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Forecasting Temperature using Fuzzy Neural Networks and Genetic Algorithms (Case Study Lorestan Province, Khorramabad City)

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ABSTRACT

Predicting temperature is one of the most important phenomena studied in climatology studies that from the user's perspective to many human activities, especially agricultural activities linked. Planning against the dangers of this phenomenon is necessary to studies on forecasting methods and the effects of climate signals on the minimum and maximum temperature taken. Due to limitations such as insufficient data available, low accuracy and high error in Hakol statistical methods in this study using fuzzy inference nervous system and genetic algorithm in MATLAB software boxes used as an efficient method to predict temperature. The model used in this study includes a hidden layer and an output layer, fuzzy system used in this study is Sugeno model. In this method, non-linear relationships between variables are assumed. In this study, we tried to predict the minimum and maximum temperatures in the city of Khorramabad (using the variables of sunshine, and climate signals) are necessary. For this purpose, the capabilities of fuzzy neural network and genetic algorithm were used to make the prediction. Monthly and daily statistical model inputs of signals in the area of climate and sunshine period (2014-2008) and output data minimum and maximum temperature. The neuro-fuzzy model, in the period (2014-2008) in estimating the minimum was trained and the maximum temperature is conducted using a genetic algorithm in 945 years. The results indicate that the fuzzy neural network with genetic algorithm capable of more and high accuracy to predict the minimum and maximum daily temperature and monthly than usual statistical methods as temperatures with reasonable accuracy predict with a confidence level of 90%.

KEYWORDS
predicting temperature (minimum, maximum), fuzzy neural networks, genetic algorithms

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Introduction

Among the available methods, including statistical methods and noted that based training methods are based on intelligent training and the accuracy and faster processing than statistical methods. Of education-based methods, neural networks and neural network techniques - can be named fuzzy neural network capable of dealing with different issues in signal processing, pattern recognition, modeling, identification, prediction, control and optimize various examples in the past few decades has been confirmed.

To investigate the correlation between meteorological variables is considered a balanced approach among them the genetic algorithm, support vector machines, clustering and Markov Chain and fuzzy neural network noted. (Lucas, 2004) Fuzzy Systems based on the approximate decision based on individual and collective human experience are built. The team's intuitive qualitative and quantitative modeling paid (instead of small quantities) and so there have been efforts in the face of uncertainties. (HiKane, 1999)

Neural network model for radiation temperature-analysis presented at different scales in the climate system in this model a completely non-linear analysis of the effects of radiation on the temperature of the climate system using neural network model has been fundamental factors Global-scale temperature behavior and logic in the past 140 years has been determined (Antoine Nelo Pasiny et al., 2005). Great benefits fuzzy systems, and the ability to understand them is simply that they are very easy to use and understand. Adjustable approximate reasoning abilities and accuracy in dealing with issues another advantage of this system unfortunately, this system has the ability to learn not and in the face of complex systems, difficult to set a time-consuming and exhausting membership functions and rules are necessary. Although the ability to solve complex problems in fuzzy systems modeling and prediction and control and artificial intelligence has been confirmed by many examples (Jang et al., 1997). Of different factors affect each species for climate and in order to take advantage of them is aware of the temperature rise of these factors are considered as intelligent inputs. The network using the information provided by the education and optimization then the temperature is forecast in the next 100 years and value optimization and genetic algorithm, however, is played back (Ashrafi et al., 2009).

Research questions

1) Is there a difference between weather centers predicted outcomes, genetic algorithms, and fuzzy neural network?

2) How is the impact of meteorological parameters on any of the anticipated results?

3) What are criteria for evaluating and selecting a preferred effective method?

Research Methodology

In this study, after searching the Internet and library for the methods discussed in the forecast temperature and since the proposed approach is based on education and required data, in order to collect the Meteorological Department (province) is referred. Fuzzy Neural Network in the number of inputs and outputs should be clear from the data that has been determined.

