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Predict the Average Temperatures of Baghdad City by Used Artificial Neural Network

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ABSTRACT
This paper utilizes artificial neural networks (ANN) technique to improve temperature forecast performance of Baghdad city. Our study based on Feed Forward Backpropagation Artificial Neural Networks (BPANN) algorithm of which trained and tested by used a real world daily average temperatures of Bagdad city for ten years past for months of January and July. Aimed at providing forecasts in a schedule, for all Days of the month to help the meteorologist to foresee future weather temperature accurately and easily. Forecasts by ANN model has been compared with the actual results and the realistic output (with IMOS). The results has been Compared to the practical temperature prediction results, and shows that the BPANN forecasts have accuracy that gave reasonably very good result and can be considered as a good method for temperature predicting..
Keywords: Artificial Neural Network, Backpropagation, Temperature predicting, weather forecasting

I. INTRODUCTION

Temperature predicting is the application of innovation and scientific research to forecast the condition of the temperature level for a futurity of a given area, which been concern in agriculture, industry and environment. The temperature level forecasts are made by accumulating measurable information regarding the present state of the environment. ANN is an effective information modeling tool that has the ability to capture as well as represent intricate input/output connections that can been made use of as a method to predicting the temperature [1]. The ANN design is a structure that could be gotten used to create a mapping from an offered collection of data to attributes of or partnerships amongst the information. The ANN model is changed, or trained, utilizing a collection of data from a provided resource as input, commonly described as the training set. After felicitous training, the ANN will certainly have the ability to carry out category, estimate, forecast, or simulate on new data from the comparable or same sources. An ANN is a model of data processing that is influenced incidentally organic nerve systems, like the brain, process details [2]. The essential element of this standard is the unique framework of the info handling system. It is consisted of a great deal of much interconnected handling aspects (nerve cells) operating in alliance to resolve particular troubles. ANNs, like individuals, discover by instance. An ANN is set up for a specific application, such as data classification or pattern recognition, with a learning procedure. Discovering in biological neural cell includes changes to the synaptic connections in-between the neurons [3].

The one effective method of such algorithm is Backpropagation Artificial Neural Network (BPANN). The main benefit from the BPANN technique is that it could relatively approximate a huge functions class. This technique is most effective compared with numerical differentiation. A backpropagation network is composed of at least 3 layers: input, output and at least one hidden layer. Unlike the Hopfield networks and also Interactive and Activation Competition neural networks (IACNN), in a BPANN the connection weights are in one way. Generally, in a FFNN the input neurons are fully connected to hidden layer units as well as the hidden units are completely connected to output layer units [4]. When a BPANN is cycled, the input pattern is propagate forward to the output units via the intervening input-to-hidden as well as hidden-to-output weights. In backpropagation algorithm, it indicates the errors and it consequently the learning propagate backwards coming from the output nodes to the internal nodes. Thus, backpropagation is actually utilized to compute the gradient of the error of ANN regard to the network's modifiable weights. This gradient is a constantly used in a basic stochastic gradient inclination algorithm to locate weights that reduce the errors. Typically the term "backpropagation" is used in a most overall sense to describe the whole entire operation including both the calculation of the gradient and its usage in stochastic gradient descent. Backpropagation generally makes it possible for fast convergence on satisfying local minimum error in the type of networks to which that is satisfied [5].

The goal of this research is to utilize BPANN technique for forecasting the temperature. The proposed system results is compared with real working from meteorological (IMOS), also these results affirm that our proposed system have ability for effective predicting of temperature. Real time

reading from climate records show that the weather forecasting that based on BPANN have shown improvement not just over guidance prediction from mathematical models, but also over official regional climate service prediction too. The results are compared with practical temperature forecast results [6, 7]. This proposed system assists the meteorologist to forecast the future weather accurately and easily.

II. RELATED WORK

In this part, some literature on the related subject will be given:

Y. Radhika and M. Shashi [8] presents a Support Vector Machines (SVMs) application for weather forecasting. maximum temperature data that recorded daily at certain location is analyzed to forecast the next day maximum temperature of at that location based on the day-to-day maximum temperatures for a period of previous n days referred to as input order. The system performance has been observed over different periods of two to ten days by using optimum values of the kernel

B. Smith et.al [9], concentrated on building an ANN models with minimized average forecast error through raising the number of specific observations used in training, adding extra input terms that explain the time of an observation, raising the period of previous weather records included in each observation, and reexamining the amount of hidden nodes utilized in the system. Models were developed to forecast the temperature of air on an hourly basis periods from (1) to (12) hrs. ahead. Each model of ANN, composed of a set of connected parameters and network architecture, that was assessed through training and instantiating a thirteen networks and computing the mean absolute error (MAE) for some set of patterns for the resulting networks.

