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DESIGN AND DEVELOPMENT OF ARTIFICIAL INTELLIGENCE SYSTEM FOR WEATHER FORECASTING USING SOFT COMPUTING TECHNIQUES

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ABSTRACT

The main aim of this paper is to overcome the drawbacks of LIDAR which are non-linearity in climatic physics based on statistical modeling and evaluation. However, modeling is shown to be a successful method to forecast weather parameters by using different types of Soft Computing Techniques such as Neural Networks, Fuzzy Logic and Probability Theory which are suitable to these meteorological processes for prediction of an important weather parameter that is temperature. Design and development of different types of Soft Computing Techniques approaches in an agricultural systems based on objective of predicting the temperature (one day ahead forecasting of temperature from selected meteorological data) and tested using eighty years past data (meteorological data) and to evaluate the different types of Soft Computing Techniques which depicts that the performance. The results are carried out using MATLAB software.

Keywords: artificial neural networks, fuzzy logic, temperature forecasting, LIDAR, non-linearity.

1. INTRODUCTION

A. Background

The Weather forecasting for the future is one of the most important attributes because agriculture sectors as well as many industries are largely dependent on the weather conditions and also human living.

However, there is no proper control over the emission of pollutant from different sources into the environment, due to the weather is an environment of uncertainty and imprecision, this is different from classical system, and warn about natural disasters those are caused by abrupt change in climatic conditions based on meteorological data such as wind speed, Wind Direction, Relative Humidity, Temperature, Pressure and Dew point. Therefore, development of modeling is an attempt to provide a tool to understand the physical process of environment as shown in Figure-1.

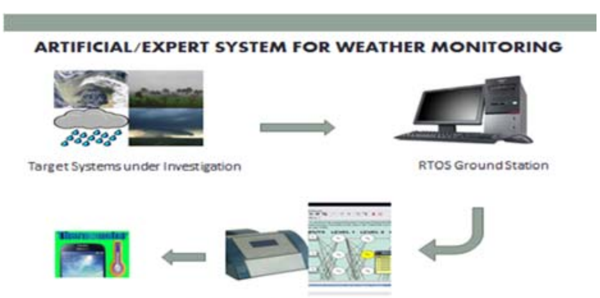

Figure-1. Schematic diagram of artificial intelligence system for weather forecasting.

B. Objectives

a) To develop the weather forecasting model for the temperature.

b) To Design and develop the Artificial Intelligence System/Expert System by Soft computing techniques for effective utilization in the agriculture sectors because, Temperature forecasting is an ever-challenging area of investigation.

2. PROBLEM DESCRIPTION ON WEATHER FORECASTING

A. Problem description on temperature forecasting

Initially Temperature forecasting is done using LIDARS and microwave radiometers. The drawback's of LIDAR and microwave radiometer which is non-linearity in climatic physics based on statistical modeling and evaluation as follows:

a) LIDAR

Detection based on the principle of RADAR, but uses laser light instead of radio wave.

- LIDAR is light detection and ranging.
- LIDAR technology in general was developed a number of decades ago.
- LIDAR measures temperature by scanning the different frequency of light reflected from the moving dust particles of the atmosphere as shown in Figure-2.

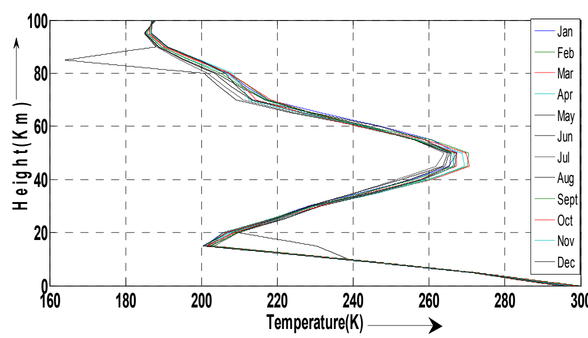

Figure-2. Temperature measurement using LIDAR.

