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Flow Forecasting of Tapi River At Mandvi Station By ANN

* Gajjar Kamleshkumar Hasmukhbhai
** Prof. H.M.Gandhi

* P.G. Student, 11-A/1-Murlidhar Society, Opposite Gaushala Ghagha road, bhavnagar

** Associate Prof. & Head, Shantilal Shah Engineering College, Sidsar campus, Bhavnagar

ABSTRACT

The application of artificial intelligence tools in Water Resources Engineering is quite complex because there are many dependent are concern with independent variables. In this paper attempt have been made to apply the simulation applicability of the Artificial Neural Network to the Tapi River for flow forecasting at mandvi station. The river is having wide variety of flow and the region is widely affected by the variation of the flow.

Keywords : Algorithms, Artificial Neural Network, Evaporation, Flow Forecasting, Inflow, Rainfall, Regression, Simulation, Water level

I. INTRODUCTION

Flow is common and mostly natural parameter of a river that is rate at which water is flowing. When river is overflows, their banks they cause damage to lives, property, infrastructure and crops. Floods are common and mostly natural disasters which are simultaneously related to heavy flow.

Heavy flow is usually local, short-lived events that can happen suddenly and sometimes with little or no warning. They usually are caused by intense storms that produce more runoff than an area can store or a stream can carry within its normal channel. Rivers can also flood its surroundings when the dams fail, when ice or a landslide temporarily block the course of the river channel, or when snow melts rapidly. In a broader sense, normally dry lands can be flooded by high lake levels, by high tides, or by waves driven ashore by strong winds. Small streams are subject to floods (very rapid increases in runoff), which may last from a few minutes to a few hours. On larger streams, heavy flow usually last from several hours to a few days. A series of storms might keep a river above flood stage (the water flow rate at which a river overflows its banks) for several weeks.

Variation in Flow has always been a recurrent phenomenon in India. More than 12 per cent of the total land area in India prone to heavy flow. That's why, it is necessary to understand the concept of flow. This section on 'flow forecasting' will help us understand the term better. When river overflows their banks they cause damage to lives, property, infrastructure and crops. Floods are common and mostly natural disasters.

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Flowing water in high rate has been a major concern for people inhabiting in the vicinity of river and water bodies since the down of civilization. Despite the fascinating developments achieved in many areas during the last three decades, the hazard of flooding has not yet been eradicated. In fact recent floods seem to have been more abundant and more destructive in many regions of globe than the earlier ones, and the projections for the future look gloomy. This is call for a need to re-think the strategy for flow parameter. Traditionally, the strategy was to protect as far as was technically possible and an affordable. However, since complete protection is never possible and an acceptable level of protection may be expensive, an approach is to accommodate high flow i.e. to prepare to live with floods.

In terms of high flow, Floods are the recurrent phenomena in India from time immemorial. Almost every year some or the other part in India are affected by floods of varying magnitudes. Different regions of the country have different climates and rainfall patterns and as such, it is also experienced that while some parts are suffering from devastating floods, another part is form draughts. With the increase in population and development activity, there has been the tendency to occupy the flood plains which has resulted in more and increasingly serious damages over the years. Because of the varying rainfall distribution, areas which are not traditionally prone to high flow also often experience severe inundation. Thus, flood is the single most frequent disaster faced by the country.

A heavy flow is an overflow of expense of water that submerges the land. Flooding may result from the volume of water within a body of water, such as a river or lake, which overflows or breaks levees, with the result that some of the water escapes its usual boundaries. While the size of lake or other body of water will vary with seasonal changes in precipitation and snow melt, it is not a significant flood unless such escapes of water endanger land areas used by man like village, city or other inhabited area. It often causes damage to homes and businesses if they are placed in natural flood plain of the rivers. Damage can be virtually eliminated by moving lived and worked by the water to seek sustenance and capitalize on the gain of cheap and easy travel and commerce by being near water. That human continue to inhabit areas treated by flood damage is evidenced by the fact that the perceived value of near the water exceeds the cost of periodic flooding. Floods can also occur in rivers, when flow exceeds the capacity of the river channel. In India billions of rupees are spent every year in control of flow and flood forecasting.