M. hayati et al. [10] used artificial neural network for one day forecast of temperature level. In their work, a multilayer perceptron (MLP) has been used a (65%) of patterns for trained and a (35%) of patterns for tested, for 10 years meteorological records of Iran which was divided in to 4 seasons (winter, spring, summer and autumn. They has been used a multilayer perceptron network of 3 layers along with sigmoid transfer function for hidden layers and linear transfer function for output layer. Variety of hidden neurons and epochs were utilizing to use the trial and error approach. This work concludes that multilayer perceptron, through this design has minimal forecast error, excellent performance and also sensible forecast accuracy.

Ch. Jyosthna Devi et al. [11], 2012 provided an artificial neural network based algorithm for forecasting the temperature. The BPANN is utilized due to the fact that it could fairly approximate a huge functions class. They propose a model that has a dataset of real time along with 15 parameters as input, where after that normalized by used min-max normalization to scale records in between} zeros to one(0 to 1). After that it is trained as well as tested by used the BPANN. The results are compared with the meteorological department to examine the accuracy and the minimum error of model. They found that the proposed model has the good ability for temperature predicting.

I. Shereef et al. [12], proposed a Modified Levenberg-Marquardt (LM) Algorithm for ANN learning. In this modified Levenberg-Marquardt, the learned parameters has been modified. The suggested algorithm has great convergence as well as it minimizes the quantity of oscillation in learning method. The proposed method is compare with the BPANN and also the practical working from meteorological department. From experiment, it shows that the proposed method results has a much better accuracy of forecast when compared with the regular method of weather forecast.

M. Narvekar1 et al. [13], study many weather forecasting techniques including Ensemble Neural Network, Artificial Neural Network, Backpropagation Network, General Regression Neural Network, Radial Basis Function Network, Fuzzy clustering, Multilayer Perceptron, Genetic Algorithm, etc. and so on which are utilized various types predicting the much better technique for predicting which compares several approaches. Among those reviewed techniques, it has appeared that the backpropagation algorithm performs forecast with a minimal errors. They used twenty-eight input parameters in testes to predict the day-to-day weather in regards to humidity, temperature, cloud condition, rainfall and weather of the day.

III. THEORETICAL BACKGROUND

3.1 Artificial Neural Network Technique

The Multi-Layer precptron (MLP) is the most used ANN for non-linear modeling, it is a feed forward neural network (FFNN), generally trained with backpropagation, therefore it is one of the most popular nonlinear ANN architecture that utilized variety of problems in applied atmospherical scientific researches. Also the most basic type of MLP network with an adequate variety of processing elements which is called an universal approximate because of its ability to approximate any kind of nonlinear relationship inputs as well as outputs to any degree of an accuracy [14,15]. Theoretically, the architecture of MLP is composed of an input layer, an output layers, and one or several hidden layers as illustrated in figure 1.

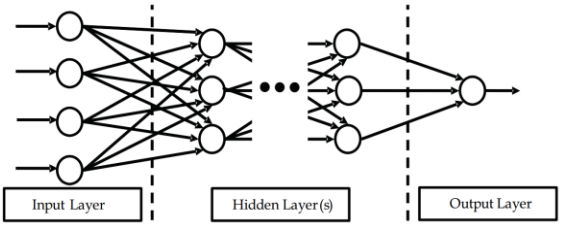


Figure (1): A Multi-layered perceptron (MLP) network

Neurons that are the fundamental elements of the ANN are interconnect via various layers like (input, output and hidden layers). The degree of interconnection is determine by weight (w_{ij}) that implies the effect of neuron (i) on neuron (j). The structure of ANN is illustrate in Figure 2. Every neuron is activated through an activation function according to a threshold value. The transfer activation is refined through both input signals neighbor nodules belonging to various layers and output signal like bias in order to get the output from neuron. The typical transfer functions in the ANN are linear sigmoid function and tangent sigmoid function illustrated in Figure 3. The formula of liner and tangent transfer functions are shown respectively in formula (1) and (2) [16, 17]
:…… (1)

$$F_k(s_k) = \frac{2}{1+e^{(-2s_k)}} - 1 \qquad \ldots\ldots\ldots (2)$$

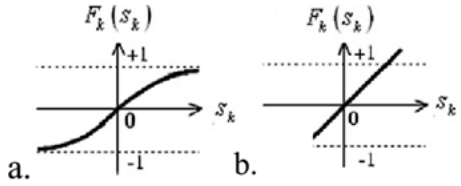


Figure (2): a. tangent sigmoid function **b.** linear sigmoid function [13].

