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Artificial Neural Networks applied to flow prediction: A use case for the Tomebamba river

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Abstract

The main aim of this research is to create a model based on Artificial Neural Networks (ANN) that allows predicting the flow in Tomebamba river, at real time and in a specific day of a year. As inputs, this research is using information of rainfall and flow of the stations along of the river. This information is organized in scenarios and each scenario is prepared to a specific area. For this article, we have selected two scenarios. The information is acquired from the hydrological stations placed in the watershed using an electronic system developed at real time and it supports any kind or brands of this type of sensors. The prediction works very good three days in advance. This research includes two ANN models: Backpropagation and a hybrid model between back propagation and OWO-HWO (output weight optimization–hidden weight optimization) to select the initial weights of the connection. These last two models have been tested in a preliminary research. To validate the results we are using some error indicators such as MSE, RMSE, EF, CD and BIAS. The results of this research reached high levels of reliability and the level of error is minimal. These predictions are useful to avoid floods in the city of Cuenca in Ecuador.

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Keywords: Artificial Neural Networks, ANN, Forecasting, Hydrology, Floods

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1. Introduction

This model, can be used to predict water flow in a river in order to estimate the hydropower generation. Additionally, this model can be used to prevent disasters such as flooding and also to optimize the use of hydrological resources. This research used information from Tomebamba river basin. This data has been used to train and validate artificial neural network models in order to evaluate the results of those models.

In this context, this research can be considered as a primary tool for hydropower generation organizations to determine in the best way, the exact amount of water that has to be present in a reservoir when there is not too much water to generate electricity. The application of mathematical models in water management basins has very high requirements of information and commonly they are not applicable in the mountains regions. Computer techniques from artificial intelligence allow establishing relationships between input and output data in a hydrographical basin.

This paper has already evaluated different Artificial Neural Networks (ANN) to select one and implement it to allow control every connection inside the network. This, with the objective of obtaining a quick convergence and to reduce the overall error rate.

2. Background and related work

In this section, we provide a brief introduction to Neural Network and two specific types such as: Backpropagation and OWO-HWO (output weight optimization–hidden weight optimization) algorithms and genetic algorithms that will be used in order to obtain a good initialization of the weights of each connection. Additionally, a description of the current state of the art related to the rainfall forecasting.

2.1. Artificial Neural Networks (ANN)

Components

Artificial neural networks try to reproduce the human brain behavior, the model in which neurons are considered processing units [1],[2]. Typically, there are three types of neurons:

- Receive impulses or external signals, takes information from the outside, because if it, they are known as input units.
- Internal elements to process input information. These elements are called hidden units, because they don't have any relationship between input and output units.
- Output units, these units give the result to the system.

Each neuron has associated with a numerical value or activation state and there is an output function fi associated to each of this units. This function transforms the activation state of an output signal yi. This signal is sent to all communication channels of the network(connections). In this channels, the signal is modified because of the synapsis (connection weight) associated to each one of them based in a specific rule. Modulated signals arriving to the j-th unit joins each other generating the total Netj. An activation function F, determines the new neuron activation state aj(t+1), taking in account the total net input and the previous activation state aj(t)[1],[2].

Structure

Artificial Neural Networks are organized in function of:

- The number of levels or layers.
- The number of neurons per level.
- Connection patterns.
- Information flow.

The neurons distribution inside of the network is made creating levels/layer composed of a certain number of neurons in each layer. In this sense, can be identified three layer types [1]: