

SESSION-5 :

**ANN, GENETIC
ALGORITHM, DECISION
SUPPORT SYSTEMS**

APPLICATION OF ANN TECHNIQUE IN RAINFALL-RUNOFF MODELLING

Archana Sarkar, Rakesh Kumar, R.D. Singh

National Institute of Hydrology, Roorkee

Nayan Sharma

Indian Institute of Technology, Roorkee

Modeling of runoff is of prime importance in many water resources planning, design, and management activities. The involvement of many often-interrelated physiographic and climatic factors makes the rainfall-runoff process not only very complex to understand but also extremely difficult to model (Singh, 1988). The use of rainfall runoff models in the decision making process of water resources planning and management has become increasingly indispensable. Such models are used, for example, in the design and operation of hydraulic structures, for discharge forecasting, and for evaluating possible impact of land use land cover changes as well as climate changes over the catchment. The development of rainfall-runoff models has gone through substantial changes since Sherman pioneered the unit hydrograph theory in 1932. Over the years, several hydrological models ranging from empirical relationships to physically based models have been developed for the prediction of runoff. Physically based models are better because they consider the controlling physical processes, but at the same time their data requirements are also high. Often, even in intensively monitored watersheds, all the required data are not available. Therefore, there is a need to look for alternative methods for the prediction of runoff (e.g., rainfall, runoff and temperature).

Artificial neural networks (ANNs) have been proposed as efficient tools for modelling and prediction in hydrology, as black-box models. In recent years ANNs have shown exceptional performance as regression tools, especially when used for pattern recognition and function estimation. They are highly non-linear, and can capture complex interactions among the input variables in a system without any prior knowledge about the nature of these interactions. The main advantage of ANNs is that one does not have to explicitly assume a model form, which is a prerequisite in conventional modelling approaches. Indeed, in ANNs the data points themselves generate a relationship of possibly complicated or orthodox shape. In comparison to the conventional methods, ANNs tolerate imprecise or incomplete data, approximate results, and are less vulnerable to outliers.

In the present study, back propagation ANN technique has been applied for developing two types of rainfall-runoff models in two different Indian catchments. Continuous daily rainfall-runoff ANN models have been developed for a part of the Brahmaputra River basin (a Himalayan basin with huge hydropower potential) using available daily data of rainfall, temperature and discharge at various locations in the basin. Event based rainfall-runoff ANN models have been developed for the runoff simulation of Ajay River basin (a flood prone basin) using

the hourly data of available storm events. Results obtained indicate that the ANN approach for modelling the complex rainfall-runoff process produces reasonably satisfactory results for both the catchments.

APPLICATION OF NEURAL APPROACHES TO ONE-STEP-AHEAD DAILY RIVER-STAGE FORECASTING

Sahay Rajeev Ranjan

Department of civil engineering, Birla Institute of Technology, Mesra, Ranchi

ABSTRACT

Knowledge of river stages at places in a continuous time frame is important for developing the flood fighting and water diversion strategies. The importance of accurate river-stage forecasting may be appreciated by recalling annual floods in the North Bihar rivers which cause great destruction to life and property. Many excellent literatures are available on modeling river stages, which are primarily conceptual or heuristic. Conceptual models, which are based on comprehensive theories may be more accurate and robust but defining parameters of the hydrological system which depend on too many variables and their non-linear interrelationships make these models complex and difficult to adopt. Moreover, the occurrence of river stages being probabilistic may not always be conducive for deterministic modeling. The relatively recently developed soft-computing techniques, particularly artificial neural networks (ANNs), offers great promise in modeling complex and nonlinear processes without underlying physics being explicitly provided. The ability of NNs to capture relationships from given patterns has enabled them to be employed in various hydraulic and hydrologic problems such as modeling of river runoff, stream water level, river salinity, river flow, evapotranspiration, ground water table fluctuation, reservoir operation rule to name a few.

The present work demonstrates the applicability of neural networks in forecasting one-step ahead river stages when few data are available. The only records available are previous day's river stages. The model was applied in forecasting stages of monsoon period at a gauge site on the River Gandak in North Bihar. Gandak, a tributary of Ganga, is an international river whose upper catchment lies in Nepal. The river is notorious for extensive flood damages every year.

Various NN models with different number of neurons in the input and hidden layers were tried and the model which yielded the lowest root mean square error and highest coefficient of correlation was selected for prediction. The results of the study found the feed forward backpropagation network, with input set consisting of past four days' river flood levels, i.e., K_{t-1} , K_{t-2} , K_{t-3} , K_{t-4} , and 8 neurons in the hidden layer, to be the best performing model for forecasting the flood stages at time t . The same data were utilized for the developed autoregression models and results compared. Based on various performance indices, as given in Table 1, it was concluded that NN predictions were better than AR predictions. In case of peak flood forecasting as well, the NN model outperformed the AR model, as percentage relative error was lesser and greater number of estimates were closer to the observed values.