Research model

In this study, the collection of data on meteorological variables was used. According to the database and partly valid information and access detailed information from the National Weather Service since the data and meteorological data are different and have suffered different changes and the first data normalization was done to better forecast. Meteorological data available (press, sundial, minimum and maximum temperature, relative humidity, rainfall ...) according to studies conducted and guidelines to minimize variables and record temperature, relative humidity, pressure, sundial as input variables considered in the model. Therefore, the objective function (fitness function) is the sum of errors estimated values with actual values. Each chromosome is equal to the parameters set in this case neural - fuzzy genetic algorithm by changing the parameters of the best parameter for the nervous system - will get fuzzy. In this study, genetic optimization algorithm to reduce forecast error and phase adjustment coefficients may be used. In this case, the genetic algorithm trained neuro-fuzzy system is a good alternative and the basic structure of the neural network - learning fuzzy operation carried out by methods intended but with the introduction of genetic algorithms, learning can be done based on genetic algorithm. So that the smallest error between the actual output and the output calculated is based on neural fuzzy network.

This step is also shown in Figure 1:

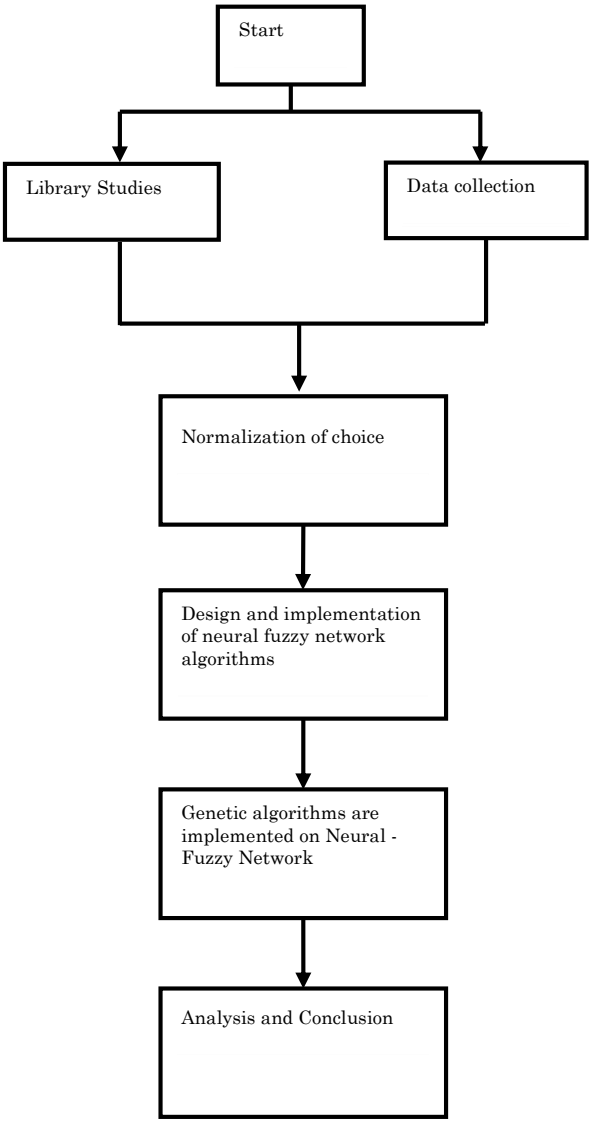

Figure 1 Moradi Bisootoni 2015

Data collection

Research methodology in this study is applied and the method of data collection is a practical idea.

The data collection tool

This information is obtained mainly through face to face interviews.

Data descriptive and analytical

In this study, neural - fuzzy networks and genetic algorithm is used.

A review of the literature

Internal investigations

Before 1500 years ago, by Leonardo da Vinci Italian painter and a great scientist invented a toy mechanical hygrometer and a full vane. Later, in the late sixteenth century, about 1553 years until 1513 Galileo, invented the thermometer and the completion of his disciple John Ray. It is actually the first official moves scientists measure climate is considered with an option for a while by a common scale for measuring the climate was considered. The meteorological activities as a new science in the nineteenth century were the first (Shakiba, 2013). One of the basic elements of cognition air due to the irregular solar energy received by the earth, the air temperature at ground level has been many changes. These changes, in turn, causes changes in other factors affecting the temperature of the air: radiation conditions and its relationship with the effects of Earth's surface, thermal conductivity in the upper stratum of the Earth's surface, altitude, temperature inversion (Ahmadi, 2003).

