International Journal of Applied Engineering Research ISSN 0973-4562 Volume 16, Number 8 (2021) pp. 651-659

Colombia, Case Study: Detection of Breast Cancer Through a Neuronal Network

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Abstract

This document exposes the concepts of artificial intelligence, government and governance, then shows the definition of an artificial neuronal network and the main characteristics of smart cities, to observe the current situation of Colombia and the application of artificial intelligence in the sector of health, where breast cancer was taken as a case study, which was observed through several parameters that were entered into a neural network that was tested with several architectures, observing that the best network was generated through the algorithm of training of Levenberg-Marquadt.

Keywords: Artificial Neural Network, Government, Governance, Breast cancer.

INTRODUCTION

First, we reviewed the literature that discusses the basic concepts used in the article, such as artificial intelligence, intelligent governance and governance [1] [2] [3] [4], and then explain the structure of a neural network [5] [6] and in this way to be able to observe in a simple way the basic principles that make up an intelligent city [7] [8], where we subsequently proceeded, to the analysis of the methodology that is used in Colombia, to later cover intelligent health, putting breast cancer as a case study.

Then a supervised artificial neural network was carried out, generating a multilayer perceptron as a classifier of patients who are healthy and likely had breast cancer, with different training methods, generating a variation of the hidden layers and the number of neurons with the sigmoidal logarithmic function where we proceeded to observe the absolute mean error (mae) in the validation part and the mean square error (mse) in the training part.

The article was organized as follows: in section 2 the basic concepts referred to for the understanding of the article are discussed, in section 3 a brief explanation about the neural networks is made, in section 4 we proceed to explain the current situation of artificial intelligence with governance in smart cities, to then enter section 5 to explain the situation in Colombia today and proceed to discuss the case study, which is the detection of breast cancer that will be evaluated in a neural network , in section 6 the code for the test generation of different architectures was carried out, in section 7 the results of the different tests generated are shown, in section 8 the respective analyzes and discussions of the results obtained are shown, Finally, section 9 shows the respective conclusions obtained.

1. ARTIFICIAL INTELLIGENCE AND GOVERNANCE

In 1979 John Mcarthy defined Artificial intelligence as "The science and engineering of making intelligent machines" [1], it can also be thought that he was born from philosophical studies, taking into account the concerns that were for the human mind, to imagine capable objects that will imitate the nature of their thinking [2], there are many definitions that try to address this great field which would give for multiple books, however artificial intelligence consists of some basic principles, which are used in all applications, which They are:

- A capacity for autonomous learning.
- A real time reaction.
- A continuous interaction with the user.
- Must have good autonomy [2].

It is important to comment that artificial intelligence as a tool must be supported by other concepts such as the definition of “intelligent government”, which is dependent on an excellent government that is able to choose honest, equitable and participatory measures that are directly linked to technology so that it is also an electronic government, with which progress is made in technological advancement and with it from the same society [3], however it is important to bear in mind that a direct link must be generated with the concept of electronic governance which is aimed at the provision of services desired by the inhabitants of a city, carried out through the telecommunication, information and communication systems that are those that generate a specific model in a given area, so that citizens through their participation can make Smart cities, interactive areas that are always for the benefit of the community Give and help her grow [4].

2. ARTIFICIAL NEURONAL NETWORK

An artificial neural network is a model that describes the behavior of a neuron in the biological system [5] [17] [18], then we proceed to show the following illustration:

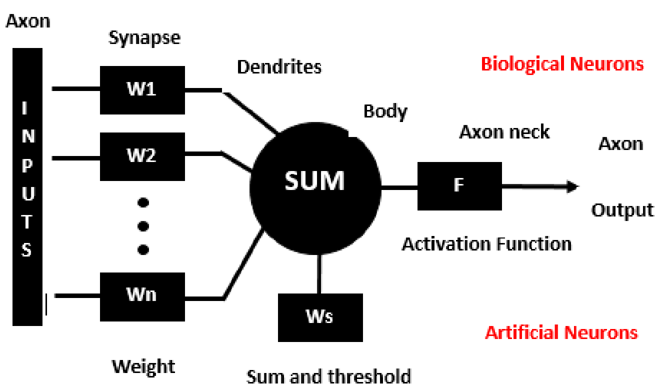

Figure 1. Analogy between artificial and biological neuron

Source: [5]

