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Research Article

EVALUATION OF ARTIFICIAL INTELLIGENCE MODELS (ARTIFICIAL NEURAL NETWORKS) TO FORECASTING THE DISCHARGE OF MONTHLY RIVER FLOW (CASE STUDY: BAHMAN SECTION, QAREAGHAJ RIVER)

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ABSTRACT
Estimates of river flow, due to its impact on water resources management can have an important economic role. Different methods can be used to predict the flow of the river. One method that has recently attracted the attention of many Researchers is the use of artificial neural networks.
Nowadays, intelligent systems (ANN) with its capability to solve nonlinear and complex phenomena, become useful for different problems of water engineering including hydrology, in this study we presented the evaluation of this system for predicting the flow of the QAREAGHAJ river.
MATLAB software was used in this study. For this purpose gauging, rainfall, temperature, evaporation and monthly discharge of the BANDE BAHMAN station on QAREAGHAJ River in 30-year period (October 1982 to October 2012) were used for the model. The results showed that the artificial neural network can predict monthly discharge of the river with solidarity coefficient of 75.0. According to the analysis done TANSIG with 3 layers, 8 neurons was chosen as the best model based on factors such as rainfall, temperature, evaporation, river discharge has an effect on the permeability. But generally in this study, the most important factor that changes the river flow is rainfall, discharge and somewhat temperature.

Keywords: *Flow Simulation, Artificial Neural Networks, QAREAGHAJ River – BAND BAHMAN*

INTRODUCTION
One of the most important problems in water resources engineering, is predicting that the river provides water that is important in resource planning. Water control structures such as dams, flood dams have an effective role in reducing or eliminating the damage caused by floods. But in many circumstances, economic or topography factors, makes the flood control impractical. In these conditions, river flow forecasting provides an alternative tool that to reduce flood damage.
A prior flood warning gives us time to evacuate people, livestock and equipment. To estimate the inflow into reservoirs, rivers flow forecasting is needed to be done with high efficiency reservoir flood control or other applications Moreover, nowadays, for navigating, water supply, water pollution and many other issues, predicted of river stage and discharge are needed Traditional instruments of predicting the rate of flow includes the precipitation - runoff unit hydrograph relationships methods, dynamics, graph flow rate- scale.
Because of the importance of the time factor it should be paid great attention to the development process in other to use flood warning system in the shortest possible time In order to speed up operations and minimizing human and tools errors, the methods of data collection and management, basic food preparation and publication of these forecasts needs to be carefully organized. Late warning given to evacuate people and property from the danger zone has no value (Chow, 1964).
newly established hydrometric stations, existing deficiencies in the statistics, most of the stations located mainly in the arid rivers, groundwater withdrawal and the need for greater attention to the critical situation and all causes of surface water is more subtle and statistics of the categories of predicting ARTIFICIAL effects in our catchment area and gives a more complete expression.

MATERIALS AND METHODS

Artificial Neural Networks

Artificial Neural Networks is a new name in engineering sciences that the primary and early by Frank Rosen Blatt in 1962 and seriously affecting by inventing and improving Perceptron model by Rvmlhart and Mkklnd 1986 was introduced to the world. This method is a neuronal and intelligent structure. It is modeled on neurons in the human brain.

Defined by mathematical functions, simulated brain neurons to intracellular behavior experimental and flexible nature of this method makes matters in categories like predicting that such a view can be seen in their structure and behavior are nonlinear can be used.

Simple Perceptron Neural Network

Frank Rosen Blatt, with connecting the neurons created and invented the Perceptron in a simple way, and analyzed them formally for the first time in a digital computer simulation model.

Multilayer Perceptron Neural Network (MLP)

In many complex mathematical problems that leads to solve complex nonlinear equations, a Multilayer Perceptron network can be used easily by defining appropriate functions and weights Different functions according to the method used by the neurons.

In this kinds of networks type of an input layer, hidden layer and a layer of output that ultimately provide answers to the question the input layer nodes, are sensory neurons and the output layer nodes, are neurons responding.

The hidden neurons are in the hidden layer such networks are often trained using error back propagation. An example of a multilayer perceptron network is shown below (Figure 1).