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b) Microwave radiometer

The term microwaves refer to alternating electromagnetic signals with frequencies between 300 MHz and 300 GHz (wavelengths 1 mm to 1 m). Because of the long wavelengths, compared to the visible and infrared, microwaves have special properties that can be used for many applications. In addition, various molecules and atoms resonances occur in the microwave range. The majority of microwave applications can be found in communication systems, radar systems, environmental remote sensing, and medical systems. The measurements are made on the roof terrace of the building and should be performed under clear sky conditions as shown in Figure-3 since clouds affect the measurements, which is a major drawback for weather forecasting using microwave radiometer.

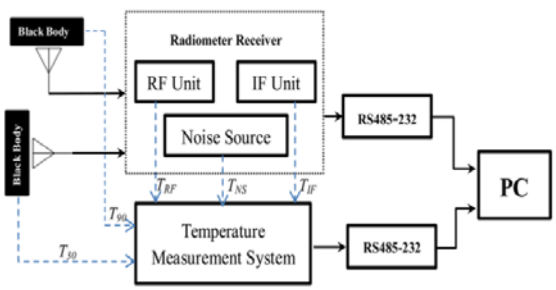

Figure-3. Temperature measurement using microwave radiometer.

However, to overcome these drawbacks the World Meteorological Organization acts to standardize the instrumentation, observing practices and timing of these observations worldwide using diverse techniques.

Artificial neural network (ANN) is one of the mostly used parallel computational models, comprising closely interconnected adaptive processing units. The important characteristic of neural networks is their adaptive nature, where 'learning by example replaces programming'. This feature makes the ANN techniques very appealing in application domains for solving highly nonlinear phenomena. During last four decades various complex problems like weather prediction, stock market prediction etc has been proved to be areas with ample scope of application of this sophisticated mathematical tool.

3. NEURAL NETWORKS

A multilayer neural network can approximate any smooth, measurable function between input and output vectors by selecting a suitable set of connecting weight and transfer functions. Our study was based on Multi Layer Perceptron (MLP) which trained and tested using past ten years (1996-2006) meteorological data.

The training a neural network to perform a particular function by adjusting the values of the connections (weights) between elements using supervised method. Typically, neural networks are adjusted, or trained, so that a particular input leads to a specific target output. Figure-4 illustrates such a situation. There, the network is adjusted, based on a comparison of the output and the target, until the network output matches the target. Typically, many such input/target pairs are needed to train a network.

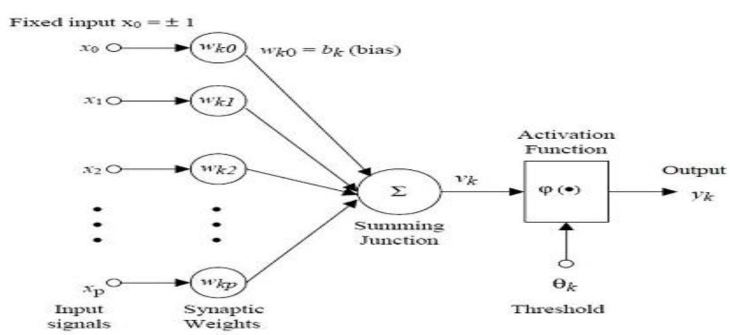

Figure-4. Training of a neural network.

a) Data Preprocessing: The daily weather parameters collected from TUC weather station are shown in Table-1 along with their units of measurement. The parameters chosen for prediction in this setup are mean air temperature (ºC), relative humidity (%) and wind speed (Km/h) by hour. Different day's data will be used for training and different day's data will be used for testing purposes.

Table-1. Parameters collected from TUC weather station.

No.	Meteorological	Unit
	Variables	
1	Temperature	ºC
2	Relative Humidity	%
3	Wind Speed	Km/h

After the collection of data and selection of the weather parameters, next issue is normalization of data.

Neural networks generally provide improved performance with normalized data. The use of original data to train the neural network may cause convergence problem. All the weather data sets were, therefore, transformed into values between 0 and 1 through dividing the difference of actual and minimum values by the difference of maximum and minimum values.

b) Training the neural network

Defining Input and Output: We use a two layer neural network. The proposed neural network has three inputs and a output as shown in Figure-5 where hyperbolic tangent sigmoid function (tansig) are used corresponding to the two hidden layers.

