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Study of Climate Change in Bogota, using Colombia and Global Temperature Data

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Abstract

This document presents the analysis of climate change in Bogotá, using data from Colombia, global and neighboring countries using the data facilitated by the Berkeley project, 2 techniques will be used for this. One is neural networks and fuzzy systems to classify and predict temperature changes and evidence the phenomenon of global warming in Bogotá, presents specific case studies on climate change and its applications in different fields, as a conclusion is presented the reasons for the only temperature prediction performed for Bogotá and not a classification exercise.

Keywords: Climate change, fuzzy, neural network, nntool, prediction.

INTRODUCTION

Climate change is one of the biggest problems facing mankind today and although many studies prove their existence, several communities worldwide says it is just a myth. These people are generally related to the energy sector and insist that taking action to prevent or combat it means losing time and, more importantly, money. Due to this situation the Berkeley Earth institute decided to release a data set on the temperature in the planet from the middle of the XIX century until the end of the year 2013. According to the institute, its objective is that data scientists of the world can draw their own conclusions about the supposed climate change that the earth is suffering mainly due to human intervention.

This document takes as basis for the study presented the data offered by the Berkeley Earth Institute to make an analysis on the climatic change in the main cities of Colombia and bordering countries.

DATA SET USED

The data set used contains average temperature data associated with climate change worldwide. The averaging process generates a variety of output data including a set of cross-linked temperature fields, these data are collected by the Berkeley Earth project, the data set includes global temperature data by cities and countries, the data set Contains information from the year 1850 to 2013 and contains an average temperature value per month [1].

PROBLEM APPROACH

In this project, we intend to classify and predict the temperature of different cities of Colombia and neighboring countries with Colombia based on algorithms neural networks and diffuse systems, as well as predict the temperature and evidence the phenomenon of global warming for the different cities that are selected

THEORETICAL FRAMEWORK

Nowadays, the scientific evidence of climate change is indisputable, according to the IPCC research and conclusions by its acronym in English Intergovernmental Panel on Climate Change, leading international organization on the subjects related to the climatic change. Or as mentioned by the US Environmental Protection Agency (EPA), with the slogan "Climate change is happening.".

Climate change is defined as a stable and durable change in the distribution of climate patterns over periods of time ranging from decades to millions of years. It could be a change in the average climatic conditions or the distribution of events around that average (for example more or less extreme climatic events). Climate change can be limited to a specific region, as it can cover the entire land area.

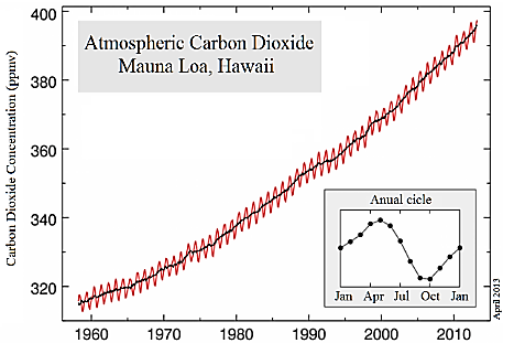

Figure 1. Concentration of atmospheric carbon dioxide (CO2).

In the scientific journals, "global warming" refers to changes or increases in surface temperatures, while "climate change" includes global warming and all other aspects that are influenced by an increase in greenhouse gases.

The evidence is based on observations of increases in air and ocean temperatures, melting of ice and glaciers around the world and rising sea levels worldwide and other clear signs of change.

It has been determined that the increase in global temperature should be limited to 2 ° C to avoid irreversible damage to the planet and subsequent disastrous effects on human society. In order to avoid this irreversible change and its effects, greenhouse gas emissions should reach their peak in 2015 and progressively decrease thereafter until reaching a 50% reduction by 2050.