STATIC RADIAL BASIS FUNCTION ARTIFICIAL NEURAL NETWORK FOR RAINFALL-RUNOFF MODELLING UNDER VARYING LEARNING RATES AND ITERATIONS

Avinash Agarwal, A. R. Senthil Kumar

National Institute of Hydrology, Roorkee – 247667

K. S. Kasiviswanathan

Indian Institute of Technology Madras, Chennai- 600036

Rakesh Kumar, R. K. Nema

National Institute of Hydrology, Roorkee – 247667

ABSTRACT

Radial Basis Function Artificial Neural Network (RBFANN) is widely used in many hydrological applications in recent years by many researchers. However, the study of the internal characteristics of RBFANN has been very limited. The data domain determines the optimal ANN structure, suitable learning rate and optimal number of iteration. An improper selection of these parameters leads to over or under-learning of RBFANN model. Suitable selection of learning parameter and optimum number of iteration achieves the optimal ANN structure which simulates the process in reliable accuracy. This paper investigates the suitable selection of learning rates and optimum number of iteration required for RBFANN to model the rainfall-runoff process. The daily rainfall and runoff data of Vamsadhara basin, Andhra Pradesh, were used to develop the model. The learning rates ALR and ALRG were used in function layer and output layer respectively. The optimum number of iteration was identified through appropriate selection of learning rate ALR and ALRG values and the model for the rainfall-runoff process was developed. The performance of the developed rainfall-runoff models were compared with the observed data.

EVALUATION OF VAIGAI RESERVOIR OPERATING RULES USING SIMULATION MODEL

V. Jothiprakash, R. Arunkumar

Department of Civil Engineering,
Indian Institute of Technology Bombay, Mumbai

J. Nirmala

Department of Civil Engineering, NIT Tiruchirapalli

ABSTRACT

Reservoirs are the major storage structures which serves many purposes. To assess the effectiveness of the reservoir, it is very much essential to assess the performance of the reservoir using simulation studies. Simulation is the process of reproducing the essence of the system without reproducing the actual system. Simulation is a powerful technique used for solving a wide range of problems through analysis of the behavior of the physical system. It is the primary tools used in reservoir system studies to assess the behavior of the real system for the given input condition. Based on the simulation studies the operational efficiency of the reservoir can be improved. In the present study, it is proposed to develop a comprehensive storage based simulation model to assess the performance of Vagai reservoir system, Tamil Nadu, India. The releases resulted from the developed simulation model will be compared with the actual releases made from the reservoir.

MODELING DAILY SOIL MOISTURE VARIATIONS FROM WEATHER DATA USING GENETIC ALGORITHM

Bhabagrahi Sahoo, B. P. Bhatt

ICAR Research Complex for NEH Region, Nagaland Centre,
Jharanapani, Medziphema-797 106, Nagaland, India

ABSTRACT

Considerable evidence on future global climate change shows that there will be increase in the air temperature altering the global soil temperature, thereby affecting the global soil water dynamics. Consequently, a simple semi-physically based soil heat transfer model is developed to estimate the soil moisture frequency at daily scale from the daily weather data. The model involves three steps: i) estimation of net solar radiation from the observed weather data to compute the soil heat flux, ii) estimation of soil temperature using the soil heat flux, and iii) estimation of soil moisture content from soil temperature. The model is tested using the observed data during the soil drying phase available at two soil depths of 5 cm and 15 cm in Nagaland State, India. The parameters of this heat transfer model are estimated using the limited observed soil temperature data using the Genetic Algorithm (GA). The results reveal that the GA-based soil heat transfer model can be effectively used for modeling the variation of soil moisture content at daily scale, hence indirectly modeling the possible agricultural drought under global climate change scenarios. Since, in contrast to the other meteorological variables, soil temperature and soil moisture are rarely measured on a regular basis spatially across landscapes, not even at a well-equipped weather station, this GA-based model could be used for agricultural water management directly based on the weather variables.

APPLICATION OF DECISION SUPPORT SYSTEM IN WATER RESOURCES PLANNING AND MANAGEMENT - CASE STUDY

B. Chakravorty, N.G. Pandey, R.V. Ramana

Centre for Flood Management Studies, National Institute of Hydrology, WALMI Complex, Phulwari Sharif, Patna-801505, Bihar.

ABSTRACT

A Decision Support System in water resources management provides the Water Management Authorities with a well-structured, user-friendly, practical and complete Management Information System (MIS). The main objective of water resources planning and management is to solve the equation of demand and supply of water resource for a specific area and maximize water use benefits subject to constraints on area available, meeting crop water requirements, meeting in-stream water use requirements, etc. A case study is presented here to illustrate the application and importance of DSS in water resources planning and management.

