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River flow model using artificial neural networks

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Abstract

The use of artificial neural networks (ANNs) is becoming increasingly common in the analysis of hydrology and water resources problems. In this research, an ANN was developed and used to model the rainfall-runoff relationship, in a catchment located in a semiarid and Mediterranean climate in Algeria. The performance of the developed neural network-based model was compared against multiple linear regression-based models using the same observed data. It was found that the neural network model consistently gives superior predictions. Based on the results of this research, artificial neural network modeling appears to be a promising technique for the prediction of flow for catchments in semi-arid and Mediterranean regions. Accordingly, the neural network method can be applied to various hydrological systems where other models may be inappropriate.

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Keywords: Artificial neural network; modeling multiple regressions; semi arid climate; Rainfall-runoff; Catchment, MLP, Algeria.

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1. Introduction

The ANN models are powerful prediction tools for the relation between rainfall and runoff parameters. The results will support decision making in the area of water resources planning and management. Besides, they assist

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urban planners and managers undertake the necessary measures to face the bad productions. Thus, they help avoid losses in public and private properties, and health and ecological hazards that are likely to occur due to flooding.

In addition, the ANN models have been used increasingly in various aspects of science and engineering because of its ability to model both linear and nonlinear systems without the need to make any assumptions as are implicit in most traditional statistical approaches. In some of the hydrologic problems, ANNs have already been successfully used for river flow prediction (Riad et al.) [1], 2004; Lallahem et al., 2005) [2], for rainfall-runoff process (Smith and Eli,) [3] for the prediction of water quality parameters (Maier and Dandy, 1996) [4]. In addition, ANNs are applied for prediction of evaporation (Sudheer, 2002) [5], for rainfall-runoff forecasting (Minns and Hall, 1996) [6], for prediction of flood disaster (Wei *et al.,* 2002) [7], and for river time series prediction (Hu et al., 2001) [8]. In these hydrological applications, a multilayer feed-forward backpropagation algorithm is use (Lippmann, 1987, Riad et al., 2004) [9]. It usually is composed of a large number of interconnected nodes, arranged in an input layer, an output layer, and one or more hidden layers. The transfer function selected for the network was the sigmoid function. The aim of this paper is to model the rainfall-runoff relationship in the Seybouse catchment located in the northern part of Algeria using a black box type model based on ANN methodology. The Seybouse River Basin is located in northeastern Algeria. With a total area of 6,471 km2, the basin extends over 68 municipalities and 7 prefectures. The Seybouse River and its tributaries are vital for sustaining the majority of economic activities in the region.

2. The artificial neural networks approach

2.1. The basics

An ANN is a computational approach inspired by the human nervous system. It is based on theories of the massive interconnection and parallel processing architecture of biological neural systems. The main theme of ANN research focuses on modeling of the brain as a parallel computational device for various computational tasks that were performed poorly by traditional serial computers.

ANNs have a number of interconnected processing elements (PEs) that usually operate in parallel and are configured in regular architectures. The collective behavior of ANN, like a human brain, demonstrates the ability to learn, recall, and generalize from training patterns or data. The advantage of neural networks is they are capable of modeling linear and nonlinear systems.

In this research, we use an MLP trained with a back propagation algorithm to predict the drainage basin runoff. The MLP consists of an input layer consisting of node(s) representing various input variable(s), the hidden layer consisting of many hidden nodes, and an output layer consisting of output variable(s). The input nodes pass on the input signal values to the nodes in the hidden layer unprocessed. The values are distributed to all the nodes in the hid-den layer depending on the connection weights Wij and Wjk between the input node and the hidden nodes. Connection weights are the interconnecting links between the neurons in successive layers.

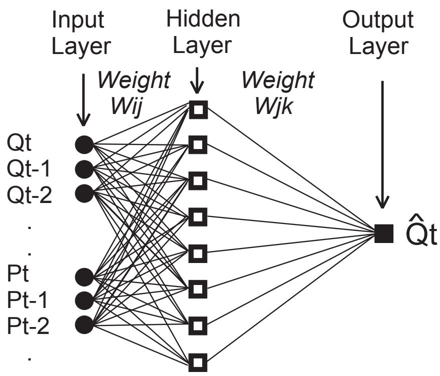

Fig. 1. Architecture of the neural network model in this study.