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Research Paper

Prediction of stream flow by utilizing artificial neural network in flood plain (Case study: Sepidroud watershed)

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Abstract: For knowing the hydrological behavior and water management of Sepidroud River (North of Iran-Gilan) the present study focused on stream flow forecasting with artificial neural network. Ten years (2000-2009) historical inflow data, observed from the Sepidroud River, were selected ; then 10 years inflow of the Sepidroud River have been forecasted by neural network. Finally, the results obtained from forecasted data compared with observed data. The results showed that neural network could predict stream flow with high precision and the maximum error between predicted and observed data was 3% approximately.

Keywords: Stream flow, neural network, water management, Sepidroud watershed

Introduction

Generally, short term forecasts applicable for real time operation of water management and flood warning (3), whereas, long term forecasts are applicable for management of water supply system (5). Non-linear relationships between input and output flow, challenges stream flow forecasting processes and lot of uncertainty is involved in stream flow data (4). Artificial neural network (ANN) has become one of the commonly technique to predict time series data which has a non-linear mathematical structure leaning on interactions between input and output data (9). It is comprised of data processing units (neurons) connected via adjustable connections (weights) (10). The function is established based on the connections between elements of the network. The network learns by applying a back propagation algorithm which compares the neural network simulated output values to the actual values and calculates a prediction error. The error is back propagated through the network and weights are adjusted as the network attempts to decrease the prediction error by optimizing the weights (7).Application of ANN to problems involving rainfall-runoff modeling and river flow prediction have been investigated by several researchers (2, 6, 8, 11).The present study focused on stream flow forecasting for Sepidroud River by neural network.

Martial mad Methods

In this paper, for model development, 10 years historical inflow data of Sepidroud River has been used. Two years inflow of Sepidroud River has been forecasted by ANN and validated by observed data. The characteristics of Sepidroud watershed (Guilan-North of Iran) were shown in Table 1.

Table 1. Basic characteristics of Sepidroud catchment

Catchment area (km2)	Sp	10.80
Forested catchment area (km2)	SL	9.84
Forestation (%)	l	90.14
Length of river(km)	L	6.438
Length of inflows (km)	ΣLpi	9.263
Catchment perimeter (km)	O	14.905
Length of talweg (km)	Lu	6.834
Max. catchment altitude (a.s.l.)	H max	1458
Min. catchment altitude (a.s.l.)	H min	569
Average catchment altitude (a.s.l.)	H ave	909.86
Average width catchment (km)	Bp	1.580
Average river slope (%)	It	15.75
Average talweg slope (%)	Iú	12.34
Average catchment slope (%)	Is	31.15

Also the inflows observed data at Manjil station of Sepdroud River were shown in Figure1.

The historical time series data for stream flow forecasting was taken of 10 years averagely. For forecasting stream flow ANN was used leaning on 2 years average inflows. In the present study, neural network fitting tool of MATLAB 7.8 has been used (Beale et al 1996). Hyperbolic function according to Equation 1 was applied for hidden layer and the linear transfer function was used in the output layer.

$$F(x) = 1/(1+\exp(x)) \quad (1)$$

Input data was applied after normalization process between -1 and +1. To evaluate neural network performance, initialization of connection weights, training, validation and testing has been performed with five independent trials. The comparison of the mean

squared errors (MSE) values indicates the average squared difference between outputs and targets, which is used to asses the network performance has been given by equation 2.

$$MSE = (\sum_{m=1}^{M} (Ym - Dm)\text{^}2)/M \quad (2)$$

Where Ym and Dm are the network output and the desired output at any sample "m" respectively and M is the length of the investigated data sets. Also correlation coefficient R values provide how well model is close to actual values. In other words, it provides a measure of how well future outcomes are likely to be predicted by the model. It is desired that R values to be very close to 1.

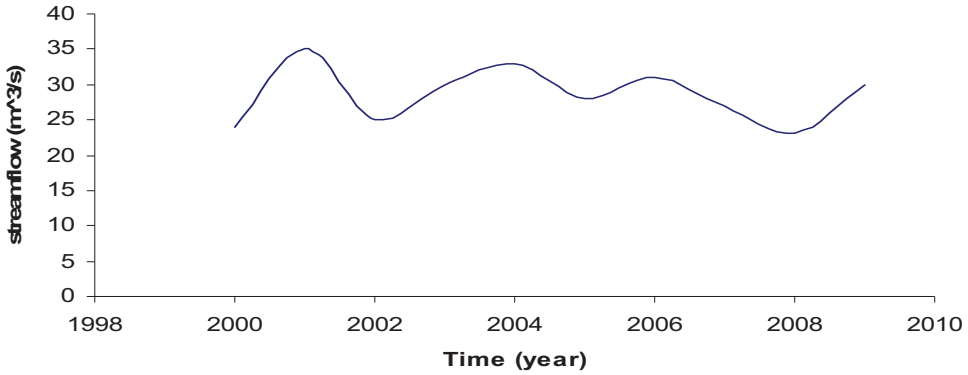

Figure 1. Mean stream flows observed data at Manjil station –Sepidroud River

Results

In Table 2 MSE and R were shown.