STATE OF ART

Reviewing the literature there are several studies related to climate change, with statistics and data from Italy is analyzed, investigated and simulated the possible relationship between CO_2 emissions of carbon dioxide and variables taken from the Italian national institute of statistics, the application that uses Artificial intelligence, presents the possibility of having a model of provision to study the temperature of the earth and its constant increase, finding problems related to the environment and the world economy. [2]

The proposed neural network is EBP, which can be learned from past experiences and used to estimate CO_2 values in the past, present and future, variables were chosen based on the relationship with solid fuels, petroleum, natural gas consumptions Electricity and economic variables such as the gross domestic product of Italy and the resident population. The impact of CO_2 emissions related to natural gas, oil, solid fuels and electricity was also studied, taking into account the weighted average of aggregate consumption in macro-categories. [2].

This model allows to perform a sensitivity analysis in order to calculate the impact of each input parameter of the neural network on the total emission. From the experimental results, it is possible to argue that oil has the greatest impact on emissions. According to the analysis, it is necessary to reduce the use of natural gas by 40%, oil consumption by 60%, electricity by 20%, and avoid solid fuels, in order to achieve the objectives of the Protocol of Kyoto. Vitoantonio [2].

The proposed CO_2 estimation model can be used to test the effectiveness of the energy policies adopted by each country in order to achieve the Kyoto targets.

Another work on climate change but using fuzzy systems is to quantify the impacts of climate change on the reproductive processes of fishes in the Northeast Pacific Ocean. The major changes in marine ecosystems from global climate change pose enormous challenges to those responsible for the assessment and management of fishery resources. Successful implementation of policies that allow sustainable fishing, especially during periods of climate change, usually requires a good understanding of the relationships between player numbers and subsequent recruitment. Non-traditional analytical techniques, including artificial intelligence (AI) methodologies, offer significant advantages over traditional techniques in the analysis of these relationships, and can therefore improve our understanding of how climate change can affect fish abundance. [3]

Fuzzy logic is applied to several time-series datasets of fish reproductive processes. Using fuzzy logic, we incorporate environmental changes into our analysis and thus model the uncertain and ill-defined impacts of environmental regimes. Unlike traditional approaches, fuzzy logic uses a continuous membership function that provides a rational basis for categorizing data. Based on the research results are obtained that seek to order fishing more efficiently. [3].

Studies are being carried out in different parts of the world related to climate change, just mentioned are only 2 cases using the methodologies that are intended to be used in this article for the analysis of climate change in Colombia. [4], [5], [6], [7], [8], [9]

DATA ANALYSIS USED

Data Distribution:

Analysis of the data used one of the characteristics that are identified when analyzing temperatures is the difference in the distribution of the world data and the distribution of Colombia or Bogotá. While Colombia and Bogotá present a Gaussian distribution in their histogram, the world does not present an ordinary distribution. This can be seen in Figures 2 and 3.

Figure 2 shows that the average temperature in Bogotá for approximately 160 years is 13 ° centigrade and that on average there has been an average temperature below 11 ° C or above 15 ° C.

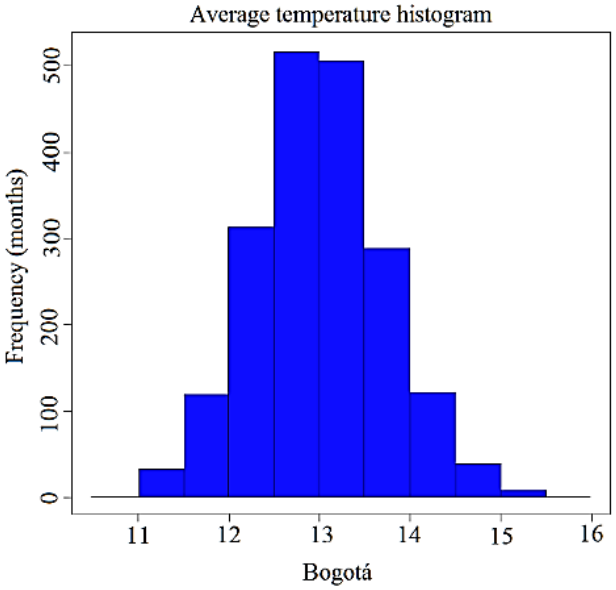

Figure 2. Histogram of the average monthly temperature (° C) in Bogotá from 1851 to 2013.