At a given location of the stream, flood peaks vary from year to year and their magnitude constitutes a hydrologic series which enables one to assign a frequency to a given flow peak value. In the design of hydraulic structures, the peak flow that can be expected with an assigned frequency (say 1 in 100years or so) is of primary importance to adequately proportion the structure to accommodate its effect.

The total control of the flow is not practicable economic consideration and therefore flood mitigation is essential. The flood management rationally refers a provision of reasonable degree of protection against heavy flow by structural or non-structural measures to mitigate the recurrent havoc caused by flow. Non-structural measures like flow forecasting and warning of incoming floods have also played a significant role in reducing the loss of life and movable property apart from alerting the civic and engineering authorities, in-charge of various works to take appropriate advance action to fight the onslaught of floods.

Flow forecasting for a river basically means estimating future discharges or water levels in the river at selected places along the river during the high flood season. The aim is to forecast river stage and its time of occurrence at a place along the river. For formulating flow forecasts, it is necessary to have relevant hydrological data, such as physical and geographical characteristics of the river catchment and flood plains, such as current levels of water and flow in the river, and hydro-meteorological data, such as rain fall in the catchment and weather forecast.

Forecasting river flow or stage after heavy rain is important for public safety, environment, and water management. An early warning system is a set of procedures design to protect human lives and minimize damage to be expected from a flood which exceeds a certain critical level. It contains of a number of related and connected parts, i.e. forecasting, transformation of forecast into warning, transmission of warning to local decision markets, conversion of warning into remedial action.

A forecasting model can be a black-box or a physically based or a conceptual model the models are based on transfer functions which relate inputs with outputs. These models, as the name suggests, generally do not have any physical basis. Some commonly used black-box models include the unit hydrograph approaches, regression analysis, and time series models. The physically based models use the physical laws of various processes to model the catchments response. These laws are expressed through partial differential equations solved using numerical methods. The conceptual models fall intermediate to the physical and black-box models. Generally, the term 'conceptual' is used to describe models which relay on simple arrangement of a relatively small number of interlinked conceptual elements, each represents a segment of land phase of hydrologic cycle.

The field engineers face the danger of very heavy flow of water through the gates to control the reservoir level by proper operation of gates to achieve the amount of rate of water flowing over the spillway. This can be limited to maximum allowable flow and control flood downstream restricting river channel capacity so as to have safe florid levels in the river within the city limits on the downstream.

By keeping the water level in the dam at the optimum level in the monsoon the post monsoon replenishment can be conveniently stored between the full reservoir level and the permissible maximum water level. Flow estimation is very essential and plays a vital role in planning for flood regulation and protection measures.

The total runoff from catchments area depends upon various unknown parameters like Rainfall intensity, Duration of rainfall, Frequency of intense rainfall, Evaporation, Interception, Infiltration, Surface storage, Surface detention, Channel detention, Geological characteristics of drainage basin, Meteorological characteristics of basin, Geographical features of basin etc. Thus it is very difficult to predict runoff of the river due to the nonlinear and unknown parameters.

II. Study area And data used

Tapi River is much more susceptible to Flooding conditions once in 5-6 years. In this constrict the flow measuring is vital for the river. In this paper, the flow of water at mandvi station is forecasted. Co-relation between upstream data of the ukai dam and mandvi station data is made by ANN. U/S Hydrological and Meteorological data leads to give forecasted flow at mandvi station situated downstream side (D/S) of the Ukai Dam. At ukai a Dam is Constructed called Ukai Dam. Mandvi station is at D/S side few KM from Ukai Dam.

The data of U/S side of the ukai dam are main deciding the flow at mandvi station are Water Level, Rainfall, Evaporation and Inflow of the Reservoir as the input values of the ANN.