3.2 Back Propagation

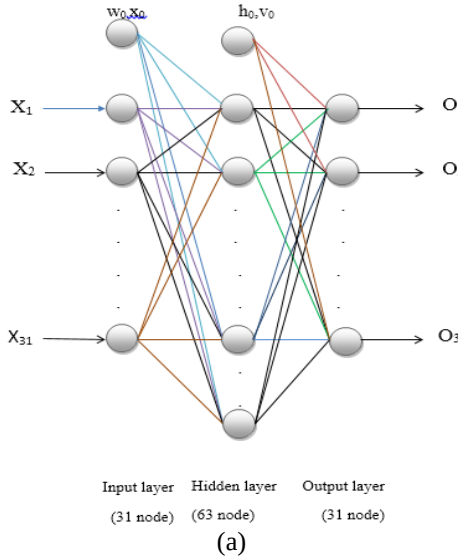
Backpropagation (BP) algorithm is utilized in layered FFANNs. (BP) utilizes a supervised learning that implies the model learns itself with using target output. For each set of data input, the target for output is given. ANN will treat the input data with a random values for weights and appropriate sigmoid function uses a one hidden layer inbetween, then generates the forecasted output. This forecasted output is after that compared with target output offered same input dataset. Therefore, errors is computed by deducting forecasted output from intended output division through intended output. Utilizing this error, the weights are readjusted and once more the whole process is repeating for several times till the error is very little or in appropriate range [13, 18].

The method of BP is a repetitive that begins with the final layer (output layer) and relocates backwards via the layers till the 1st layer (input layer)is reached. By suppose that for every layer, it can know the error in the output of layer, so by knowing the error it is certainly not difficult to compute improvements for the weights in order to minimize that error (the only concern is that it could only notice the error in the output from the last layer) [11]. BP provides a method to identify the error in the output of a previous layer through providing the output of an existing layer as reviews [19].

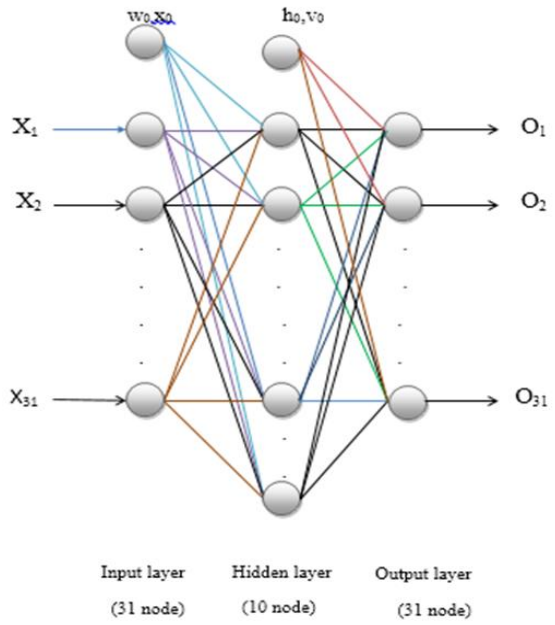
IV. PREDICT THE TEMPERATURE BY USING NEURAL NETWORKS (SYSTEM MODEL)

Our model of weather predicting is based on used BPANN method. The data input is to be took from a certain region where the model is trained and tested to ensure the model has the ability to produce precise results. The variety of input data provided to model likewise assists to enhance accuracy of the model through providing the results along with a higher level of similarity between forecasted output and real records. This model is actually of very complicated type since the fact that it consists of several neurons linked with one another in a well-formed design to create complex output along with minimal error [13].

This model is mainly utilized to create forecasts through training the model using previous dataset as well as experience. Figure (3) illustrated an ANN in proposed model where several input parameter is utilized as input neurons, which are then forwarded to a hidden layer where sigmoid function is used and then forwarded to output layer along with an additional sigmoid function where it lastly calculates the output of ANN [13].



(a)



(b)