Figure 1 shows that the architecture of the neural network is composed of the vector of weights w, which can be expressed as follows:

$$W = (W_1, W_2, \dots, W_n) \quad (1)$$

In the same way there are n X entries having:

$$X = (X_1, X_2, \dots, X_n) \quad (2)$$

Having an α activation function, a summation is performed to observe an output and, having:

$$Y = \alpha\left(\sum_{i=1}^{m} X_i W_i - W_0\right) \quad (3)$$

The activation functions can be chosen depending on the type of problem to be solved, there are functions, Relu, Softmax, sigmoidal logarithmic, hyperbolic tangents, Gaussian functions, among others, which can er or lesser elasticity in the range and data analysis [6].

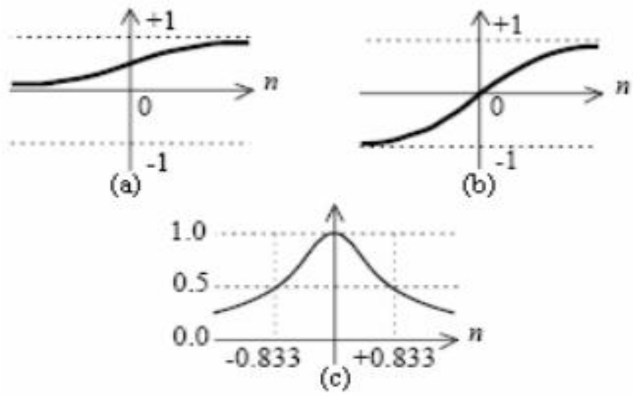

Figure 2. Some activation functions, (a) Logistic function, (b) Hyperbolic tangent function and (c) Gaussian function.

Source: [6]

3. CURRENT SITUATION OF SMART CITIES

It is important to understand that smart cities are currently strengthening their telecommunications, information and communication systems so that they can integrate and apply parallel concepts such as electronic government, open government (free data), cloud computing, Big data and internet of things [7], to strengthen and implement relatively new concepts such as artificial intelligence and industry 4.0, aiming at greater interaction with the citizen to provide a better quality of life and better performance in all areas [8] [9] [10] [19] [20] [21] [22]. Some elements of a smart city are:

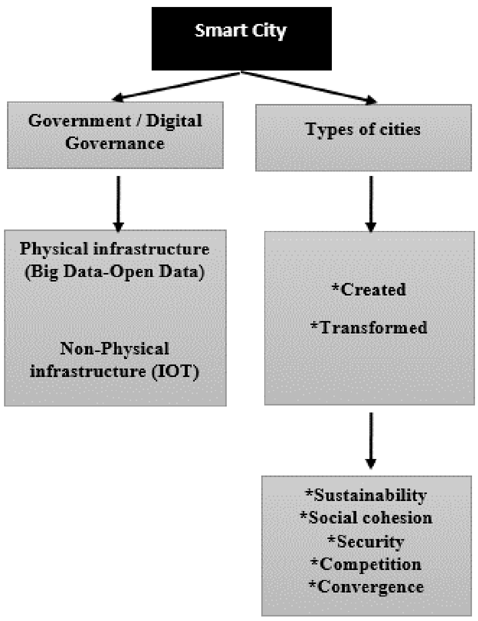

Figure 3. Some elements of a smart and sustainable city

Source: [7]

Some cities that already implement these technologies and can be considered intelligent are:

- Londres.
- París.