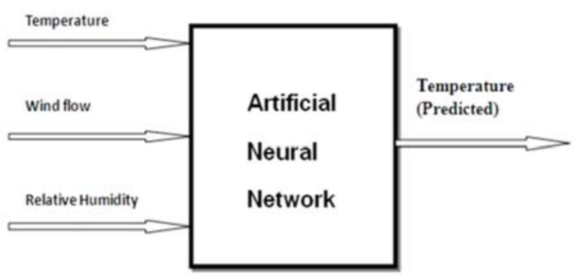

Figure-5. System model with three inputs (Wind flow, Relative humidity, and Temperature) and one output (Temperature).

One external variable to be used as input so that one input to network further 5 neurons are used for hidden layer. There must be one neuron in the output layer because there is only one target value associated with each input. Proper parameters (weight and biases) are selected by training the network using the MATLAB.

Training the network: In the last section, no matter how many neurons we try, the best MSE always stay at about 10^{-2} compared to the true order of magnitude 10^{-5}. So in this section, we are going to use less or more historical data to find the fittest mode in this forecasting.

- one day as training data and to predict 24 hours in one day (N1=5, N2=10)
- three days as training data and to predict 24 hours in one day(N1=5, N2=10)
- thirty days as training data and to predict 24 hours in one day(N1=40, N2=20)
- thirty days as training data and to predict 24 hours in one day(N1=40, N2=20)

Finally by analyzing the outputs, we can increase the performance (reduce error) by hybrid system.

4. FUZZY LOGIC SYSTEM

Weather has always been elemental to the course of human history. In this part, we are mainly concerning about the effect of temperature, which is the most important parameter of all. The aim is to predict the temperature tomorrow by using the data today, which is representative and effective. Due to the weather is an environment of uncertainty and imprecision, this is different from classical system, while the fuzzy logic system can aim at modeling the imprecise models of reasoning and deal with approximate rather than precise model. Therefore, the fuzzy logic is chosen as a suitable method for weather forecasting.

A. Fuzzy logic design

Design of Fuzzy Systems from Input-Output Data To design this fuzzy system, we view the rules of temperature changing as a black box and measure the inputs and outputs that is we can collect a set of input-output data pairs. In this way, the rule can be transformed into a set of input-output pairs; hence, a problem of fundamental importance is to construct fuzzy systems from input-output pairs as follows:

a. Inputs

- Min-minimum value of the current day
- Average-average value of the current day
- Max-maximum value of the current day

b. Output

T: Temperature measured at tomorrow.

c. Fuzzy inference model: The fuzzy inference technique we used is Mamdani method. In Mamdani's model the fuzzy implication is modeled by Mamdani's minimum operator, the conjunction operator is min, the t-norm from compositional rule is min and for the aggregation of the rules the max operator is used.

Our attempt is to forecast temperature with the help of fuzzy logic based approximate reasoning. This process uses the concept of a pure fuzzy logic system where the fuzzy rule base consists of a collection of fuzzy IF–THEN rules, the rules can be written by using the past days temperature as in Figure-6.

5. RESULTS AND DISCUSSIONS

A) Results of Neural Network

a) Figure-7 shows the change of error for the four options. the most concurrencies of predicted error is about 0.5℃ in 1, and 0.5℃, 0.3℃, 0.2℃We can find as the number of neurons increase, the error is decreased. 4 is relatively better than others, no error bigger than 1℃ and small concurrencies of the bigger error.

b) Figure-8 shows the training performance of the four options. It's easy to find the best MSE stays at 0.001 for all of them. 1 shows a little better convergence and 2 reach its best performance at epoch 78. While at least 2000 epochs are needed to achieve the same performance for 3 and 4. Apparently, more neurons used, longer time and of higher complexity the training network can be.

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	Configuration		
And method		Min	
Or method		Max	
Implication		Min	
Aggregation		Max	
Defuzzification		Centroid	
Membership function			
Define range, fuzzy set and membership function:			
MINIMUM[15 35]			
Fuzzy set	very cold	cold	Little cold
Params	[11 15 19]	[16 20 24]	[21 25 29]
Table: Membership function of Minimum			
AVERAGE[20 35]			
Fuzzy set	Less normal	normal	beyond normal
Params	[14 20 26]	[21.5 27.5 33.5]	[29 35 41]
Table: Membership function of Average			
MAXIMUM[25 40]			
Fuzzy set	Less hot	hot	Very hot
Params	[19 25 31]	[26.5 32.5 38.5]	[34 40 46]
Table: Membership function of Max			
TEMPERATURE[15 45]			
Fuzzy set	freezing	cozy	warm
Params	[3 15 27]	[18 30 42]	[33 45 57]

Figure-6. Membership functions of temperature linguistic hedges.

c) Figure-9 shows that regression (R) Values measure the correlation between outputs and targets. All the plots have a high value better than 0.99. The outputs of the training network are quite close to the targets. So the network model has a good training performance.