The radiation and changes in temperature are very important so that in tropical areas with high radiation and air temperature is relatively constant over the years has been relatively stable and high. Temperature is also very effective absorption rate level so that, for example, in the ocean and the sea that absorbs more solar radiation, temperature adjustment mode, arid regions where absorption is low but quickly heated surface and warms the air around you and the subsequent extremely cold and ambient air is cool itself (Ahmadi, 2003).

Mohebi et al (2011) Genetic Algorithm and Neural Network should be used to estimate the moisture content of dried bananas. They genetic algorithm neural network parameters such as the number of hidden layers, the number of hidden nodes, the learning rate for each hidden layer can be inferred.

Shakiba (2013) thesis as predicted minimum air temperature in Karaj city case study using artificial neural networks offered and the results of this study show if based on fuzzy artificial neural network to be built can offer better results to predict temperature.

Ashrafi et al (2009) a study entitled predict a rise in temperature due to Iran climate change using neural networks have offered, which examines various factors that each species on climate change are effectively investigated. Moreover, to take advantage of those in order to be aware of the temperature rise of these factors have been considered as intelligent input. The network using information provided by trained and optimized then the temperature is predicted to be 100 years and back and genetic algorithm optimization method is used.

Ebrahimi et al (2011) The role of meteorological variables such as temperature and pressure on the drought and seasonal rainfall are examined and to predict the central index Rahimi (85) using artificial neural network models such as Neural Networks Multilayer Perceptron. Germany's return delayed input network and neural networks and statistical models to predict the Kajoo watershed runoff in South-East Iran is studied. The runoff signals and signals delay in 4 different scenarios and with 3 to 5 independent predictors in the model of the neural network is closed. The results show that neural networks

are more accurate static than dynamic neural networks. This is due to the nature scheduler and sudden changes of runoff in the region are justified. Halibian (2009) article for more information and knocked rainfall estimation using artificial neural networks offered monthly rainfall data in this study during the period of 53 years (1950-2003) and artificial neural networks as a non-linear method is used to predict rainfall. As well as after a single training network and test network with hidden layers and different learning coefficients and learning different coefficients indicated in combination with genetic algorithms and the network combines the features of genetic algorithms to reduce errors and speed up and provide a better model.

Foreign investigations

Asiom et al (1995) in southern Europe using artificial neural networks to predict and compare the results with other methods indicated the superiority neural network to predict the temperature. Asqool (2011) of the air temperature with relative humidity to calculate the moisture bulb temperature at standard sea level pressure can be used. Smith et al (2006) accurately predict winter weather models include quarterly data input patterns and the development of improved data prior to 24 hours. The neural network model to predict air temperature data collected for the entire year until 2005 to develop. Shank et al (2004) to predict the dew point temperature up to 12 hours earlier on the basis of weather, dew point temperature is a sultry, sun radiation, air temperature, air speed and high-pressure steam generated. Jin et al. (2003) neural network model to predict air temperature during the winter months to be rejected. This model uses weather information patterns that last 6 hours, including temperature, humidity, wind speed, relative, wind and radiation, exposure to sunlight as well as hours and days to be included. Aijoon et al (2004) Genetic Algorithm to select preferred combinations of features for defect classification neural network model used for monitoring mechanical systems. The structure of neural network based on genetic algorithms to deduce the number of hidden layers. Koongradaee et al (2007) model to reduce electricity consumption chillers, combining neural networks and genetic and neural network was used to build the model chiller and genetic algorithms to optimize chiller model parameters were used.

Vito Antonioboilakoa et al (2007) neural network models for climate change analysis presented in Italy. The neural network modeling to model the relationship between publications and the number of statistical variables are used.

Lucas et al (2004) to investigate the correlation between meteorological variables and drought and precipitation have to consider a different approach. Such as artificial neural networks that can be noted.