- Ámsterdam.
- Osaka.
- Dubai
- Tokio
- New York [7] [11] [12]

4. CURRENT SITUATION IN COLOMBIA

In Colombia, some studies have been done that demonstrate important technological advances implemented in sectors such as mobility, the environment, government, the economy and with it in the quality of life and in the active participation of people, mainly in cities such as Bogotá and Medellín, who are pioneers in the country for the continuous use of sensors, apps and other alternatives that try to interact continuously with people [13], however there is a sector that sometimes is not much deepened, which is the intelligent health sector, which can be observed from several fields such as telemedicine, in which several projects have been carried out as detailed in [14], where the present telecommunications infrastructure, computers, cell phones and cameras are used the same, for the taking of images, sending and transmission of data, in order to generate an integral health that can be coupled with an intelligent government and in the same way to an electronic governance [3] [4], however, in these projects no artificial intelligence is still applied to process the data and analyze it, either for prediction or classification, so in this document we will proceed to analyze the data of several patients, to classify them in healthy people or with a high probability of breast cancer. Before starting, it is important to note that breast cancer is the most frequent tumor in women with 1.67 million new cases reported, in addition to generating high mortality [15], in Colombia, breast cancer occupies second place in incidence with 8686 cases registered in 2014, with respect to other types of cancer that women may suffer [15], that is why a neural network was carried out supported by the data acquired from [16], of which the following inputs for the neural network were visualized (see table 1).

Table 1. Neural network inputs

INPUTS	Feature
INPUT 1	Sample Code Number
INPUT 2	Group Thickness
INPUT 3	Uniformity of cell size
INPUT 4	Uniformity of cell shape
INPUT 5	Marginal Adhesion
INPUT 6	Single epithelial cell size
INPUT 7	Bare cores
INPUT 8	Soft chromatin
INPUT 9	Normal nucleoli
INPUT 10	Mitosis

Source: Own Elaboration

Taking as a way out if the person is healthy or sick.

5. NEURAL NETWORK ARCHITECTURE

The first step that was carried out was the normalization of the information granted by the database [16], taking into account the following equation:

$$V_n = \frac{V - V_{minimun}}{V_{maximun} - V_{minimun}} \quad (4)$$

The second step was the generation of the code in Matlab to begin testing the architectures with different training algorithms for the neural network and their respective validation of the information, taking into account that 28% of the data was taken for validation and a 72% of the data for training, where the data matrix is 699x11, the code made was:

```
close all; clear all; clc
load('NORMALIZACION.mat');
cont = 0;
%%------------------Training Data------------------------
%%----M. Inputs
x = NORMALIZACION(1:500,1:10)';
%%----M. Outputs
y = NORMALIZACION(1:500,11)';
%%--------------------Validation Data--------------------
%%-----M. Inputs
xx = NORMALIZACION(501:699, 1:10)';
%%-----M. Outputs
yy = NORMALIZACION(1:500,11)';
nets = [];
for h=1:50
%%------ Creating and Training of the net---------------
PR  = [0 1;0 1;0 1;0 1;0 1;0 1;0 1;0 1;0 1;0 1];
% ---------Universe of inputs normalizate----------------
% %---Architecture of  the net
ARC = [2 1];
net=newff(PR,ARC,{'logsig''logsig'},'traingd','learngdm','mse'
);
[net,tr] = train(net,x,y);
%%-----------Validation (calcule of error)---------------
[Y] = sim(net,xx);
cont =0;
for i=1:length(Y)
  if Y(i)<0.5
     Y(i)=0;
  else
     Y(i)=1;
  end
  if Y(i)==yy(i)
    cont = cont+1;
  end
end
errorpercent(h)= (250-cont)*100/250
```

```
nets = [nets ; net];
end
figure;
hist(errorpercent);
set (gca,'fontsize',12);
title('Error de validación');
xlabel('Porcentaje de error');
ylabel('Repeticiones');
print('NET.png','-dpng','-r300');
save('NET.mat','errorpercent','nets','ARC');
```