Table 2. Performance evaluation of training, validation and testing for data

Number of hidden layer neurons	operation	MSE	R
2	Training	124	0.741
2	Validation	106	0.750
2	Testing	53	0.800
3	Training	82	0.880
3	Validation	43	0.890
3	Testing	22	0.890
4	Training	29	0.975
4	Validation	16	0.978
4	Testing	13	0.980
5	Training	28	0.999
5	Validation	22	0.989
5	Testing	18	0.991

Also Figure 2 showed the prediction accuracy of model.

It can be realized that good prediction accuracy has been achieved with 5 numbers in the hidden layer on fifth trial for best model chosen values of R was 0.999 that showed a perfect fit where outputs and targets were equal to each other approximately. Stream flow forecast results for 10 years, with proportions of data ratio 90:05:05 have been shown in Table 3 and Figure 3.

Table 3. Various percentage of forecast errors in ANN model with

Ratio	**PME**	**Accuracy (%)**
90:05:05	0.0015	97

If Zt is forecasted data and Zi is actual observed data, the forecast error is:

$$Ei = Zi - Zt \quad (3)$$

Hence percentage mean error is obtained by Equation 4:

$$PME = (1/n) \times (\sum_{i=1}^{n} (Ei/Zi)) \quad (4)$$

According to Table 3 and Figure3, the accuracy of forecasting stream flow reached 97% approximately. Thus, the ANN prediction model would be useful in evaluating the performance of inflows and different operating policies.

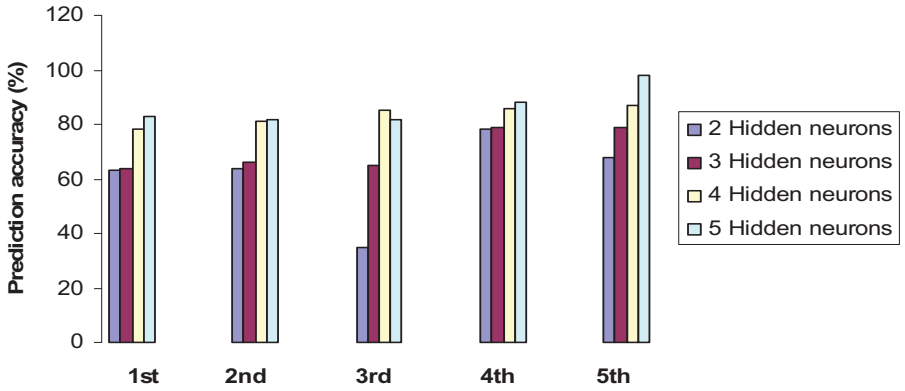

Figure 2. Prediction accuracy of versus number of trials with different hidden neurons

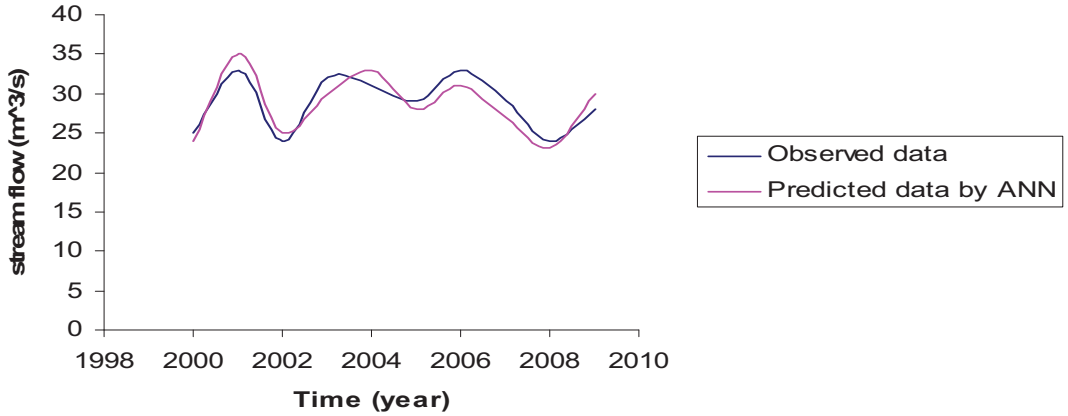

Figure 3. Comparison of best forecasted results by ANN model and observed data

Conclusion

In this paper, stream flow forecasting in long term series of time, has been investigated by ANN model. In order to evaluate the accuracy of ANN model observed and forecasted data have been compared and analyzed. The results showed the best accuracy of model reached 97% approximately in Sepidroud River.

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