Paeesi et al (2009) article titled neural network modeling to analyze temperature - radiation at different scales offered in the climate system. In this study, a highly non-linear analysis of the effects of radiation on water temperature and air using neural network modeling has been done.

Stanley and Mikulin (2004) to name a neat (or optimal alignment method according to native features) gave the parallel development of neural network architecture and communication weight in meteorology enabled and of different models such as Markov chain and have a neural network.

The type and nature of study

In summary, the research based on the nature and purpose or method that follows, is divided into different groups. Based on objective, scientific research can be divided into 3 categories, basic, functional and practical divided. Type of this application is here briefly described below.

Statistical Society

In reviewing the statistical period is longer climate research will benefit from a higher value (Farajzadeh, 1374). In this study, the oldest statistics from statistics stations synoptic in Khorramabad, Lorestan Province, precipitation and temperature are to be used. In this research to predict temperature data (2014-2008) is used. The reasons for choosing the impact and importance of the availability of data are more recent period of data.

Variables

According to studies of climate and meteorological features and according to its information database data relative humidity, pressure, sundial, ra value (the extraterrestrial radiation), minimum and maximum temperatures to predict temperature have been used.

Data collection method

Temperature forecast data from Meteorological Organization adapted province, which is calling on the information received. Algorithm design is discussed in the chapter to which the data can be derived to predict. Overall, this season algorithm is designed in three phases. The first pre-processing stage and second stage processing by neural - fuzzy networks and the third step is genetic network processing on neural - fuzzy network. In the first stage a series of measures on the real data to prepare data, these actions are normalizing. In the second phase of neural network classifiers - the phase is designed with respect to the previous season. The third stage is designed genetic network on the results neural - fuzzy network achieved the highest and the lowest error.
At this stage normalization is done, is described in the section below.

Normalized data

In many practical situations encountered with features that values within the dynamic is different. So features with large amounts may have a bigger impact on the cost to have the characteristics of small amounts, since the data in neural - fuzzy network and neural network data are different. They can vary and range changes; the normalized data is a suitable way for better predictions. If you are

suffering different numbers, work for recognition, it is hard to make the weight specified or may not acquire the proper diagnosis. Sometimes the numbers are normalized between [0,1] or between [-1,1] puts Thus, for any given (the temperature, the relative humidity, etc.) normalization is done.

The maximum and minimum values in each column are determined then use this data as normal is determined by the following formula:

(1) (Moradi Bistooni, 2015) $$Y = \frac{Y^* - Y_{min}}{Y_{max} - Y_{min}}$$

Y_{min} minimum data

Y_{max} maximum amount of data

In this case, instead of Y * as input y for the fuzzy system considered to be nervous in the above process is done for all data. It should be noted that the above work on all input and output data applied. All data are between zero and operate the system with fuzzy - neural and determine the weight of each terminal, from where the data between [0,1] is set to display should be returned to it according to the following formula conclusion of neuro-fuzzy numbers are returned to their true value:

(2) (Moradi Bistooni, 2015) $$Y^* = Y \times (Y_{max} - Y_{min}) + Y_{min}$$

The output value of the fuzzy - nervous system, thus normalizing operation and return to the real input data is performed.

Fuzzy - neural system structure in this study

The next step is to forecast using Neural - Fuzzy Networks to do this important neural - fuzzy network toolbox is Matlab software is used. This software allows design and neural network learning and assessment, and comprises different networks with different learning rules (Bagherzadeh, Chehreh, 2005).

(2) the structure of fuzzy nervous system (Moradi Bistooni, 2015)

Calculate the probability function for each

(3) (Moradi Bistooni, 2015) $$y = \sum_{i=1}^{K} y_i(x) b_i \qquad with\ \ y_i(x) = \frac{\pi_{j=1}^{p}\ \exp(-\frac{(x_j - cij)^2}{2\delta ij^2})}{\sum_{i=1}^{K} \pi_{j=1}^{p}\ \exp(-\frac{(x_j - cij)^2}{2\delta ij^2})}$$

As you know, the neural network is used to predict but at mere possibility of reaches, an appropriate answer to it is not allowed. In this case, the fuzzy rules to improve the prediction in the neural network is performed, the neural network is derived from human brain but it is different from the system through its next phase, it can be fuzzy system which is a human language used in the neural network and achieve a more accurate prediction.

