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Predicting the Daily Evaporation in Ramadi City by Using Artificial Neural Network

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ABSTRACT

In this paper the artificial neural network used to predict dilly evaporation. The model was trained in MATLAB with five inputs. The inputs are Min. Temperature, Max. Temperature, average temperature, wind speed and humidity. The data collected from Alramadi meteorological station for one year. The transfer function models are sigmoid and tangent sigmoid in hidden and output layer, it is the most commonly used nonlinear activation function. The best numbers of neurons used in this paper was three nodes. The results concludes, that the artificial neural network is a good technique for predicting daily evaporation, the empirical equation can be used to compute daily evaporation (Eq.6) with regression more than 96% for all (training, validation and testing) as well as, in this model that the Max. Temperature is a most influence factor in evaporation with importance ratio equal to (30%) then humidity (26%).

Key worlds: daily evaporation, model, Artificial neural network, Predicting

التنبؤ بالتبخر اليومي باستخدام الشبكات العصبية الصناعية

الملخص

استخدمت الشبكات العصبية الصناعية في هذا البحث للتنبؤ بالتبخر اليومي . تم تدريب موديل باستخدام برنامج الماتلاب مع خمسة مدخلات . المدخلات المستخدمة في هذا الموديل هي درجات الحرارة الصغرى والعظمى ومعدل درجات الحرارة , سرعة الرياح والرطوبة النسبية . تم اخذ البيانات من محطة الانواء الجوية في الرمادي لمدة سنة كاملة . تم استخدام دالة سكمويد للطبقة المخفية ودالة تان سكمويد لطبقة المخرجات باعتبارها الاكثر شيوعا واستخداما في المعادلات غير الخطية . كما تم استخدام ثلاث عقد كأفضل عدد لهذه المسألة .اظهرت النتائج ان الشبكات العصبية الصناعية تعتبر تكنيك جيد للتنبؤ بالتبخر اليومي كما تم التوصل الى معادلة يمكن ان تستخدم لحساب التبخر اليومي (معادلة رقم 6) بمعامل ارتباط اكثر من 96% لكل من (الاختبار, التحقق , الفحص) فضلا عن ذلك تبين ان درجة الحرارة العظمى تعتبر العامل الاكثر تأثيرا على التبخر بنسبة تصل الى 30% ثم الرطوبة النسبية بنسبة تصل الى 26 %.

1- INTRODUCTION

Evaporation is a measurement that combines or integrates the effects of several climate elements: temperature, humidity, rain fall, solar radiation, and wind speed. It is should be measured in the design of various water resources and irrigation systems. The evaporation increases with high wind speed, Max. Temperatures and low humidity **Chow, et al. [1]** The artificial neural network applied in many of study and different sciences. The behavior of ANN is same manner as biological neural networks. It is simulation the input and output data. Estimation of evaporation losses is one of this applied . (**kumar, et al** [2] **; Keskin and Terzi** [3] **; Hossein, et al** [4]) they appointed air temperature , solar radiation , relative humidity and wind speed as input data for ANN models , they proved the ANN are able to perform reliable estimation of evaporation .

Many researchers are formulate Evaporation from meteorological parameters through empirically developed methodologies , statistical , stochastic approaches and massbalance **Bruin** [5] ; **Abtew** [6] . Evaporation is a main element of the hydrologic cycle. It is considered a key factor in management of water resources for arid and semi-arid regions. There are many of experimental formulation exist for appreciation of evaporation. There are direct and indirect technique available for estimating potential evaporation from free water surfaces , because of evaporation is nonlinear, complex and unsteady process, it is difficult to derive an exact formula to represent all the physical processes involved. As a result, there are new trend in using data mining techniques such as artificial neural networks techniques to estimate the evaporation. **Kumar, et al** [7]

Pallavi and Rajeev [8] studied the Predicting Reservoir Evaporation UsingArtificial Neural Network , they are using four ANN model to predict the evaporation losses from NathSagar Reservoir of Maharashtra with change input and number of hidden neurons their study shows that the second model (ANN-2 (4-9-1)) was the best model for evaporation estimation , this model depending on four input (Max temp , Relative Humidity, Sunshine Hours and Min. Temp.) and 9 neurons with a correlation coefficient (R^2) of 0.974 and the root mean square value (RMSE) of 1.276.

The main aim of this study was to predict equation can be used to calculate daily evaporation in area under study.