The rate of flow at mandvi station is used as the Target value of the ANN. The mandvi station is selected for Flow forecasting, because the availability of the data from SWDC (State Water

Data Centre, gandhinagar)

Fig. 1.Mandvi Station and Ukai Dam

Flow at mandvi is influence by a number of factors such as upstream rainfall, water inflow, water level, heat and temperature, and evaporation rate. However, technological and management have limit the availability of the data. In this study, 1st, January, 2009 to 31st, December, 2010 daily data are used for the forecasting flow. Rainfall data, water level, inflow and evaporation of U/S side of the dam (t) are used as the input data and the flow at mandvi station at time (t+1) is used as the target.

III. METHODOLOGY

Data Scaling Methods:

Before presenting data to the neural network it is necessary to normalized the data within closed unit interval [0,1] or[-1,1].

Input data can be normalized and output result can be renormalized using following equations.

Normalized value =
(Actual value - Minimum value)/
(Maximum value-Minimum value)
Denormalized value =
Output result (Maximum value-Minimum value) + Minimum value

Artificial Neural Network Model:

Artificial Neural Network Model is designed for Flow forecasting. Selection of the Artificial Neural Network model architecture depends on the problem to be solved. The architecture includes number of layers, number of neurons within each layer, number of input variables, number of output variables and transfer function for hidden layer neuron and output layer neuron. Transfer function in the Artificial Neural Network maps the input variables to output variables. Transfer function is the key element to invoke the nonlinear relation between input variables and output variables. The architecture for feed forward neural network is as shown in fig.1.

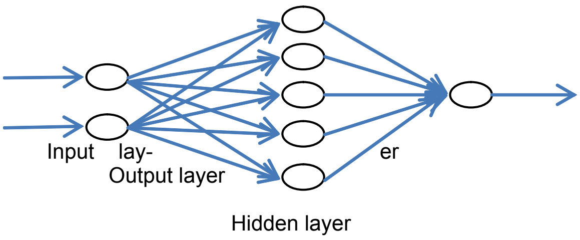

Fig. 2.Feed Forward Neural Network Architecture

Number of neurons within each layer depends upon the efficiency of the learning rule. In learning operation output is compared with target value and deviation is fed back to modify the weight .Process of weight adjustment is carried out until the error between actual and desired output is reduced to acceptable level.

The Feed Forward Neural Networks is used for Flow forecasting modeling because it is fault tolerant and come up with solutions for ill-defined irregularities, through the use of hidden layers. Back-propagation learning algorithm is used for weight adjustment to reduce the forecasting error to minimum. Number of hidden layer chosen is one. More number of hidden layers required if problem is complex. Transfer function used for the hidden layer neurons is tan sigmoid and for output layer is purlin as shown in figure 3.

Artificial Neural Network model for Flow forecasting for year 2009-2010:
Neural Network : Feed forward type
Training/Learning Algorithm : Back-Propagation Network connection : 4:10:1
Transfer function for hidden layer : TANSIG
Transfer function for output layer : PURELIN
Performance function : MSE
Training: Validation: Testing : 60:20:20