Simulation

ANFIS function defined in the MATLAB software called genfis 1,2,3 is used.

Each case is different below:

Functions

Function 1) producing fis Sugeno-type structure clamp as the initial conditions

(Initialize the membership function parameters) used for neural structure - training phase. Production Sugeno single-output fuzzy inference system used a partition on a data network.
The rules defined in this order:

Table 1 of the first type, (Zahiri 2013)

In ference method	Default
AND	Prod
OR	Max
Implication	Prod
Aggregation	Max
Defuzzification	Wtaver

Function 2) a fis and identified using subtractive clustering and cluster center area of influence.

Table 2 of the second type, (Zahiri, 2013)

In ference method	Default
AND	Prod
OR	Prod
Implication	Prod
Aggregation	Max
Defuzzification	wtaver

Function 3) producing fis using fuzzy system tools (fcm) clustering by extracting a set of rules that model the behavior. Using fcm function to determine the number of rules and membership functions used for records and outcomes.

Figure 3 The second type function, (Zahiri, 2013)

In ference method	Default
AND	Prod
OR	Prod
Implication	Prod
Aggregation	Sum
Defuzzification	wtaver

Data processing

The dataset used in this study were related to weather information in Khorramabad. The pressure variables, relative humidity (minimum and maximum), temperature (minimum and maximum), ra, rainfall, is intended. According to the organization's information database as well as access to accurate and credible information about daily and monthly temperature data for predicting found and at a later stage through genetic algorithm is the best coefficient of error for each variable has been obtained experimentally.

Table 4 variables in study

No	Variable name
1	Pressure
2	Relative humidity (minimum and maximum)
3	Temperature (minimum and maximum)
4	Ra value

As can be seen in the figure below, the pre-processing stage and second stage processing by neural network and the third stage processing of genetic networks in the first stage performed a series of measures on actual data or prepare data for analysis, these measures are such as normalization and feature selection. In the second phase of the neural network - genetic network design phase and the third phase is due to last season's content is designed.

Output

Figure 5 shows the general diagram of a classification algorithm (Moradi Bistooni, 2015)

In this chapter, the results of simulation algorithms are discussed. In the simulation algorithm attempts to change rates and the number of repetitions education, training and testing results Categories with fewer errors, as a result of the simulation in this chapter. The data used to simulate a two-class (monthly data and daily data) 84 and 2555 respectively feature in accordance with the following common features between daily and monthly data is intended.

Table 5 Data Features Name

No	Feature name
X_1	Pressure
X_2	ra value
X_3	relative humidity
X_4	Minimum Temperature
X_5	Maximum Temperature
X_6	Sun clock

Here, 80 percent of all data to train the neural network - phase and 20% is used for network testing.

Research data

Weather center to be able to offer several models and the results of its monitoring centers and agencies any kind hearts and their results has divided the case: seasonal forecasting, evaporation forecast, predicting drought, precipitation forecast, predicting the ice, monthly forecast, annual forecast, daily humidity forecast, forecast for pressure, temperature forecast. The data is in the data years (2014-1331) due to the large size of the data Hoya over recent years (2014-2007) have been mentioned.

Sugeno structure can be seen by comparing diagrams testing and training in the charts Sugeno structure, indicate the Sugeno in determining the structure of the input samples. Since the meteorological data are non-linear and non-linear phenomenon itself is temperature forecast Sugeno structure of the strengths of this structure. By comparing the amounts of precision test and train both neural - fuzzy network structure and genetic algorithms can be seen that the difference is negligible but Sugeno structure is better. After applying genetic data network, as the tables, depending on the type of data and data features and neural - fuzzy network choice and compare the results between these two methods to choose the best method among the available functions are as follows.