2- AREA UNDER STUDY

This study was carried out in Al-Ramadi , western Iraq (N 33.43° , E 43.33 °) . The data were obtained from meteorological station in this city. This meteorological station recorded in the World Meteorological Organization (WMO) with code 645. The data were Min. Temperature, Max. Temperature wind speed and relative humidity for one year . The ANN model was applied to provide a math. Equation for estimating free surface evaporation.

3- THE ARTIFICIAL NEURAL NETWORK MODEL

A neural network is considered in MATLAB which consists of 5 input nodes in a layer and one output figure (1). The transfer functions (sigmoid – tangent sigmoid) were used in this network; sigmoid at hidden layer and tangent sigmoid at output . The input vectors and target vectors was divided into three sets as (70% for training , 15% used to validate that the network is generalizing and to stop training before overfitting and 15% used as a completely independent test of network generalization) **Shahin** [9]. The default number of hidden neurons using in this model are (3 , 6 , 8) . Different nodes in hidden layer are taken in order to determine the optimized number of nodes in hidden layer by trial and error for three nodes above we conclude that the best number of nodes is 3 nodes in hidden layer. There are a wide types of algorithms available for training a network and adjusting its weights. In this study, the Levenberg–Marquardt (trainlm) technique was using because it is recommended for most problems .

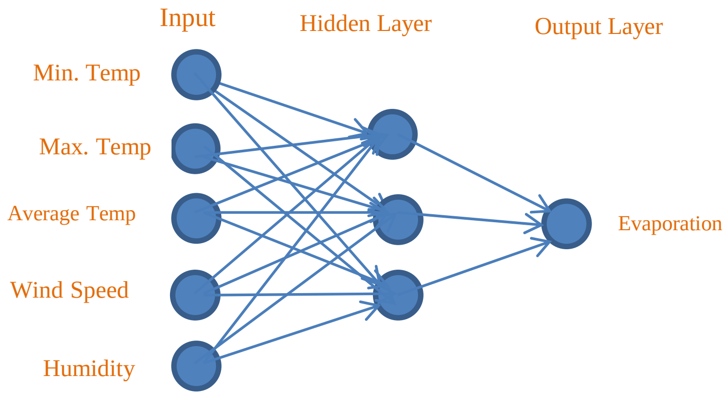

Figure1. Architecture of the Evaporation Network Used in This Paper .

Before the training the input and output variables, scaling them is important to eliminate their dimension and to ensure that all variables receive equal attention during training. Scaling procedure normalizes the input and output so that they will have zero mean and unity standard deviation **Mahmood and Aziz** [10]. Depending on the output transfer function, the data scaled by using Eq (1) below.

$$X_n = \frac{2(X - X_{min})}{X_{Max} - X_{min}} - 1 \qquad (1)$$

4- THE APPLICATION OF MODEL :-

The result of model depending on types of transfer functions in hidden and output layers. There are many of transfer function using in ANN modeling, three of the most commonly are liner, sigmoid and tanh. The Mathematical expressions to output equation, generated by simple regression neural network that predicts new formation are known by equations (2-5)

$$(2) S1_j = \sum I_i w_{ji} + b$$

$$(3) O1_j = \frac{1}{1+e^{-S1_j}}$$

$$(4) S2_k = \sum O1_j w_{kj}$$

$$O2K = TANH(S2_K) \qquad (5)$$

Where, i= 1,2,3..,9 ,10 (input layer nodes),j=1, 2, 3, 4, …12, 13 (hidden layer nodes), k=1 (output layer node), w_{ji} and w_{kj} are training Weights given in table (1) . I_i= Inputs, b= bias . $O2_k$= Calculated outputs:

Table1. The Training Weight and Bias For Network

Weights and bias from Input (I) to Hidden (H) layer				Weights and bias from Hidden (H) to Output (O) layer		
	H1	H2	H3	H1	H2	H3
I1	-2.1455	-1.1707	-0.13898	-0.767	-9.7043	4.3546
I2	-1.8893	-2.0118	-1.6164			
I3	-2.8145	-0.10381	-1.298			
I4	-2.1882	-0.3086	-0.59735			
I5	2.3967	-0.96702	-2.3843			
Bias	-0.767	-9.7043	4.3546]	Bias	5.0227	

The training of model stopped when the result is reasonable because of the following considerations:

- - The final mean-square error is small.
- - The test set error and the validation set error has similar characteristics.
- - No significant overfitting has occurred (where the best validation performance occurs). as shown in the figure (2).