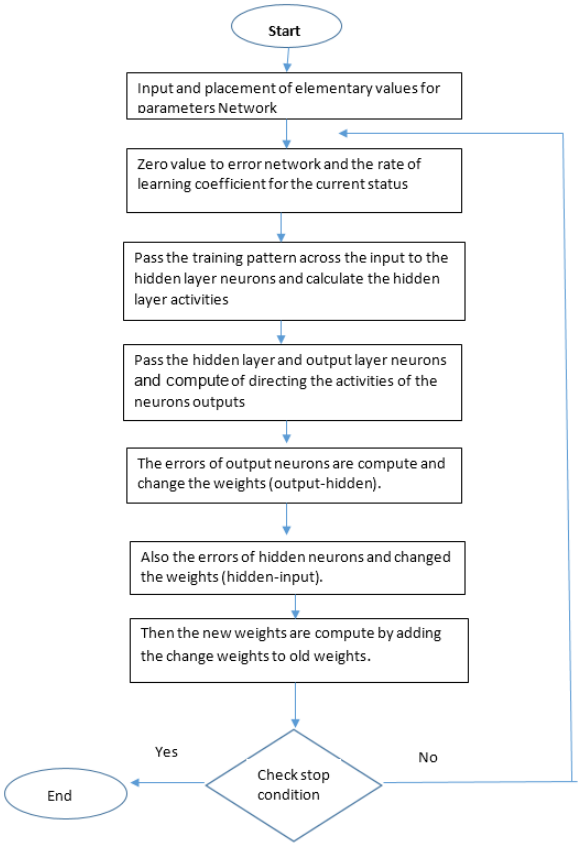
Figure(3): structure of our model for :(a) one year (b) ten years

From the figure (3) a, b:

1. X_i:-The neuron input in a layer relocated all neurons in the next layer.
2. W_{ij}, V_{jk}:- Every neuron possesses its own input weights. and the layer weights are randomly in range between (zero to one) for each neuron .
3. O_k:- The ANN output is gotten by using input values to the input layer, going through hidden layer to each neuron output of following layer as input.
4. The BPANN must contend at least input and output layer. It can possess a one hidden layers too.

The amount of neurons in the input layer is determined by available amount of possible inputs, in this work we used a 31 input (numbers of the day). The amount of neurons in the output layer relies on amount of intended outputs, which is (31) output in this work (numbers of the day). The number of hidden layers as well as number of neurons in all hidden layer couldn't be properly determined} beforehand, and might be modified per type of data and network configuration. In general add-on the hidden layer might make it possible for the network to learn more complicated patterns. The A configuration of network of this work could possess a single hidden layer about (63) hidden node. The training starts with random weights and it will be readjust in order to minimize the error.

For practical reasons, the artificial neural network applying the BP algorithm do not possess much layers, because the training time of the networks increases exponentially. Likewise, there are improvements to the BP algorithm that allow a very fast learning. Figure (4) illustrated the main program phases of our system.



Figure(4): main phases of program

- ***Data collection***

Use the daily average temperatures for the month of January, July the period of 2015-2005 the city of Baghdad by the General Administration of meteorological and seismic monitoring Iraqi IMOS.

- ***Stages of the algorithm***

There are two stages for (back- propagation) algorithm [20, 21].

1) A Feed Forward Stage

In FFNN, the neurons are evaluated in order, and there are no connections from higher order neurons to lower order ones. The neurons in FFNN are often organized in layers: the input and output layers which could be interact with the environment, and one or several hidden neurons layers = that is not possess any contact with environment. There is a certain order of assessment of neurons. The system gets the input signals, propagates all of them via all the layers and returns signals to the environment via the output neurons. This implies that, for the same input, the network always returns the same output [22].

The training pattern is entering from input layer to output layer through hidden layer, the output of neuron.

1. Neuron of input layer (Its input equal to its outputs)

$$Xi=Si \text{ for } n\epsilon \quad \text{..... (1)}$$

Where: - $1 \leq i \leq n1$, n_1: number of input nodes

2. Neurons of hidden layer.

$$Hj = f(net_j) = f(\sum_{i=0}^{n1} w_{ij}\, s_i \quad \text{... (2)}$$

$$\text{Where: } 1 \leq j \geq n2$$

n_2: hidden node number, w_{ij}: the weight between input and hidden, $f(net_j)$: the activation output of hidden node(j) in hidden layer.

3. Neurons of output layer.

$$O_k = f(net_k) = f \sum_{j=0}^{n2} V_{kj} h_j \quad for\ neuron(k),$$

Where, $1 \leq k \geq m$ number of output node, V_{kj}: the weight between hidden and output, $f(net_k)$:the activation output of hidden node(j) in hidden layer, F(net) is is sigmoid function.

2) Back Propagation Stage:-

A widely used training procedure for multilayer feed forward networks is back propagation. This learning paradigm propagates the error signal associated to the output of the network, from the output layer to the previous layers. In this process, the weights are adjusted by a steepest-descent strategy based on local information about the gradient of the error signal as a function of the weights. By interpreting the weights as components of a vector, the gradient defines a directional vector along which the weight vector is updated [14, 15, 23, 24]. The following steps explain above.