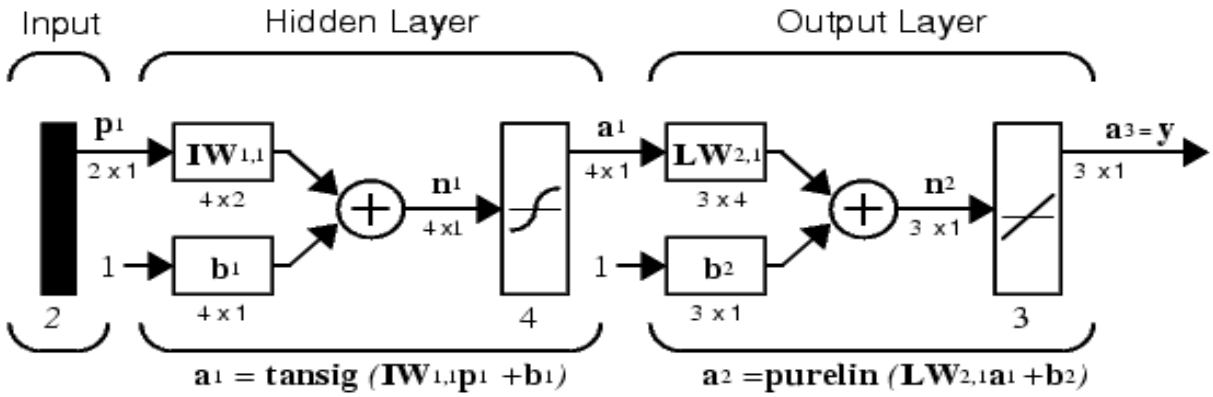

Figure 1: MLP structure with TANSIG hidden neurons and output neurons with a linear function

RESULTS AND DISCUSSION

The Study Area

BAND E BAHMAN hydrometric station is located at a distance of 7 km upstream of the KAVAR city on QAREAGHAJ River basin. QRHAGHAJ River North West of KAVAR Plains (KHANZNYAN Area) emanates of the mountains ANAR, ARJAN and KHANYBAK.

Length of the RIVER (Branches to enter the plains KAVAR) is 125 km and a catchment area is about 1586 km.

After arriving in the plain of the River KAVAR, from the North West to the South East and move along its path, while drainage of adjacent lands, agricultural lands are also liquor given the importance of this river, especially the agricultural sector, the rate anticipated in the coming years is important.

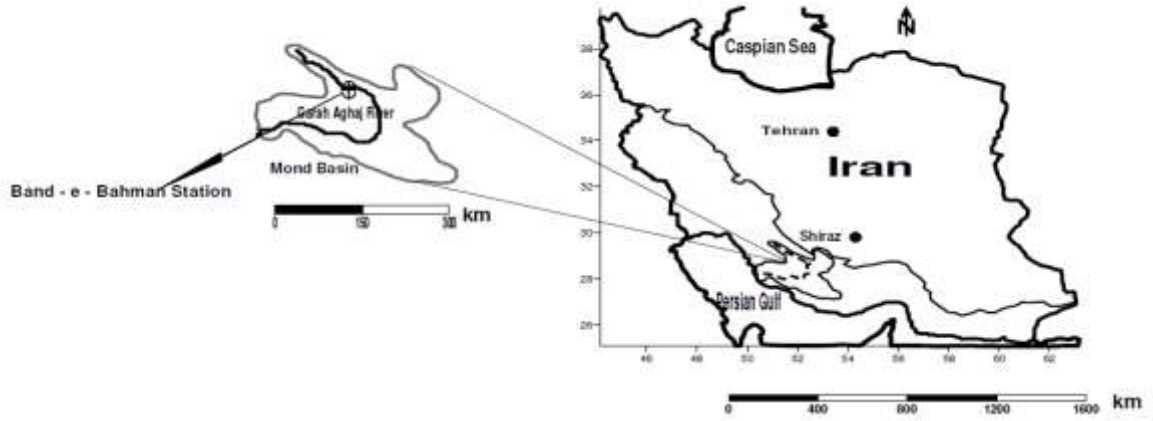

Figure 2: Regional map of Iran, Fars Province and location of study areas

Model Theoretical

1. **Providing training pairs:** The pair will include statistical data about phenomena that constitute the neural network input.
2. **To normalize the training pairs:** Data normalizing means to change their scale to be in a certain range according to the following formula from 1/0 to 6/0:

$$Xnormalized = 0.1 + 0.5\left(\frac{X_{Real}-X_{Min}}{X_{Max}-X_{min}}\right) \quad (1)$$

3. **Finding the best network structure:** The best neural network structure is to establish an appropriate combination of the number of hidden layers and number of neurons in order to achieve the minimum neural network error, it uses try and error (Menhaj, 2000).
4. **Learning neural Network:** About 80 percent of data was used for training artificial neural networks with different training algorithm is presented that the most famous one is back propagation learning algorithm (BP) that Was used in this study. In this method, first the data from the input layer is transferred to the output layer, then the error rate is calculated And finally back to the output layer from the input layer of the network weights will be modified to achieve the minimum network error continues.
5. **Neural network testing:** 20% of the remaining data was used to evaluate and test the accuracy of the trained network is essential to the operation of artificial neural networks to perform the test or exam. It will be performed by providing a pair of test set error rate of the network and compute the network. Obviously selecting the best structure of a neural network and the input pattern and comparing the values of errors in network testing must be done.

Talk About

Generally the amount flow per month can be related to discharges occurred in the past month as rainfall depends on factors such as the amount of snow and river discharge per month In this study River flow were studied with river flow in recent months, and monthly evapotranspiration and precipitation and temperature in the past month. Data of water year which is about October 1982 to October 2012 were studied those data includes discharge, rainfall, evaporation and temperature. 80% of data was evaluated for training and the remaining 20% for the test.