Figure 3 shows that, unlike Colombia and Bogota, the Earth does not have a well-defined average temperature, but it has a more uniform distribution between 13 ° and 17 ° with peaks at 13.5 ° and 16.5 °.

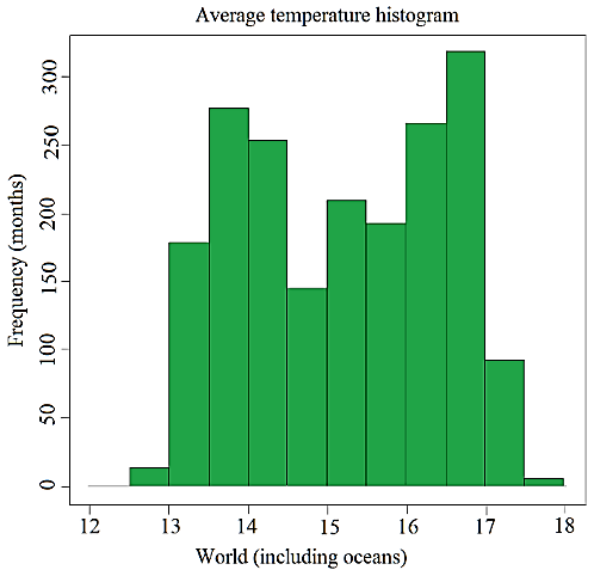

Figure 3. Histogram of the average monthly temperature (° C) on Earth from 1851 to 2013

Relationship between variables:

When comparing the average temperature of Colombia with the temperature of their cities, there is a very close relationship between them. This, taking into account that the temperature of the cities must be used to calculate the average Colombian temperature. This can be confirmed by the scatter plot in Figure 4 and the correlation values in Table 1.

Table 1. Correlation between the average temperature of Colombia and some cities of the country.

Bogotá	Medellín	Cartagena	Tunja	Villavicencio
0.8461	0.8179	0.1628	0.9461	0.8523

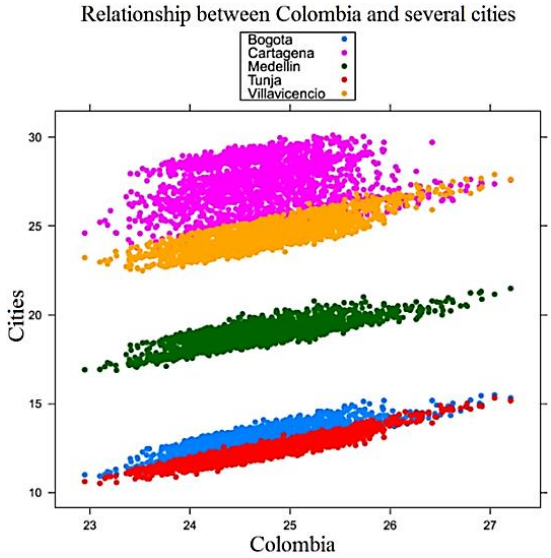

Figure 4. Scatter diagram between the Temperature of Colombia and some cities.

Another valuable comparison for this study can be seen in Figure 5 and Table 2. They show the affinity between the temperature of Colombia and some of its neighboring countries,

Table 2. Matrix of correlation between the average temperature of Colombia and some neighboring countries.

	Brasil	Colombia	Panamá	Venezuela
Brasil	1	0.5790	0.0633	0.4677
Colombia	0.5790	1	0.7229	0.8225
Panamá	0.0633	0.7229	1	0.7045
Venezuela	0.4677	0.8225	0.7045	1

Table 2 shows how the proximity of Colombia with Brazil, Panama and Venezuela makes the similarity in the temperature behavior of these countries very high. In contrast, it can be seen how the temperatures of Brazil and Panama have a correlation value very close to zero.