6. RESULTS

We proceed to show the results obtained through the gradient descent training algorithm with adaptive learning rate by backpropagation, better known as “traingda”, having the following results:

In Table 2, 12 different architectures were tested, with the traingda training algorithm and the logsig activation function, taking into account important indicators such as the mean absolute error (mae) at its maximum and minimum value as a fundamental parameter, since this shows the behavior of the network with the validation data, the mean square error (mse) and the linear regression as secondary factors in the choice of architecture, because they are parameters focused on the training of the network, where it was observed that the architecture [2 2 1] was the lowest mae, with a high regression coefficient, having:

Table 2. Architectures with traingda

SIZE	NEURON	MSE	MAE		REGRESSION
			Min	Max	
[2 1]	3	0.025	0.47	0.49	0.94
[4 1]	5	0.014	0.46	0.48	0.96
[7 1]	8	0.013	0.46	0.49	0.97
[9 1]	10	0.010	0.46	0.48	0.97
[2 2 1]	5	0.021	0.42	0.48	0.95
[4 2 1]	7	0.021	0.42	0.48	0.95
[5 3 1]	9	0.018	0.46	0.49	0.96
[7 5 1]	13	0.012	0.45	0.48	0.97
[2 2 2 1]	7	0.022	0.42	0.48	0.95
[4 3 2 1]	10	0.018	0.46	0.48	0.95
[7 5 3 1]	16	0.021	0.46	0.50	0.95
[9 7 5 1]	22	0.017	0.45	0.48	0.96