General function of river flow in each month is defined as follows:

$$Q_t = f\ (\ Q_{t-1}\ ,\ Q_{t-2}\ldots,\ P_t\ ,\ P_{t-1}\ ,\ldots,\ P_{t-n}\ ,\ T_t\ ,\ T_{t-1}\ ,\ldots,\ T_{t-n}\ ,\ E_t\ ,\ E_{t-1}\ ,\ldots,\ E_{t-n}\ ) \quad (2)$$

Where Q, P, T and E, respectively is, monthly flow rate, rainfall, temperature and evaporation." n " indicates the number of previous months. As it can be seen, the above Equation is a large equation with many parameters. The overall flow rate per month depends to the last few months of discharge and rainfall in the past few months. Effect of temperature and evaporation is low compared to other parameters; however, the effect of temperature and evaporation has been used in analyses of each month. The advantage of the ANN method is that the impact of multiple parameters such as rainfall, temperature, evaporation and discharge may be examined at any time. Now it has to be examined to determine parameters that depend on high river discharge of QAREAGHAJ. The below models shown in Table 1 will be selected and we will start the network training:

Table 1: Selection of river flow forecasting model

Model	Function	R
Ma	$Q_t = f(P_{t-1}, Q_{t-1}, T_{t-1}, E_{t-1})$	0.59
Mb	$Q_t = f(Q_{t-1})$	0.57
Mc	$Q_t = f(Q_{t-1}, P_{t-1})$	0.56
Md	$Q_t = f(Q_{t-1}, P_{t-1}, T_{t-1})$	0.75
Me	$Q_t = f(Q_{t-1}, P_{t-1}, E_{t-1})$	0.56

The survey found that the Md model with the lowest error and highest correlation is the best model for prediction of monthly stream flow for QAREAGHAJ RIVER. The layer of neurons and LOGSIG and TANSIG model was evaluated as follows:

Table 2: The number of layers and neurons selection to predict river discharge

Network	Number of layers	Number of neurons	R	Transfer function
1	4	5	0.57	LOGSIG
2	3	3	0.60	LOGSIG
3	3	4	0.49	LOGSIG
4	3	6	0.50	TANSIG
5	4	7	0.57	TANSIG
6	3	8	0.75	TANSIG
7	3	10	0.50	TANSIG
8	4	3	0.55	TANSIG

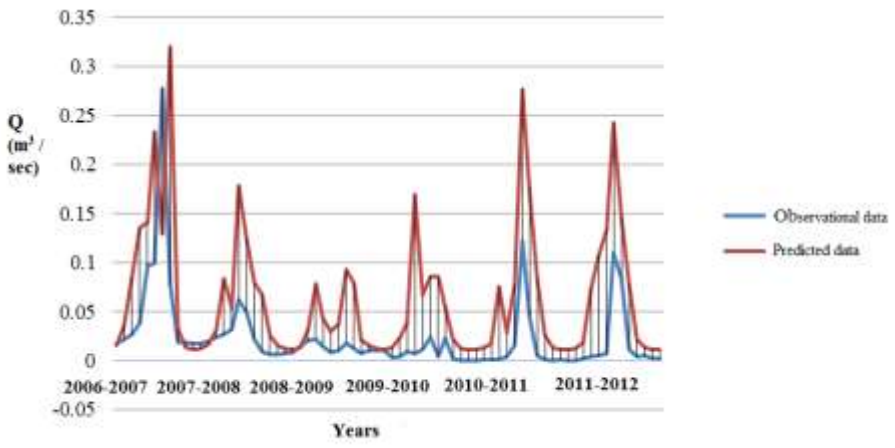

Figure 3: Verification of the model Md

As the study was conducted it was found that Step 6 with the lowest error and highest correlation with the number of three layers, 8 neurons the best model for forecasting monthly river discharge QAREAGHAJ selected by using TANSIG the correlation coefficient of 75%.
As in Figure (3) is specified, the blue curve shows the 20% observational data and the red curve shows the predicted data.

Conclusion

1-Due to factors such as rainfall, temperature, evaporation, infiltration has an effect on the flow of rivers, but generally the main cause of changes in river flow, is rainfall.
2-In this study, the parameters of flow, rainfall, evapotranspiration and temperature were studied on river discharge TANGAB that the precipitation model was tested on:

$$Q_t = f(Q_{t-1}, P_{t-1}, T_{t-1}) \quad (3)$$

Per month to the monthly discharge of rainfall, discharge and to some extent depend on the temperature in the previous month and the correlation coefficient is calculated as 75% of that amount is acceptable.
3-Power of using neural networks owing to the large number of parameters can be simultaneously used as inputs to the model definition are much higher than other methods.
Finally, in this recent research by using artificial neural network the performance of this method has proven extremely accurate. Based on experiments with a small number of domains, the flow rate in exchange for all of the calculated domain parameters has calculated therefore the remaining unknown with the desired pattern of artificial neural network needed to calculate.

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