Figure 5 shows how Colombia's data are almost linear with data from Brazil, Panama and Venezuela. However, the slope between data from Colombia and Brazil is higher than the slope between Colombia and Venezuela or Colombia and Panama, which in turn are very similar to each other.

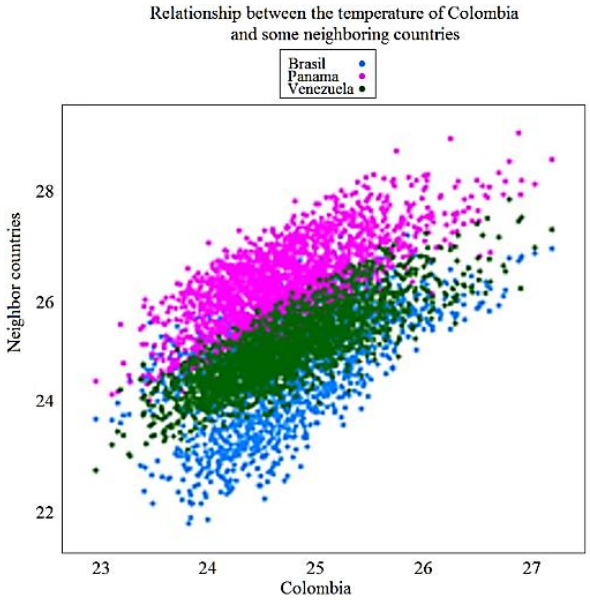

Figure 5. Scatter diagram between the Temperature of Colombia and some of its neighboring countries.

The similarity between the annual behavior of Bogota temperature and Colombian and world temperatures is estimated.

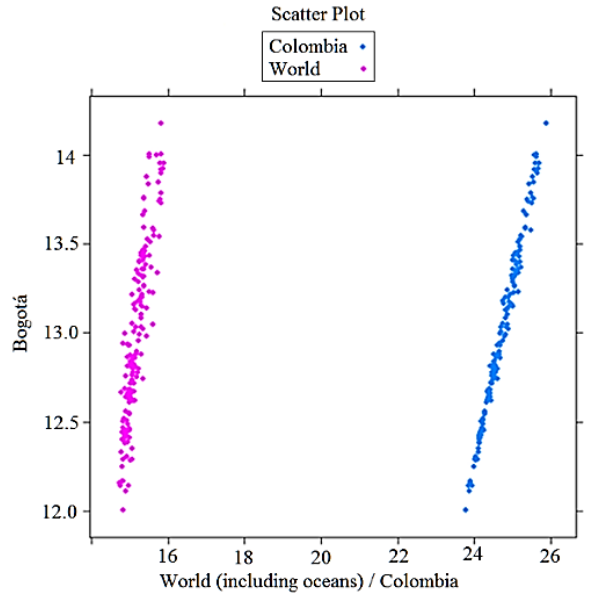

Figure 6. Scatter diagram between the annual temperature of Bogota against the temperature of the Earth and Colombia.

Table 3. Matrix of correlation between the Earth, Colombia and Bogotá.

	Bogotá	Colombia	Tierra
Bogotá	1	0.9927759	0.8877439
Colombia	0.9927759	1	0.9023129
Tierra	0.8877439	0.9023129	1

A very close relationship can be observed between the Earth's temperatures, Colombia and Bogota. The difference between these results may be due to the absence of stations in Colombia, which makes it maintain a very constant temperature throughout the year.

PREDICTION AND CLASSIFICATION

Input variables

Taking into account the results and analysis shown in the previous section, it is decided that the inputs to the system are the temperatures of:

- Medellín (the previous month)
- Tunja (the previous month)
- Villavicencio (the previous month)
- Colombia (two previous months)
- The Earth (two previous months)
- Bogota (two previous months)

The last one is intended to calculate a time series, so that the previous data of the variable to predict are of great help. Due to the presence of time series, we predict the temperature of Bogotá using a neural network varying its configuration parameters and not classification due to the characteristic of the data to be used.

