Univariate Time Series Prediction of Reservoir Inflow using Artificial Neural Network

Viraj Kawade, Hrishikesh Kote, Vishnukant Gangaji, Dr. Alka S Kote

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Abstract –. *Reservoir operations concerns taking decisions regarding water release as per the demand. Close monitoring of reservoir inflow data is crucial for this operation. If inflow prediction is carried out then necessary measures could be taken for planning the water resources. ANN is used for inflow prediction because it maps the nonlinear relationship between the input and output variables. In this study MLP & GFF network type of ANN's are used for developing inflow prediction models. Pawana reservoir in Pune district of Maharashtra is the study area. Historic daily data of the reservoir of 10 years between 2008 to 2018 is used for modelling. Mean square error and correlation coefficient is used as performance criteria for evaluating the models. MLP 3-4-1 with R=0.79 and GFF 3-8-1 with R=0.71 gave the satisfactory predictions.*

Key Words: **Reservoir inflow, Multilayer perceptron, General feedforward network, Daily inflow**

1.INTRODUCTION

Due to the expanding human population competition for water is growing such that many of the worlds major aquifers are becoming depleted and water scarcity is seen everywhere. So it is of utmost importance to collect, store and utilize available water by meticulous planning so as to cater the demand. Reservoir is used for various purposes like water storage, controlling floods, generating electricity, supplying water for irrigation and industries. All these purposes could be carried out smoothly with proper planning and reservoir operations. Reservoir operation concerns taking decisions regarding water release as per the demand .Close monitoring of reservoir inflow data is crucial for their operations

Artificial Neural Network (ANN) is a modeling tool that identifies the relationship between input and output variables and operates by learning relationship by studying the past data records i.e. it is based on adaptive learning. Neural network based solution is very efficient in terms of development, time and resources. ANN consists of an interconnected network of input layer, hidden layer and output layers and several parameters that drive the output of a model. Some of these parameters are weights, transfer functions, biases, number of epochs, learning rule, etc. Each node in the network has some weights assigned to it. A transfer function is used to calculate the weighted sum of inputs and bias is added. The result of transfer function is fed as input to activation function. Activation function decide which node to fire and are used in all the three layers. Based on the fired nodes, the output layer produces the final predicted output.

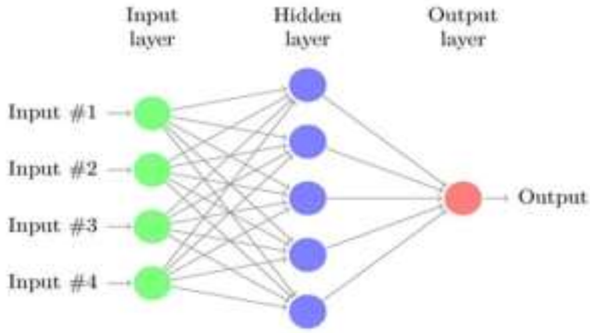

Fig. 1General architecture of ANN

2. METHODOLOGY

The data required for the present study was collected from the Khadakwasla Division of Sinchan Bhavan which is the executive authority of Pune Irrigation department. The dataset included reservoir water level , dead storage, live storage, rainfall, water discharge through canals for irrigation, domestic consumption, industries and hydroelectricity generation of monsoon period from the year 2008 to 2018.Focus area of the study is Pawana reservoir which is built on Pawana river basin in Maval tehsil of Pune.

Multilayer perceptron and Generalized feedforward network are used for developing inflow forecasting model .Various transfer functions like tanhaxon, linear tanhaxon, sigmoid and learning rules like momentum gradient, Levenberg Marquardt, conjugate gradient, gradient descent are considered to determine the best structure in the ANN modeling. To confirm the stability of the results, number of trials have been made and the developed model is simultaneously evaluated against performance criteria of mean square error(MSE)and correlation coefficient(R). Training a neural network is done by adjusting the weights of the network at each step of an iterative process to bring the output closer to the desired output. The purpose of training neural network is to get a network that performs best on unseen data. Training is done by many networks on a training set and comparing the errors of those networks. The network parameters such as the number of hidden layers, hidden nodes, transfer functions and learning rules are changed multiple times to generate the finest weights for the model. The reason for the testing phase of ANN model is to make sure that the developed model is successfully trained and generalization is effectively achieved on unseen data.

Neurosolutions software version 6.0 is used for developing the ANN inflow models.

3. RESULTS AND DISCUSSIONS

While developing the model three nodes are taken in the input layer. Daily inflow data of 10 years is arranged in sequence and taken as input to node 1. Data is lagged by one day each for the next two consecutive nodes 2 & 3 respectively. Output node is the current inflow data with a lead of one day. The best developed modes are as mentioned in table 1.

Table no.1 Comparison between best developed MLP and GFF models

Name of Model	MLP 3-4-1	GFF 3-8-1
No. Hidden layers	4	8
% Training data	80	75
% Testing data	20	25
Activation function	Tanhaxon	Tanhaxon
Learning rule	Momentum Gradient	Levenberg Marquardt
MSE	4.31	6.459
R	0.79	0.71

Time series plots (Fig 2 & 4) shows that model output and observed output overlaps which is satisfactory. Also from the scatter plots (Fig 3 & 5) it can be said that plot has good correlation R=0.79 and R=0.71 for MLP 3-4-1 and GFF 3-8-1 respectively. Certain points away from the overall data. These data points have very large values and these points are not used while training, so during testing they are under predicted inflow.