1. The errors of output neurons are compute and change the weights (output-hidden).

$$s_k = (d_k - o_k)_{o_k}(1 - o_k) \quad \text{..... (4)}$$

Where: S_k:The error of output node, d_k:desired output of node k in output layer, O_k:output node(k) in the output layer.

$$\Delta v_{jk} = \eta . s_k . h_j + \beta \Delta v_{kj} \quad \text{..... (5)}$$

Where: η: learning rate (0<η<1), β: Aconstant specifying the momentum (0<β<1), Δv_{kj}: change in weight of the connection node from node (k) in output layer to hidden layer (j).

2. Also the errors of hidden neurons and changed the weights (hidden-input).

$$s_j = h_j\,(1 - h_j) \sum (s_k . v_{kj}) \quad \text{..... (6)}$$

$$\Delta w_{ij} = \eta . s_j . s_i + \beta \Delta w_{ij} \quad \text{..... (7)}$$

$$\Delta v_{jk} = \eta . s_k . h_i + \beta \Delta v_{jk} \quad \text{..... (8)}$$

3. Then the new weights are compute by adding the change weights to old weights.

$$\Delta w_{ij} = w_{ij} + \Delta w_{ij} \quad \text{..... (9)}$$

$$\Delta v_{kj} = v_{kj} + \Delta v_{kj} \quad \text{..... (10)}$$

3) Equation for predication and compute error (Performance Measurement)

The error (predication) of neural network is compute by the equation:-

$$P=(d_k - o_k) \quad \text{..... (11)}$$

$$error = \sum (d_k - o_k)/d_k \quad \text{..... (12)}$$

Where: d_k/ the desire output for k cell, O_k the actual output for k cell

.

V. RESULTS

A backpropagation network contains multi-layer perception (a minimum of 3 layers): input, and output layer with a minimum of one intermediary hidden layer. The results are compare our model(predication) with practical.

This system assists the meteorologist to forecast the future climate accurately and easily. the Table (1,2): show compare temperature predication with actual data For the month of January and July 2015(show forecast temperatures for January and July 2015).

TABLE(1): The Forecast Results of January 2015

Day	***Actual data January 2015***	***Predication***	***Elapsed time is 241.414329 seconds***
1	11	10.57472	**Iteration=3**
2	12.7	12.6951	
3	12	11.59646	
4	10.9	10.60279	
5	11.4	10.57059	
6	13.3	12.50312	
7	12.2	11.67294	
8	9.5	8.998412	
9	8.7	8.038481	
10	7.2	6.718884	
11	5.9	5.607484	
12	6	5.202796	
13	6.8	6.751794	
14	7.3	6.909141	
15	10.1	9.966708	
16	10.1	9.21137	

17	8.1	7.106099	
18	8.8	7.947132	
19	10.1	9.106336	
20	9.1	8.845863	
21	9.6	8.65591	
22	12.6	11.7476	
23	10.7	9.70231	
24	11.5	10.57799	
25	14.3	13.30074	
26	16.6	15.61032	
27	13.5	12.73344	
28	15.8	14.81336	
29	14	13.90345	
30	14.7	14.6998	
31	11.3	11.20463	

Table(2): The Forecast Results of January 2015

Day	***Actual data July 2015***	***predication***	***Elapsed time is 224.320695 seconds***
1	34.2	33.34198	**Iteration=3**
2	37.8	37.79547	
3	39.3	38.99162	
4	37.5	37.00964	
5	35.4	34.42834	
6	35.5	34.98165	
7	35	34.70497	
8	34.6	34.08974	
9	35.6	35.31115	
10	35.9	35.58034	
11	28.3	28.21145	
12	36.5	35.97205	
13	36.7	36.69428	
14	38.9	38.48814	
15	40.4	40.10402	
16	39	38.08382	
17	36.9	35.91138	
18	36.2	35.8638	
19	38.3	37.31021	
20	38.3	37.9459	
21	38.6	37.71532	
22	37.6	36.65453	
23	36.9	35.90151	
24	38.3	37.34032	
25	39.2	38.20413	
26	40.9	39.91468	
27	38.5	37.58334	
28	37.6	36.69887	
29	39.1	39.02808	
30	40.5	40.49593	
31	42	41.37531	

VI. PREDICTION ACCURACY

Forecast precision for the proposed methods for each months is arranged in table (1) and (2). When the forecast precision of the existing method is compared with the proposed method, the proposed BPANN is noticed to possess greater forecast precision for seasons has been considered.

VII. CONCLUSION

In this work, it has been explained how ANN are useful in predicting the weather condition and the working of most effective forecast algorithm which is backpropagation algorithm. A three layered BPANN has been designed for that purpose. The results shows that this proposed system could easily predict the future temperature with less error.

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