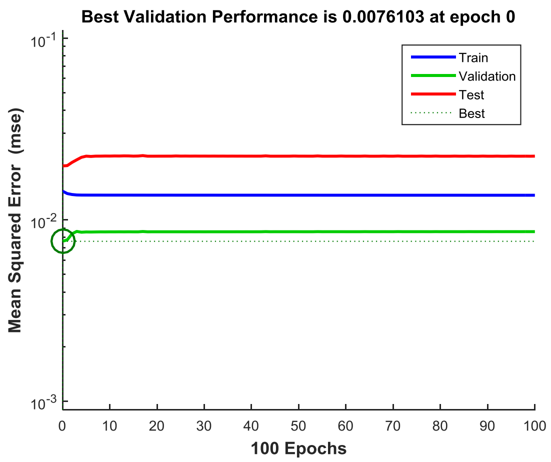

Figure 2. The Training Errors, Validation Errors, and Test Errors.

5- ANN MODELS EQUATIONS :-

Using the weights and bias shown in Table (1) and the transfer function used in network the predicted evaporation can be calculated as follows:

*Evaporation (mm/day)= 7.05 TANH(-0.766*sig1 -9.7043*sig2+4.3546*sig3+5.0227) + 7.15* (6)

Where :-

$$Sig1=\frac{1}{1+(EXP(-H1))} \quad (7)$$

$$Sig2=\frac{1}{1+(EXP(-H2))} \quad (8)$$

$$Sig3=\frac{1}{1+(EXP(-H3))} \quad (9)$$

H1 = - 0.121Min. Temp -0.087 Max. Temp – 0.15 average temp – 0.376 wind speed + 0.055 humidity + 3.73 (10)

H2 = - 0.066Min. Temp -0.092 Max. Temp – 0.0055 average temp – 0.052 wind speed - 0.0222 humidity + 8.73 (11)

H3 = - 0.0078Min. Temp -0.074 Max. Temp – 0.068 average temp – 0.1015 wind speed - 0.055 humidity + 10.12 (12)

The units of inputs factors are Temperature (C^o), wind speed (m/s) and humidity (%).

6- SENSITIVITY OF MODEL

To find which of the input factors has the most significant impact on evaporation , a sensitivity analysis is achieved on the model . Garson proposed technique can be used to explain the relative importance of the input factors by examining input and output weights of network. **Garson** [11] the importance of input factors shows in figure (3) below

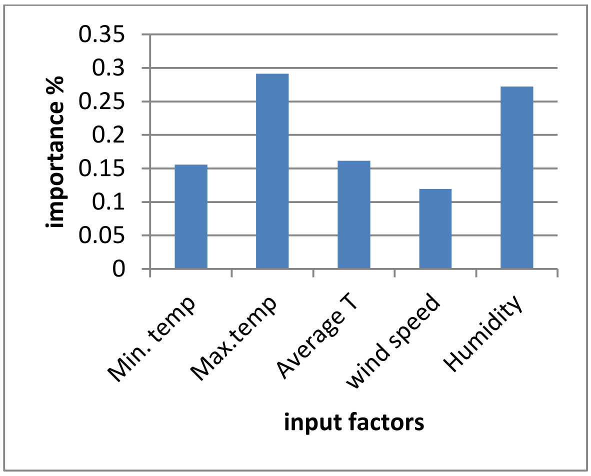

Figure 3. Input Factors and It's Evaporation Importance

7- VALIDATION OF MODEL

To ensure that the model is validate, the input factors should be check, Max. Temperature and the humidity are selected to validate the model depending on their importance as below

- All factors are fixed to their average with increasing in temperature factor (10 c^o , 20 c^o , 30 c^o ,40 c^o and 50 c^o).
- All factors are fixed to their average with increasing in humidity factor (18 % , 36% , 54% ,72% and 90%) as shown in figure(4 and 5) below.

The increasing in Max. Temperature results increase in evaporation and the increasing in humidity results decrease in evaporation , it is give a real relation. therefore the model is accepted to calculate the daily evaporation .