- **Data set:** We used 80% of the total set as a training set and the remaining 20% as a validation set:
- **Training**: 1561 data pertaining to average monthly temperatures from January 1851 to December 1980.
- **Validation**: 390 data pertaining to average monthly temperatures from January 1981 to August 2013.
- **Procedure:** To perform the prediction of the temperature for Bogotá, with the data set presented is intended to use Matlab mathematical processing software and its nntool neural network tool, having data previously prepared and organized as previously related are loaded in the toolbox, the variables set in Matlab and the way they are defined are shown below.

```
load 'Data Project.mat'

inputsTrain=TrainData.inputs';

outputsTrain=TrainData.outputs';

inputsTest=TestData.inputs';

outputsTest=TestData.outputs';
%% To enter the data to the
toolbox the data must be
transposed so the apostrophe
```

Once the variables have been defined, the toolbox is executed with the nntool command, the configuration of inputs and outputs is performed according to the declaration of variables, loading the training and validation data, and configuring the neural network with the parameters that are observed in figure 7.

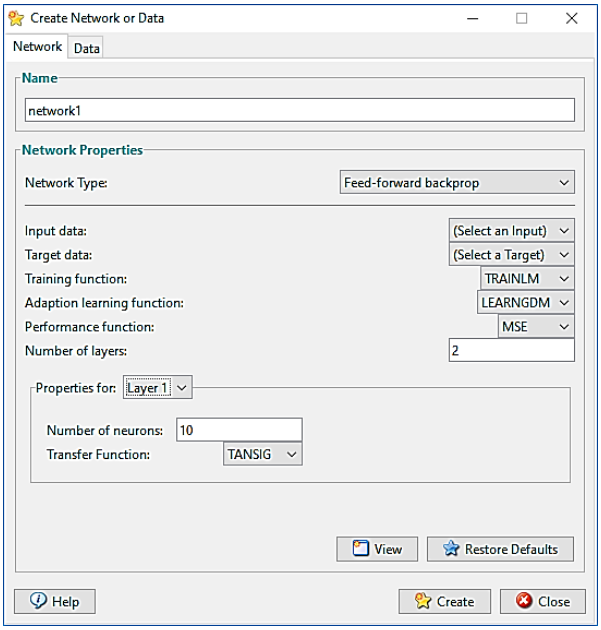

Figure 7. Configuring the neural network.

In Figure 8 the schematic of the neural network configured with neuronal 10 in the hidden layer can be observed.

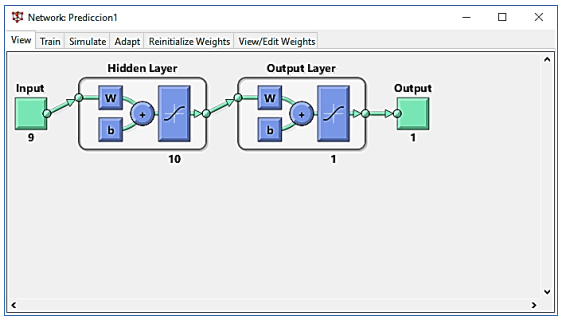

Figura 8. Esquema de la red neuronal.

The neural network is configured to perform the training indicating as input and output data corresponding to training, and its validation in the simulate option indicating as input the test data Test. Once this process is completed, the prediction variables for the training, validation and error data are obtained.

Results: Once the results of the neural network are obtained, the comparison between the actual training data and the predicted data are shown in figure 9.

