Temperature prediction using a Neofuzzy neuron approach

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Abstract: - In this paper it's presented a temperature prediction application using a modified neofuzzy neuronbased approach. This approach is an easy and accurate method for obtaining prediction results using climatic measurements from the previous days. The variables used for building the model are Temperature, Humidity, Dew Point, Wind speed, Pressure, Rain and Solar Radiation. It's also presented the obtained results for temperature prediction in Ibarra, Ecuador using three years data.

Key-Words: - Neofuzzy Neuron, Temperature prediction, artificial neural networks, fuzzy logic, Artificial Intelligence.

1 Introduction

Artificial intelligence [2] and its diverse techniques have been widely used for creating diverse prediction models [4] including virtual sensors [10], formal prediction model for identification and control systems [16], among others. Weather forecast is a very important area for building prediction models, because its related with security, environmental behavior and its impacts in basic activities as agronomy, engineering, tourism, constructions, social development, among others [12].

Some interesting contributions in the area of utilization of artificial intelligence for the prediction of weather variables can be found in [6, 13, 14].

Neofuzzy neurons approach was presented by Takeshi Yamakawa [17, 18] and tries to combine the best characteristics and capabilities of Artificial Neural Networks [8] and fuzzy logic [19]. Some applications of this neofuzzy neurons have been done in areas as Time series Forecasting [5], virtual sensors design for oil production processes [7], identification of nonlinear dynamic systems [9], fault detection and isolation [11] and operational condition prediction in mechanical systems [15].

In this paper it will be presented a proposal for building a prediction model for environmental temperature using the neofuzzy neuron approach and making some changes to the original algorithm in order to improve the convergence time and the accuracy of the prediction models.

This paper is organized as follows: Section 2 contains the Neofuzzy neuron description and characteristics. In section 3 it will be presented the proposal for Temperature prediction using the Neo fuzzy neuron-based approach and its utilization for predicting the temperature in Ibarra city in Ecuador. In section 4

will be presented the conclusions, recommendations and further works.

2 Neofuzzy neuron description

Neofuzzy neuron [17, 18] is a very simple structure that uses the capabilities of artificial neural networks and fuzzy logic and is a great tool for modeling complex systems because of the simplicity of its structure, composed by a single neuron that in its weights are defined some fuzzy partitions in order to model the complexity and nonlinearities of the systems, being only necessary to change the number of fuzzy partitions in the input variables, allowing this way to find the most suitable structure. While in artificial neural networks it is necessary to change the number of layers, the number of neurons in each layer and the activation function to find the appropriate structure for obtaining good fitness, in the neofuzzy neuron there is only one structure and the only parameter that have to be changed is the number of fuzzy segments.

In Figure 1 it can be seen the structure of a Neofuzzy Neuron, where the interconnecting weights (synapse) are replaced by a set of nonlinear functions *fi*, and the cellular body perform the sum of the synaptic signals.

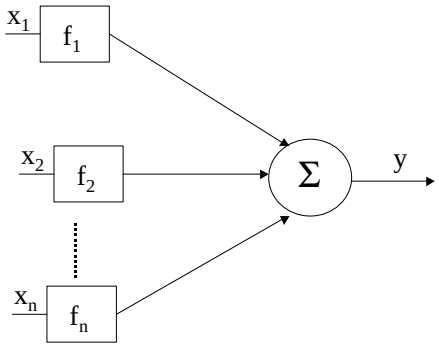

Figure 1: Structure of a Neofuzzy Neuron

In Figure 2 it's depicted the structure of each of the nonlinear functions *fi*. These functions are composed of IF <condition>-THEN <action> rules, using as <condition> the membership's function value of the input signals that are included in each of the complementary fuzzy segments defined in Figure 3. The <action> is a singleton with *wij* as corresponding value.