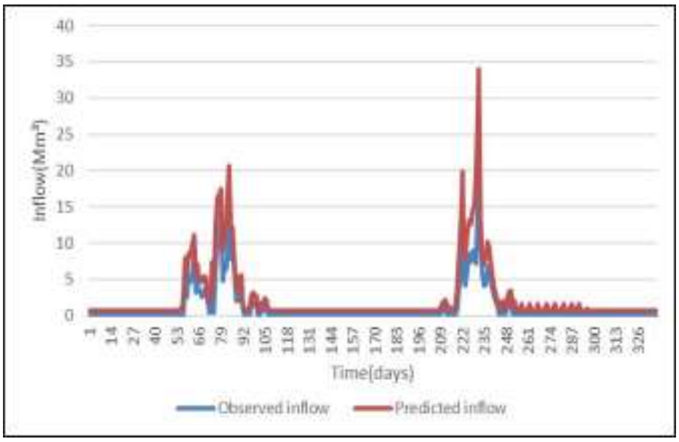

Fig.2. Time series plot of observed and predicted inflow values by MLP 3-4-1 during testing phase

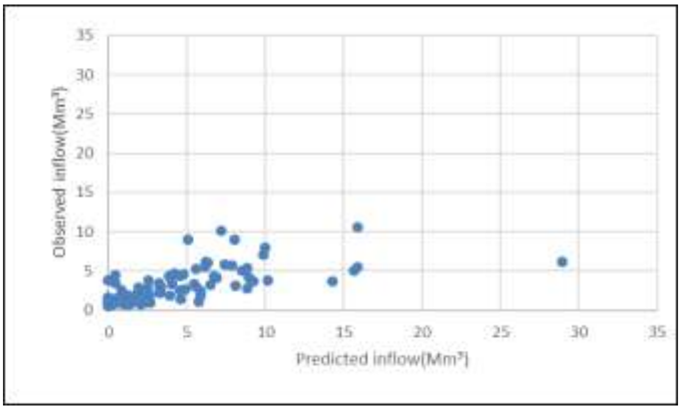

Fig.3. Scatter plot of observed and predicted inflow values by MLP 3-4-1 during testing phase

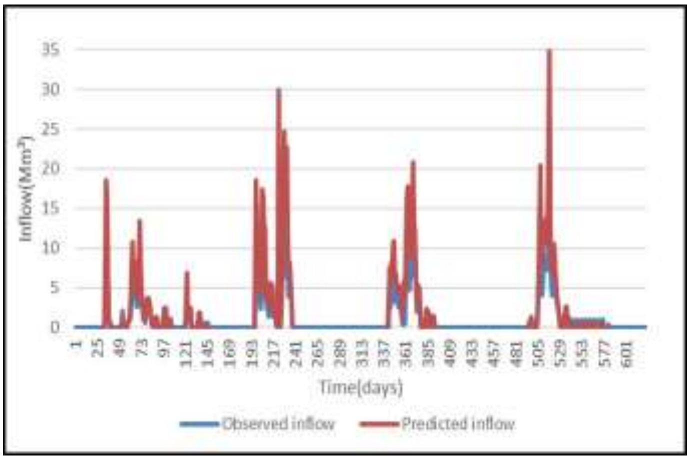

Fig.4. Time series plot of observed and predicted inflow values by GFF 3-8-1 during testing phase

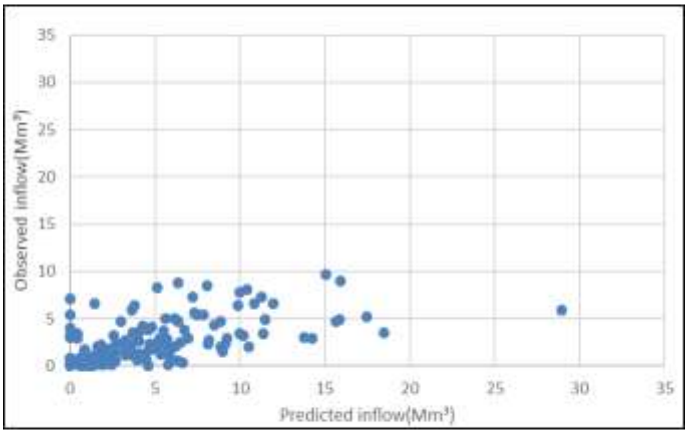

Fig.5. Scatter plot of observed and predicted inflow values by GFF 3-8-1 during testing phase

4. CONCLUSIONS

From the prediction models developed for inflow in Pawana reservoir using ANN, it is observed that MLP network gave prediction with more accuracy as compared to GFF. Values of 'R' for MLP & GFF came out to be 0.79 & 0.71 respectively. Also it is learnt that as hidden layers and nodes are increased value of 'r' increases

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