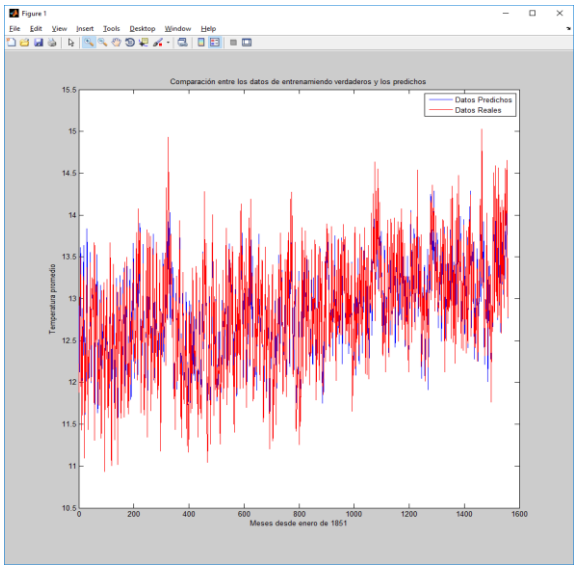

Figure 9. Comparison between true and predicted training data.

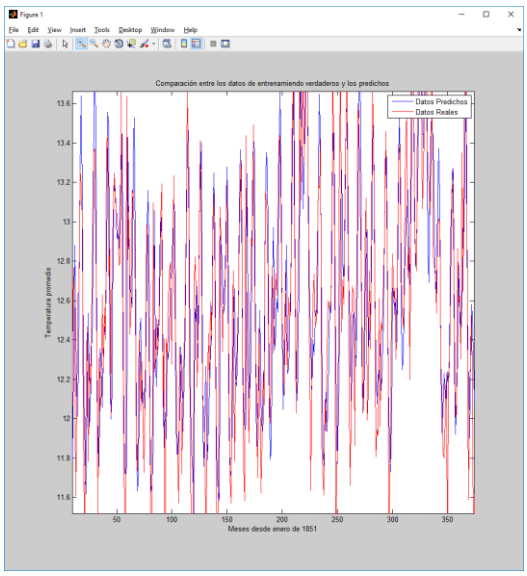

Figure 10. ZOOM in Comparison between true and predicted training data.

It is observed that the neural network achieves a good prediction of the temperature data for Bogota, however the comparison with the validation data is done, the result is shown in the graph with zoom shown in figure 11.

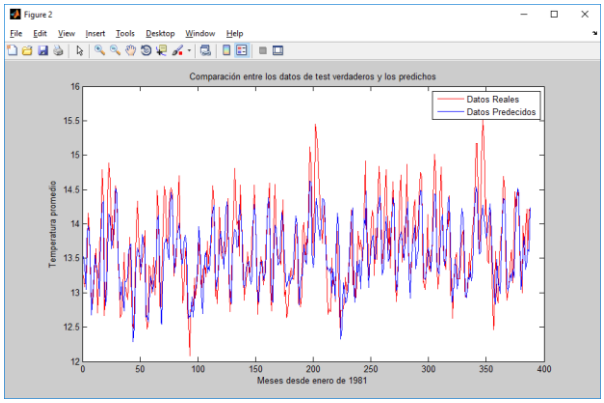

Figure 11. Comparison between actual and predicted test data.

Observing the results, a good prediction for the temperature in Bogotá is obtained, the calculation of the mean square error on the error variable delivered by the neural network is obtained, finding an error of 0.1262, a rather low error result that guarantees a less error of a half degree centigrade.

The script in .m, the used data and the neural network in the Matlab format are appended.

CONCLUSION

Performing the analysis of the data used, problems occur when performing classification procedures, in the timelines it is very difficult to perform classification, so in this document only prediction was made, although classification was contemplated.

Once the prediction procedure with the neural network preddicion1.m has been carried out, it is evident that the algorithm predicts the temperature for Bogota with an average error at half a degree centigrade, which is a good result for the temperature prediction.

In all the temporal graphs made in the analysis and preparation of the data, a global, continental and local temperature increase could be evidenced. So, it is concluded that according to the data from the Berkeley Earth Institute, global warming exists and affects directly our country.

The designed system is capable of forecasting the average monthly temperature of Bogotá with an error of approximately half a degree Celsius. Although it presents problems when there are extreme temperature changes between one month and another.

ACKNOWLEDGMENT

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