Table 6 Results The first function fuzzy neural network

Minimum Temperature	Maximum Temperature
RMSE=5.7444 Error= -6.7627 Std=5.7535	RMSE=9.1163 Error=-2.8225 Std=8.7428

The first function neural - fuzzy network

Minimum Temperature	Maximum Temperature
RMSE=2.4771 Error= -0.0048726 Std=2.4805	RMSE=2.6712 Error=3.8742 Std=2.6748

The second function neural - fuzzy network

Minimum Temperature	Maximum Temperature
RMSE=2.29 Error= -4.713 Std=2.2973	RMSE=2.8585 Error=1.7404 Std=2.8624

The third function neural - fuzzy network

The best coefficients of genetic algorithm for functions

Table 7 the results of the second function fuzzy neural network

Best coefficients	Method
1708.4	1
3857.3	2
167.5	3

Results

Due to the importance of identifying and finding solutions to manage and control the temperature forecast is better, access to high-resolution models that can predict this event, economically and practically important role in the survival and health of its meteorological industry, the lack of appropriate forecasting which widely meteorological industry in Iran is faced with extensive challenges. This means that a high percentage of predictions have been wrong and mainly because of the lack of peer review tools, equipment and lack of labor.

To solve this problem mainly in the weather center in the use of computer systems for comprehensive review of all the components is possible and in the study of neural networks - fuzzy to predict temperature (minimum and maximum) were estimated. After applying the selected data classification algorithm results indicate optimum performance combined with fuzzy neural network temperature forecast is genetic algorithm, that the lack of access to required data network can be a better solution than empirical methods.

These networks are without the need for an estimator model. This feature gives them so no need to formulate a clear model to data on the interaction record.

Phenomenon predicted his temperature is uncertain nonlinear systems and neural network - its phase of new tools in the system of relations between the components and system to identify and be able to analyze and simulate that cannot be described.

Neural - Fuzzy Networks do not require any distributional assumptions for input data and so about the statistical technique of regression analysis and diagnosis can be applied to a wider range of problems.

Neural networks that allow this property fuzzy, fuzzy neural network trained new data to be added.

In this study, using meteorological variables to predict the minimum and maximum temperature in the city of Khorramabad using Fuzzy Neural Network and genetic algorithms were evaluated. The results showed that the greatest impact relative humidity and sunshine hours were the least impact on the predicted temperature.

Another finding of this study is to standardize the data to predict better results can be achieved.

A comparison of the error Neural– Fuzzy Network and genetic algorithm neural network algorithm showed a much - a combination of temperature forecast is fuzzy.

Due to the increasing variety and number of models by the meteorological industry, as well as the increasing development of this industry in the world, the revision of the conventional forecasting techniques based on old models and even subjective judgments are based, it seems necessary. Therefore, turning to the benefits mentioned in this study, the implementation of predictive models in meteorology industry, besides that meets monthly and even yearly increase in forecasts, decisions faster, more accurately and at lower cost makes it possible.

Conclusion

Whether using neural - fuzzy network and genetic algorithms can accurately predict the increase in temperature (minimum and maximum) is effective? According to the results of the temperature forecast using fuzzy neural networks and genetic algorithms in combination with standard data and compared with the results tables (predicted temperature) in the center of Meteorology indicates a better result and a lower error rate of this method compared to the methods employed in the center.

Suggestion

• According to recent applications in the field of meteorological model temperature forecast and special importance in the formation minimum temperature and dew concept model is required that the combination of these two concepts (dew and minimum temperature) considering the possibility of dew in the process provide weather forecasts for the industry.

• Combination of fuzzy neural network and genetic algorithm methods to determine the flood hydrograph

• Combination of methods AHP, TOPSIS in networks and fuzzy environment to rank various spheres of environmental risk

• Design and maintain software systems neural network model - fuzzy and genetic algorithms to reduce the required parameters for estimating reference evapotranspiration

• Design and maintain software systems neural network model - fuzzy signal evaluation meteorological drought forecasting

• Combination of fuzzy neural network and genetic algorithms to predict the ice

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