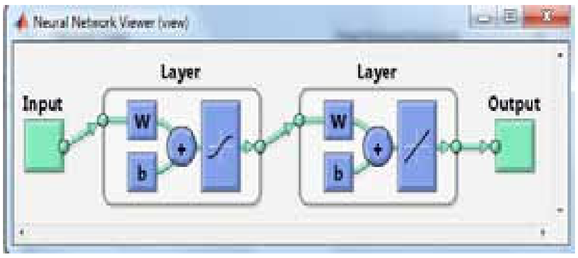

Fig.3. Feed forward type neural network

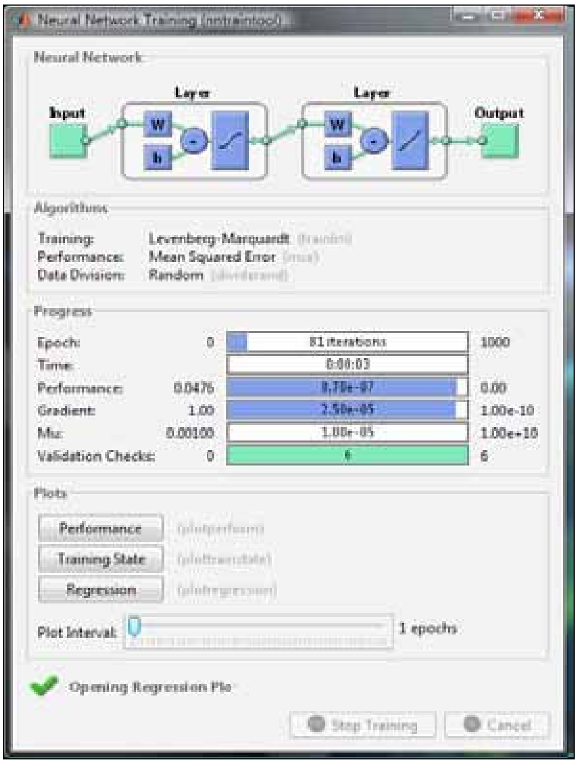

Fig.4 Neural Network Training Status.

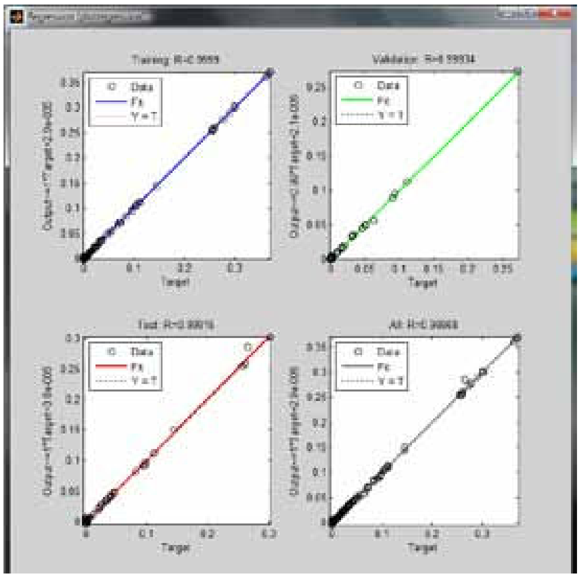

Fig.5 Regression of Neural Network (Training, Validation, & Testing)

IV. RESULT:
After applying Denormalizing equation the result is tabulated below.

Table-1
Comparison of Actual Flow and ANN Forecasted Flow is tabulated below in M3/se

Year	Month	Day	Actual Discharge	ANN based forecasted Discharge
2010	12	1	20.00	16.35
2010	12	2	20.36	16.93
2010	12	3	19.99	16.88
2010	12	4	20.13	17.52
2010	12	5	20.20	17.53
2010	12	6	19.90	18.32
2010	12	7	19.97	17.46
2010	12	8	20.19	17.49

2010	12	9	20.01	16.81
2010	12	10	19.94	16.80
2010	12	11	19.84	17.41
2010	12	12	20.00	16.78
2010	12	13	19.89	16.76
2010	12	14	19.77	16.71
2010	12	15	20.15	17.41
2010	12	16	20.13	17.37
2010	12	17	19.79	16.68
2010	12	18	19.68	17.31
2010	12	19	19.90	16.69
2010	12	20	19.81	17.29
2010	12	21	20.15	18.16
2010	12	22	19.91	17.31
2010	12	23	20.20	18.17
2010	12	24	20.02	17.40
2010	12	25	19.84	19.25
2010	12	26	19.95	17.39
2010	12	27	19.98	17.39
2010	12	28	20.15	16.76
2010	12	29	20.04	15.85
2010	12	30	19.79	17.37
2010	12	31	19.79	17.37

V.CONCLUSION:

Flow forecasting modeling is complex problem to solve because of sometime bad data measurement and deficiency in data due to bed season. Knowledge of Flow Diversion profile helps to understand the water consumption pattern and hence to propose Flow forecasting model. Here attempt is made to forecasting the total Flow of mandvi station. Separate model is proposed for each category of seasons also. The water level, Inflow, Rainfall and Evaporation at ukai dam are the best input variables to forecasting flow of mandvi station. Although the actual values of flow and flow forecasted by ANN are nearly same and Shown in Table-1. Hence, the ANN can be applicable for forecasting hydrological parameters like Flow of the river.

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