B) Results of fuzzy logic

Figure-10. Shows the rule viewer for the predicted temperature of the next day, with 100% closeness to the target.

Figure-11. Shows the surface viewer for the inputs of the best developed rules in inference mechanism.

6. CONCLUSIONS

The simulation results of neural network shows the training algorithm performs well in the process of convergence characteristics, and improve the convergence rate, a satisfactory approximation.

Hence, we conclude that by using the fuzzy logic system we can predict the temperature more accurately than the other methods including B.P neural networks.

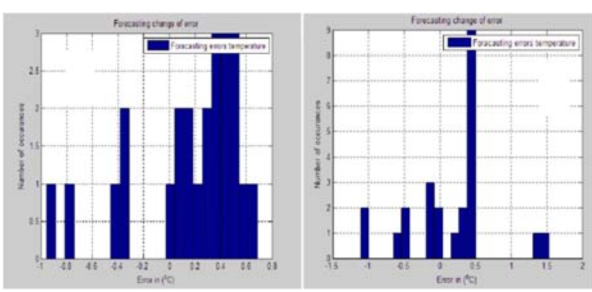

Figure-7. Change of error for four options.

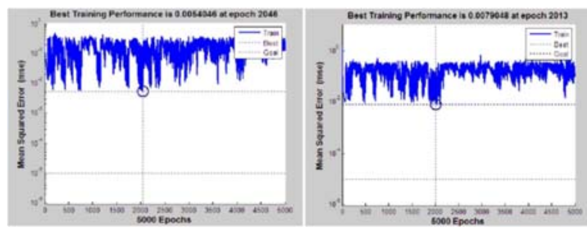

Figure-8. Training performance of the four options

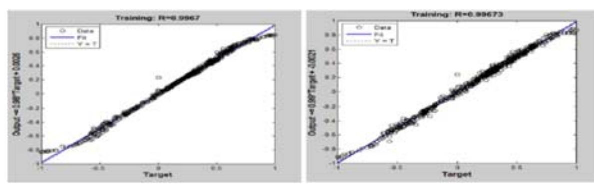

Figure-9. Regression R Values measure the correlation between outputs and targets.

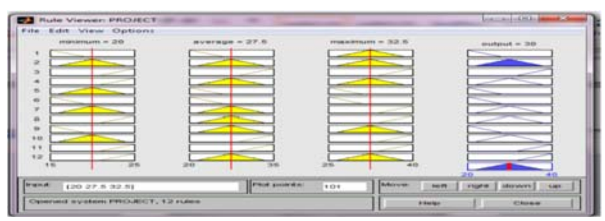

Figure-10. Rule viewer for the predicted temperature.

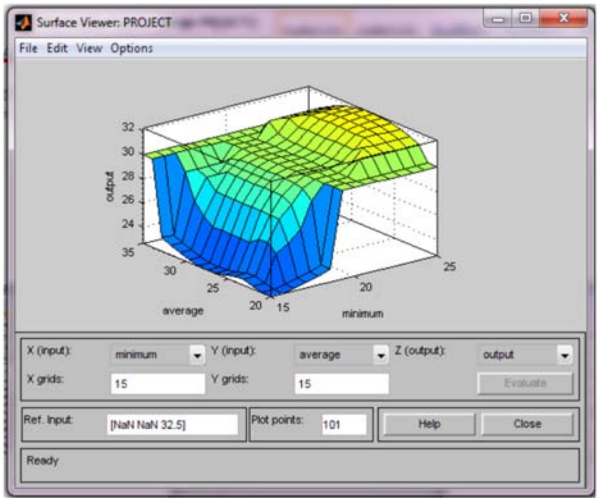

Figure-11. Surface viewer.

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