

MODELING HYDROLOGICAL PROCESSES USING NEURAL COMPUTING TECHNIQUE

by

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*dedicated
to
the loving memory of my father*

CERTIFICATE

This is to certify that the thesis, entitled "*MODELING HYDROLOGICAL PROCESSES USING NEURAL COMPUTING TECHNIQUE*", being submitted by **Mr. SUDHEER. K. P.** to the **Indian Institute of Technology, Delhi** for the award of the degree of *Doctor of Philosophy*, is a record of bonafide research work carried out by him under my guidance and supervision. The thesis work, in my opinion, has reached the standard, fulfilling the requirements for the said degree. The research report and the results presented in the thesis have not been submitted, in part or in full, to any other University or Institute for the award of any degree or diploma.



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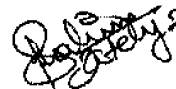
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(K. P. Sudheer)

Modeling hydrological processes using neural computing technique

ABSTRACT

An artificial neural network (ANN) is a flexible mathematical structure, which is reported to be capable of identifying complex non-linear relationships between input and output data sets. ANN models have been found useful and efficient, particularly in problems for which the characteristics of the process are difficult to describe using physical equations. The success with which ANNs have been used to model dynamic systems in other fields of science and engineering, suggests that the ANN approach may prove to be an effective and efficient way to model the complex hydrologic processes.

The present work reports the research work conducted to explore the capabilities of ANN approach to model the highly complex, non-linear hydrological processes. The study has aimed at modeling three hydrological processes, viz. rainfall-runoff, evapotranspiration, evaporation, all having significance in water resources planning and management. The study investigated two neural network algorithms, viz. three layer feed forward back error propagation (BPN), radial basis function (RBF). The analysis identified three candidate models for rainfall-runoff process viz. two BPN models and a RBF model. To have an inter comparison with conventional models, an ARMA model and a regression model have also been developed. The analysis revealed that ANN models compute the river flow with minimum error, compared to ARMA and regression models. The study also revealed that the RBF model is performing better than the BPN models.

In order to estimate the evapotranspiration (ET) from climatic variables, the study considered three different combinations of the variables based on reported dependency of ET on these variables, and employed a RBF network. The results from each of these models were compared with actual lysimeter measured evapotranspiration and it was found that the ANN models were capable of

representing the evapotranspiration process effectively. The study compared the computed ET from ANN models with that of popular ET estimation methods, and the analysis has shown that ANN model is superior to others. The results indicated that the ET could be estimated from only temperature data with reasonable accuracy using the ANN approach.

The process of evaporation, which is too an important parameter in water resources planning, has been also modeled using ANN approach. The study employed mapping of evaporation from climatic variables, using a BPN as well as RBF networks. The investigation considered four different combinations of climatic variables, and these combinations were in relevance to the input to existing models. The study clearly demonstrated the potential of ANN approach in modeling evaporation process. A comparison of the results from ANN models have been made with that of existing methods those require similar inputs, and the analysis revealed that ANN approach is superior to others.

The study indicated that for hydrological applications, ANN could take advantage of their capability to reproduce the unknown relationship existing between a set of input variable descriptive of the system. Despite the limitations, the noted advantages of ANNs are significant and promising for field scale applications in hydrology. The study has outlined a statistical procedure for defining the input vector to the neural network model while mapping the rainfall-runoff process. The results, pertaining to the research work reported, clearly indicate that ANN approach can be a viable alternative to the traditional techniques for modeling hydrological processes. The study also suggested that the radial basis function networks might be a superior alternative to the usually employed back propagation networks in modeling the complex hydrological processes.

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