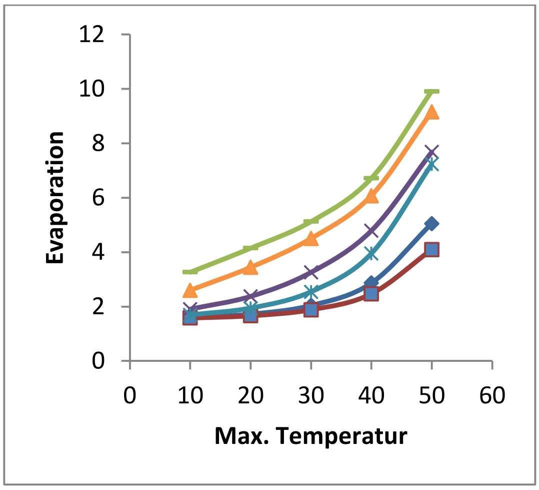

Figure 4. The Relation Between Max. Temperature and Evaporation Using Eq (6) .

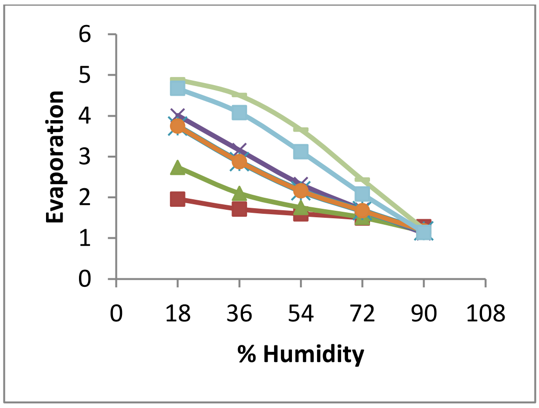

Figure 5. The Relation Between High Humidity and Evaporation Using Eq (6).

8- REAULTS AND DISCUSSION

To assess the advantage of neural network in predicting the daily evaporation , a total of one year data were used in the present study for model building and validation . The neural network is used to finding the regression between observed and predicted output , that's depend on number of hidden layer nodes, mean square error , best validation performance and transfer functions . In this study, the equation was concluded , this equation can be used to predict daily evaporation Eq (6) with a very good regression (regression more than 96% for all testing , validation , training and all data) as shown in figure (6) .

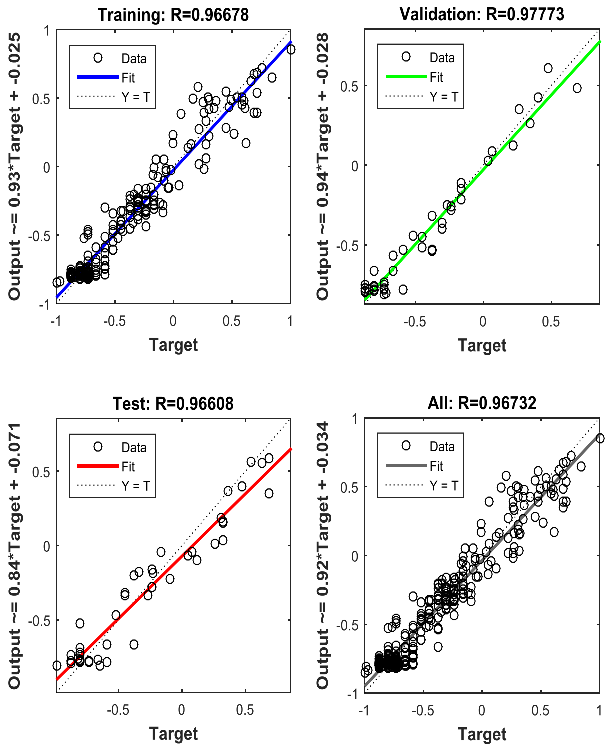

Figure 6. The Regressions Between Observed – Predicted Evaporation for (Training , Validation , Test and All)

Figure 6 above illustrated the good relation between observed evaporation and predicted. At using equation (6), increase the high temperature from 10 c° to 50 c° the evaporation is increase from 1.5 mm/day to 9.8 mm/day and when increasing humidity from 18% to 90% produce to decrease evaporation from 5.9 mm/day to 1.0 mm/day figure (4 and 5).

9- CONCLUSIONS

The present study concludes, the artificial neural network have ability to predicted daily evaporation. The biggest impact factor on evaporation is Max. Temperature (30%) then humidity (26%), average temperature (16%), Min. Temperature (15%) and wind speed (12%) .

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