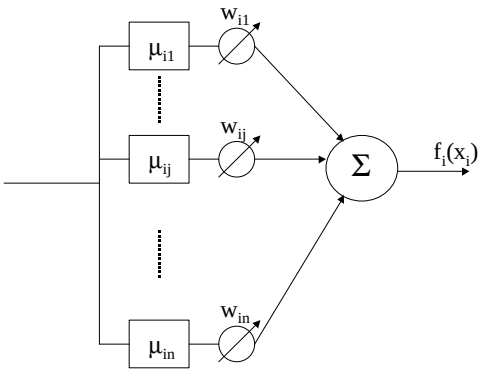

Figure 2. Structure of the Nonlinear Function (synapse)

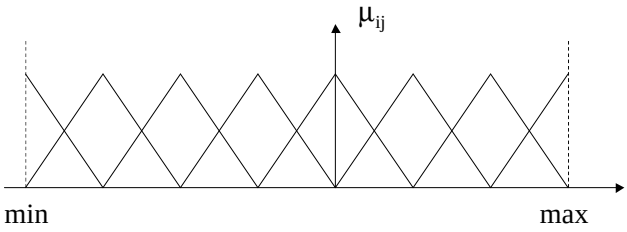

Figure 3. Complementary fuzzy segments

For obtaining the corresponding *fi(xi) (*output value of the synapse) it's used a defuzzification process that consider the complementary structure of the segments (the sum of the two activated membership functions should be equal to 1). So, the neofuzzy neuron output may be given as follows:

$$f_i(x_i) = \mu_{ik}(x_i) w_{ik} + \mu_{i,k+1}(x_i) w_{i,k+1} \quad (1)$$

Where:

$\mu_{ik}(x_i)$ is the membership value obtained for the input signal *xi*.

w_{ik} are the interconnecting weights.

The incremental updating (Stepwise Training) learning algorithm used for updating the weights, is as follows:

$$\Delta w_{ij} = -\alpha(y_k - t_k)\mu_{ij}(x_{ik}) \quad (2)$$

where:

y_k is the neofuzzy neuron output.

t_k is the desired output.

α is the learning rate.

In this particular work it has been used two different learning rate values: It was used a bigger value for the beginning of the algorithm in order to find a faster convergence and then it was uses a smaller value in order to have a better fitting and more accurate predictions.

3 Temperature prediction using the Neofuzzy neuron-based approach

It was used the neofuzzy neuron-based approach for predicting the temperature in Ibarra city [20], that is located in Provincia de Imbabura in Ecuador. Ibarra is a very particular city because it has many climatic changes during the day and is an interesting place for constructing a temperature prediction model.

As it was presented in [12] it was first studied the climatic station and the variables that have been measured during more than seven year. After that, it was studied the relationship between the variables and it was selected next variables for creating the temperature prediction model: Previous days Temperature, Humidity, Dew Point, Wind speed, Pressure, Rain and Solar Radiation.

For predicting the temperature for one day in the future, it was used information concerning the measurements from one day before and also with information from previous days up to five previous days. The general structure of the neofuzzy neurons-based approach model can be seen in figure 4, where x_1, x_2, x_3, x_4 and x_5 correspond respectively to the day, month, year, hour and minute to be predicted. x_6 is the previous day temperature, x_7 the previous day humidity, x_8 the previous day Dew point, x_9 the previous day wind speed, x_{10} the previous day pressure, x_{11} the previous day rain and x_{12} is the previous day solar radiation. For a more general model, where it's desired to make the prediction using more previous days, it will be used 5+7*previous days inputs, because the first 5 inputs variables will correspond to the day, month, year, hour and minute to be predicted and it will be required 7 variables (Temperature, Humidity, Dew Point, Wind speed, Pressure, Rain and Solar Radiation) for each or the previous days used for the prediction model.

