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Application of Artificial Intelligence Method Coupled with Discrete Wavelet Transform Method

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Abstract

In modern hydrology one of the most important applications is hydrological time series forecasting, particularly for effective information related to reservoir system. In this study, artificial neural network (ANN) such as radial basis function neural network (RBFNN), coupled with time series decomposing method (TSDM), named as discrete wavelet transform (DWT) to forecast monthly time series at upper Yangtze River and Xianjiababa is taken as the forecast hydrological station. Data has been analyzed by comparing the simulation outputs delivered by models with two performance indices named as (a) correlation coefficient and root mean square errors, which can be denoted by (R)and (RMSE) respectively. Results show that time series decomposition technique discrete wavelet transform method have shown more accuracy and can play important role to improve the corrected in discharge prediction, as compared to single ANN's.

Keywords: Monthly discharge; Radial basis function neural network; Discrete wavelet transform; Hybrid model

1. Introduction

Trustworthy information related to upcoming floods can save countless lives, properties and infrastructure[1]. Due to global warming around the whole world, in recent times, rate of water cycle has been increased, which also have increased the rate of floods in whole world[2]. Many researchers have developed and applied various models to predict floods, which could be divided into 2 major types, conceptual models (CM) and data-based models(DDM) [3]. Even though, CM contains the plus points but due to its complex nature including, model structure, its application, its parameters and most importantly related to data it was bit difficult to understand the nature of these kind of models[4]. So, to use such kind of models it was very important that to get better results one should have all knowledge about the models and its parameters[5]. However, DDM, which are basically numerical and based on biological neuron systems, recently known as artificial brain or intelligence, had received more attention in water

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related applications because of their ease, fast progress time and less data necessity. Although, data driven models have attained high levels in hydrological field but still space is present to improve the forecasting methods[6]. Hydrological processes are non-linear and arbitrary. By simply applying such models on original time series, the facts of alteration are overlooked so that predicting correctness is reduced. By applying decomposition methods to original time series which is random and is not linear, at different levels of resolutions and getting important evidence based on construction will be possible method to mark developments within analytical capability of a model[7]. Due to this intension, in this study, ANN model has been coupled with TSD to forecast discharge at monthly level[8]. Therefore, choosing TSDM and forecast methods are considered as supreme and significant parts for the present study. Adamowski established flood forecasting models (FFM) for forecasting discharge or stream flows with better precision for twenty four hours and 72 hours, than ANN. If no significant trends remained in the plenty of the TS still the correctness hurt for lengthier time lead prediction. By using the concept of wavelet and cross-wavelet principal mechanisms for TS [9], Kisi united both multi-layer perceptron (MLP) and discrete wavelet transform (DWT), for 1 month lead time stream flow predicting [10]. Wang and his team, at 3 Gorges dam in of China, established WNM to predict annual average flow, daily average flow and seasonal average flow [11]. Rajaee and his fellows established a hybrid model using wavelets and ANN to predict residue weight at river and presented advantages of DM [12]. Sahay and Chakraborty illustrated the effectiveness of hybrid model of DWT and auto-regression(AR) for daily stream flows prediction [13]. Moosavi et al. compared different hybrid models performances such as Wavelet-ANN and Wavelet-ANFIS to estimate groundwater levels. Budu developed the hybrid of FFNN with TSDM to analyze the inflow at daily level and showed hybrid wavelet-ANN model did well related to ANN[14]. S&S suggested hybrid model named WAGANN to predict 24 hours in advance river discharge and WAGANN method is more accurate as compared to the models using OFTS as inputs[15]. The decomposing technique like, DWT has been mostly applied in TS examination, wavelets have ability to remove proficiently, time as well as frequency alike signals [16]. All the above discussion proves that decomposition method can have ability to improve the results. In this study, ANN named as RBFNN is coupled with time series decomposition method named as discrete wavelet transform (DWT) method to forecast stream flow for one moth lead time. For this study upper Yangtze River which is generally known as Jinsha River has been selected.

2. Methodologies

2.1. Location and Data

Yangtze River (YR) is considered as the main and biggest in china, while 3rd biggest in the world. Approximately it is 6380 km in length, covered areas is more than $1.810*10^5$ km^2 and yearly average flow is more than $9.79*10^{11} m^3$. (YR) is divided into three sections upper i.e. Jinsha river basin, middle and lower Yangtze River basin. 2316 km is the estimated length of Jinsha River, and catchment area of 34×10^4 km^2, and mean yearly discharge is about 150 billion m^3, contains a big upright fall of 33×10^2 m. Jinsha River is rich in hydropower resources, about 1.12 billion kW, about twenty five hydropower stations are in planning, study area is shown Fig. 1. In present study two types of data has been used of (1961-2008) 48 years. Discharge data which is collected from the Xianjiaba station and the rainfall data which is collected from 32 meterological stations. For model training data from the year 1961–1991 (31 years or 65%) and remaining data from 1992-2008 (17 years or 35%) are used for model validation.

2.2. RBFNN

The RBFNN networks have a numerous advantages in contrast to other neural networks. RBFNN networks are quick and do not undergo problems like local minima which infects in training methods. Training of RBFNN networks can be done very fast. RBFNN is considered as 3 layered FNN, the hidden layer activation function of which is a set of radial symmetrical kernel function. When the input sample transfers to the hidden cell space, this set of kernel function forms a set of "Base" of input sample. Therefore, this kind of NN is generally known as RBFNN.

This is also a feedforward, but they just contain 1 hidden layer. This layer is consisting of (a) Number of nodes (b) parameter vector known as Centre. Standard Euclidean distance is used to estimate that how far an input vector is