOGY

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

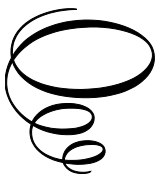
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CHAPTER 4

CUCKOO SEARCH OPTIMIZATION NEURAL NETWORK MODELS FOR FORECASTING LONG-TERM PRECIPITATION

KUOK KING KUOK¹, CHIU PO CHAN²,
MD REZAUR RAHMAN³,
KHAIRUL ANWAR MOHAMAD SAID³

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

It is more crucial than ever to make quantitative prediction patterns of precipitation due to climate change and global warming concerns. The foundation for many climate change simulations is global circulation models (GCMs). However, to create finer models for regional use, researchers have been employing various downscaling strategies due to their coarse resolution. Technological developments in metaheuristic algorithms have given rise to a different method for downscaling. This paper presents the application of a novel optimization algorithm, Cuckoo Search Optimization (CSO), to train feedforward neural networks to forecast long-term precipitation using three climate models, namely HadCM3, ECHAM5, and HadGEM3-RA. The selected study area is Kuching City, Sarawak, Malaysia, and the models' performance was assessed using

historical precipitation data validation through square root of correlation of determination (r), mean absolute error (MAE), root mean square error (RMSE), and Nash and Sutcliffe coefficient (E). With the setup of 20 numbers of nests (n), 0.6 initial rate of alien egg finding ($p_{a\text{ initial}}$), 100 hidden neurons (HN), 1000 iterations (IN), and learning rate (LR) of 1, the results demonstrated that Cuckoo Search Optimization Neural Network (CSONN) is capable of forecasting precipitation up to 95%~99% of r and 85%~94% of E confidence levels, overall lower RMSE and MAE. Future precipitation forecasts revealed that the city would experience an increase of mean monthly precipitation from 2%~26% in the 2030s, 0%~34% for 2050s, and 4%~43% for 2080s during wet seasons, relative to the 1970s. The findings also showed that the mean monthly precipitation decreases to the following ranges during dry seasons: 1%~4% for the 2030s, 1%~2% for the 2050s, and 3%~4% for the 2080s, compared to the 1970s.

Keywords: Cuckoo Search Optimization Neural Network (CSONN), Climate change, long-term prediction, climate model, performance criteria

1. Introduction

Artificial Neural Network (ANN) is a computational model inspired by the human brain's real structure and function (Chiu et al., 2022). ANN can carry out tasks analogous to how a brain learns from previous experiences. ANN comprises several artificial neurons, each equipped to execute specific mathematical operations. Neurons are grouped to form layers. ANN consists of an input layer, one or more hidden layers that house most of the processing, and an output layer. The initial data is delivered into the network through the input layer. This initial data is processed in a hidden layer, and the network reacts to the data it receives through the output layer. Information is transmitted through connections between neurons in one layer and the next. The learning process started as the network received data from the first input layer to the lower hidden layers, then from the hidden layer to the output layer.

The training and validation phases are the two main stages of ANN implementation (Kuok et al., 2019). A significant amount of data must be provided for ANN to learn. The training set is the data that the model used for training. During training, the ANN output is compared against the desired output. The network is validated if the model output is the same as