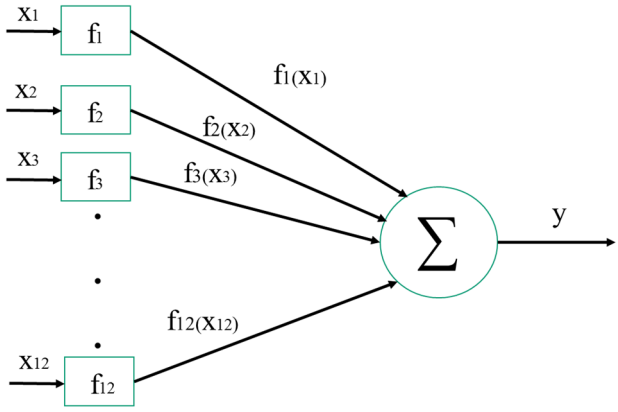

Figure 4. General structure of the neofuzzy neuron-based approach for temperature prediction

It was analyzed the data taken every five minutes from January 1st 2012 until may 15th 2015 [12]. It was made statistical analysis [3] concerning outliers, data imputations [1] and data sets selection for training and testing the model.

It was selected the data set that was going to be used for creating the neo-fuzzy neuron-based model (240.000 patterns) and the data set used for testing the model (116.640 patterns).

It was build models using diverse learning initial and final learning rate and diverse inputs from one previous day until five previous days and the model that gave the better results for training and testing phases was the one that uses the information concerning 4 previous days and the results can be seen in figure

The model that gave better result was the one created using nineteen (19) inputs variables, which means that it was used the information from two previous days from the moment wanted to be predicted. It was used as initial learning rate α=0.0001 and final learning rate (after 1000 iterations) of α=0.00001. The results can be seen in figures 5 and 6. In both cases (training and testing data sets) the error found between the real data and the predicted data is 10.37% and 9.08% respectively.

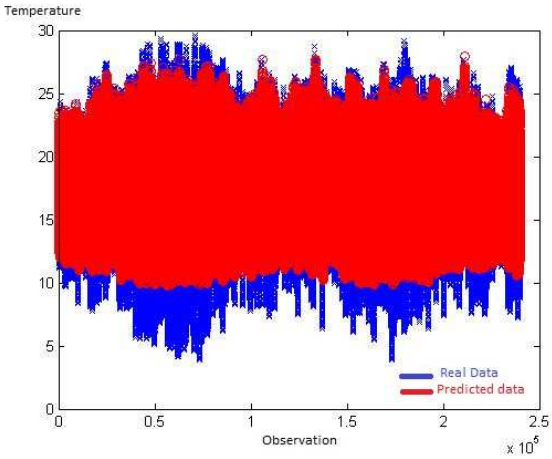

Figure 5. Result for the training data set using temperature prediction model

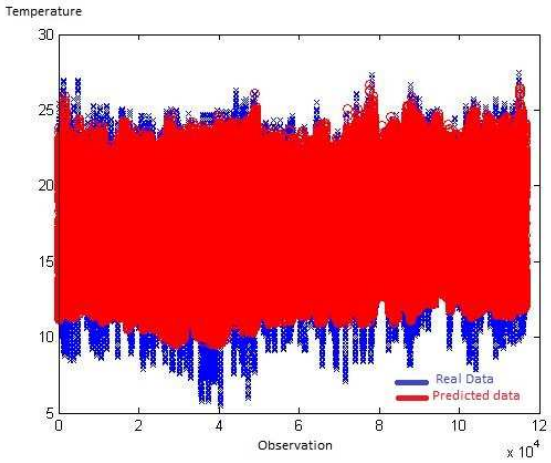

Figure 6. Result for the testing data set using temperature prediction model

4 Conclusion

In this work it was presented a proposal for creating a temperature prediction model using a neo fuzzy neuron approach.

This model was created using some modifications to the typical neofuzzy neurons approach, changing the training rate, having one with bigger value for obtaining a faster convergence and a smaller one after some iterations in order to have a more accurate values.

This temperature prediction model proposed was used for modeling the temperature in the Ibarra city in Ecuador and it was found good results with a particular selected structure.

It will be continued this research, comparing these models with other neuronal and intelligent or hybrid systems models in order to try to improve the found results.

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