

ARTIFICIAL NEURAL NETWORKS MODEL FOR PREDICTING RAINFALL-RUNOFF

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Introduction

A rainfall runoff model is a mathematical model describing the rainfall-runoff relations of a rainfall catchment area or watershed. More precisely, it produces the surface runoff hydrograph as a response to a rainfall hydrograph as input. In other words, the model calculates the conversion of rainfall into runoff.

Many approaches have been used to hydrological forecasting in the last few decades. Rule based fuzzy logic models (Hundecha *et al.*, 2001), Statistical methods (Hazarika *et al.*, 2007) and numerical methods (Singh and Frevert, 2002) are some of the alternative approaches to this problem.

The rainfall-runoff relationship is highly non-linear and it is one of the most complex hydrological phenomena to comprehend due to the tremendous spatial and temporal variability of watershed characteristics and precipitation patterns, and the number of variables involved in the modeling of the physical processes.

In this paper we examine the application of Artificial Neural Networks to predict daily runoff as a function of daily rainfall for a selected catchment area. Then a simulation study is done to find the applicability of the system. Some difficulties arise

with rule based fuzzy logic approach such as need of better knowledge about the overall system, increasing complexity if too many inputs are chosen and difficulty in defining rules for each and every possible case in the rainfall-runoff change are eliminated in the new proposed system. The statistical models in most of the cases depend upon several tacit assumptions regarding the system, where as the proposed system is based on known input data set without any assumptions. The numerical models are based on the scheme of nonlinear equations which are more intricate to solve. The proposed system avoids such complex calculations.

Methodology

The analysis was done by using a dataset collected at *Uma Oya* catchment area to evaluate the neural network for the rainfall runoff model. A study on the relationship between rainfall data and runoff data shows that for a given rainfall, there may be different runoff in different time periods. (Fig.1) Sometimes the difference between these runoff values is very large.

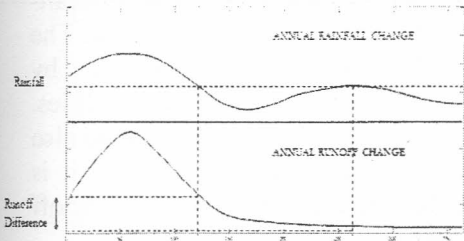


Fig. 1. Annual rainfall vs runoff

This is due to the climate change in the catchment area. If the area is dry then there is less effects for the runoff even from heavy rainfall. However, if the area is wet, a little rainfall may cause large runoff. Therefore trying to develop a single neural network to handle rainfall runoff model for the whole year might not be suitable. As a solution when developing the model, the year is divided into several time periods according to the annual rainfall (Fig.2) and an artificial neural network for each time period was developed.

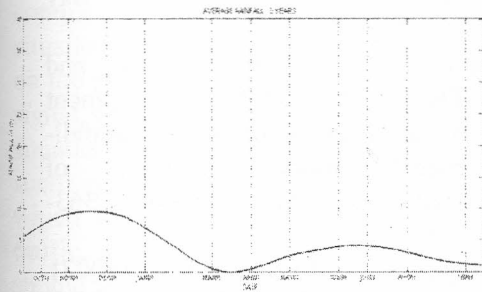


Fig. 2. Division of time periods

Each neural network takes rainfall data of past three days as the input (Window based) and predicts today's runoff value as the output. These seasonal networks were combined together to develop a model for the whole year. (Fig.3)

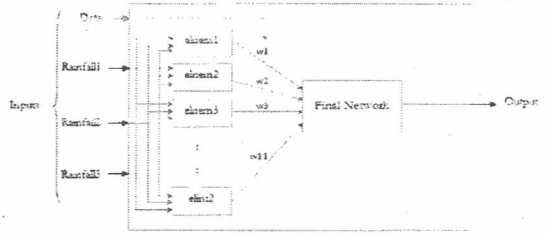


Fig. 3. Network arrangements

When rainfall data and current date is provided as the inputs, all the networks were producing output according to the input rainfalls regardless of the time period. Then each output was multiply by a weight factor, which depends on the probability of how much the output can be affected to that period of time. Then these weighted outputs are directed to another neural network. The output from this neural network is the final output of the model. The seasons were rank according to the input date and then weights are assigned to each output of the network.

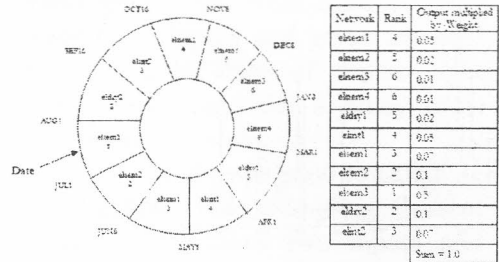


Fig. 4. Weight assignment

The weights are summed up to 1. For example assume that the current date is between July1 to August 1. Then weights assign are as in Fig. 4.

Results and Discussion

The whole model was tested with 3 years data. The testing graphs are shown below.

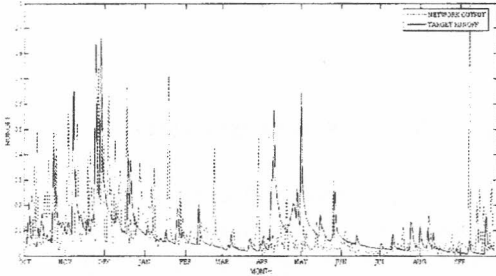


Fig. 5. Testing 1994/1995

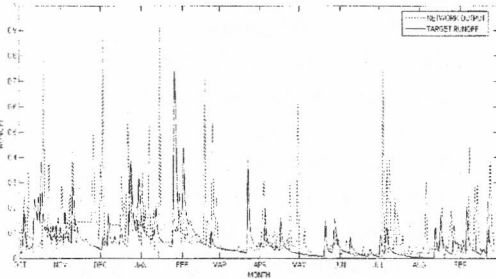


Fig. 6. Testing 1995/1996

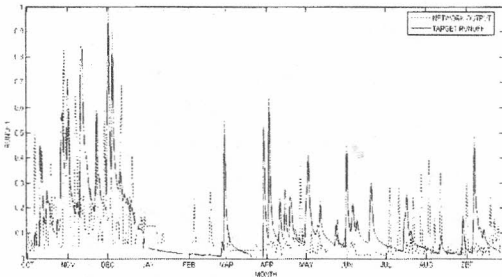


Fig. 7. Testing 1996/1997

This model generalizes the effects of the rainfall seasons on predicting the runoff into some extent.

Conclusion

The model developed indicates that the neural network approach may constitute an efficient approach to rainfall-runoff modeling and is

feasible for modeling the rainfall-runoff relationship in any region. The model can be generalized by considering the probabilities. However our illustrative example also indicate that in some situations it is still hard to identify the rainfall-runoff pattern.

The predicted runoff values obtained from the model can be use to solve problems in water resources studies and management such as purposing suitable locations for reservoirs, production of hydroelectric energy, dam safety analysis, water resource planning...etc.

References

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