The study pertains to drainage congestion of lower Gandak basin. The lower Gandak basin has the problem of excess surface water during *Kharif* season (July to October) due to flood in Gandak river and release of excess water through its canal system making *Kharif* cultivation difficult. During *Rabi* (November to February) and *Garma* seasons (March to June), flow in the river reduces and at the same time due to greater utilization of canal water in the upper reaches, lower Gandak command receives almost negligible quantum of water from the canal system. Therefore, agricultural activity of the area suffers in all three cropping seasons of the year. This problem has been managed by developing a conjunctive model of the area by solving groundwater flow model using MODFLOW. The model acts as a Decision Support System for the planners for increasing the agricultural productivity in the region.

CANAL SIMULATION MODEL – DECISION SUPPORT TOOL AND ITS APPLICATION TO SARDAR SAROVAR (NARMADA) PROJECT CANAL CONVEYANCE SYSTEM

M. B. Joshi, K. D. Acharya

Narmada Project Design Circle, Sardar Sarovar Narmada Nigam Ltd.,
Block No. 12, 4th Floor, Sardar Bhavan, Gandhinagar – 382 010, GUJARAT.

ABSTRACT

For a vast canal network, safety, flexibility of operation and improved response time are the main objectives of operating various canal regulating structures. Controlled Volume Concept (CVC) provides a means to meet the aforesaid requirements for successful operation of large water distribution system like that of Sardar Sarovar (Narmada) Project. It needs almost simultaneous operation of several regulating structure which is not feasible without Remote Monitoring & Control System. The operation of canal control structure to meet the fluctuations in demands, needs the knowledge of the inter-dependence of various parameters like discharge, gate opening, difference of head, flow depth etc. Simulation of canal flow is a numerical technique by which the effect of changing any one of these parameters on the rest of the parameters can be effectively studied. The Mathematical Model can simulate the system under different schemes of operation and provide information regarding anticipated physical system behavior. Canal Simulation Models developed in-house namely Narmada Project Steady State Model (NPSSM) and Narmada Project Unsteady State Model (NPUSM) are presented in this paper along with results of numerical experiments.

RESOURCES[®] - A REGIONAL RESOURCE CHARACTERIZING SYSTEM FOR EFFECTIVE DECISION MAKING

Ravinder Kaur

Division of Environmental Sciences
Indian Agricultural Research Institute, N.D. -12

Currently, agriculture production is facing many challenges such as increased land degradation, shortage of irrigation water, increased cost of production, adverse impacts of agriculture on the environment etc. There is increasing public concern for the environmental effects of agriculture, particularly on water quality and in turn of the environment on agricultural productivity and profitability. However to study the complete context in which resources are modified by widely distributed agricultural activities it is very essential to understand the impacts of water and soil resources and agricultural management practices at the regional scale. However this is only possible with the growth of consistent data at similar scales and the digital analytical and display techniques like geographic information systems (GIS).

In this context, an indigenously developed tool ResourCeS[®] - a customized regional Resource Characterizing System helps in overcoming most of these problems by integrating all such non-uniform and de-centralized resource information at one place in a uniform format. The ResourCeS[®] has been developed on Avenue programming language and requires Arc-View/ Spatial Analyst GIS software for its installation. The developed tool can very efficiently examine and handle a wider range of spatial data bases such as soils, hydrology, weather etc and integrate them with socio economic variables. Simultaneous examination of these variables leads to a better understanding of various agricultural related processes and their interactions over space and time and accurate assessment of the extent and source of varied resource degradation problems across a region. Further, using regional scale interpretations, it is possible to define priority areas for research on cause and effect relationships. Besides, the developed tool can support various watershed and water availability and water quality assessments, at say village/ block/ district level, across different policy zones. Examples of such studies include delineation of the actual canal command areas and their extent during different cropping seasons; assessing feasibility and implications of current canal water rotational plans; proposing alternative (demand based) canal water rotation plans and delineating areas with potential for conjunctive use of canal and ground waters. For proper crop planning it is very essential to identify areas with single or conjunctive water use potential. Successful validation of the developed tool on 58-field surveyed sites within the canal command area of Mewat district showed that despite extensive canal network, ground waters alone were the main source of irrigation in the test area. This was found to be primarily because of a lack of assured / adequate canal water supply (due to frequent electricity cuts/ mal-functional pumps) in the lift irrigated areas surrounding Harchandpur, Utawar, and Banarasi distributaries and excessive seepage from the unlined / breached sections of the Nuh, Indri, Uleta, and Harchandpur distributaries. The analysis thus illustrated that the

developed module can even be used for benchmarking/ assessing canal irrigation performance of any region.

As public policy on agriculture is generally made for very large areas, it is hoped that the aforementioned indigenously developed spatial decision support system may prove to be a very useful tool for the decision makers for understanding the possible outcomes of their decisions and developing appropriate plans and policies for meeting the increasing demand of food requirements without damaging the natural resources base of any region of interest.