Source: Own Elaboration

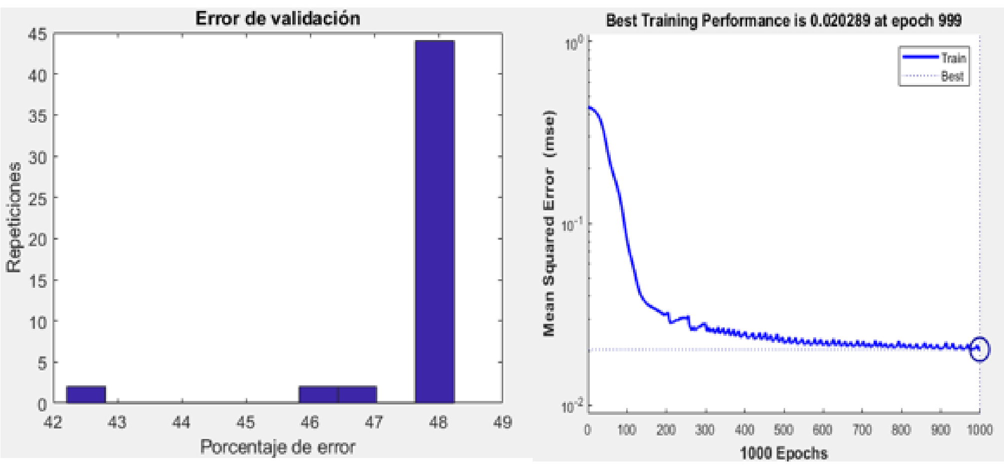

Figure 4. Mae and Mse

Source: Own Elaboration

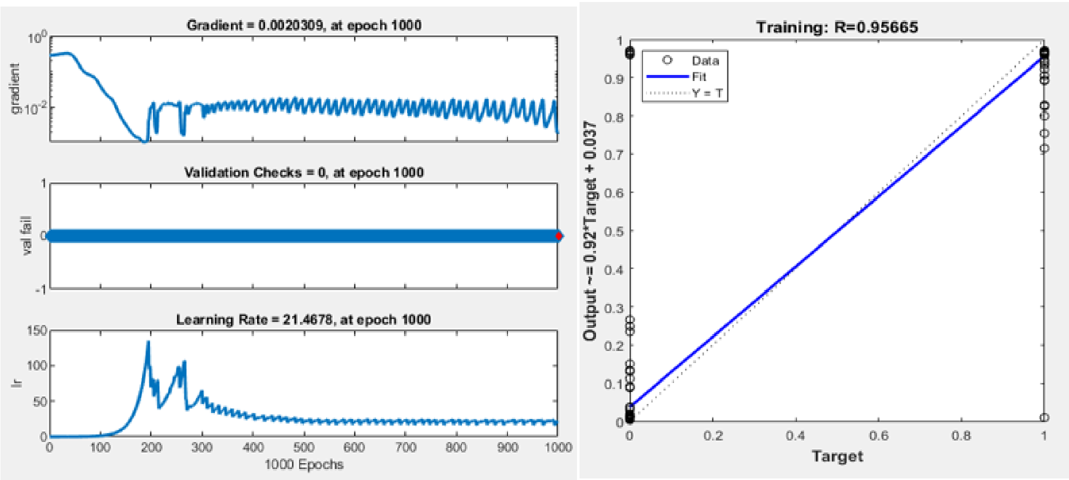

Figure 5. Learning rate and R=0.95

Source: Own Elaboration

Now we proceed to show the results obtained through the Levenberg Marquardt training algorithm better known as "trainlm" in MATLAB, having the following results:

Table 3. Architectures with trainlm

SIZE	NEURON	MSE	MAE		REGRESSION
			Min	Max	
[2 1]	3	0.012	0.45	0.50	0.97
[4 1]	5	0.006	0.46	0.50	0.98
[7 1]	8	9.95e-9	0.45	0.50	1
[9 1]	10	0.004	0.46	0.50	0.99
[2 2 1]	5	0.017	0.42	0.49	0.96
[4 2 1]	7	0.007	0.42	0.50	0.98
[5 3 1]	9	1.24e-9	0.44	0.50	1
[7 5 1]	13	1.08e-8	0.45	0.49	1
[2 2 2 1]	7	0.024	0.42	0.49	0.94
[4 3 2 1]	10	1.14e-6	0.42	0.49	1
[7 5 3 1]	16	4.83e-9	0.45	0.50	1
[9 7 5 1]	22	2.10e-9	0.45	0.49	1

Source: Own Elaboration

In table 3, 12 architectures were tested, the architecture [2 2 1] was chosen, taking into account that it was the neural network with the lowest percentage of mae and had a good behavior with the regression coefficient and mse, having:

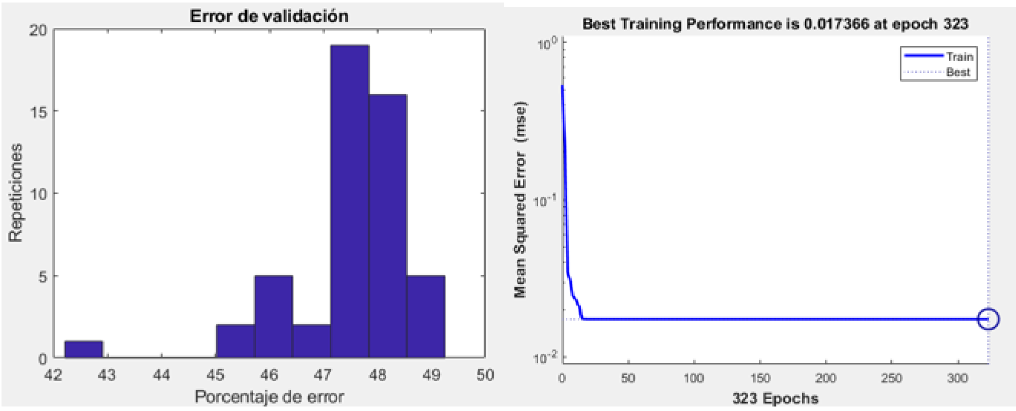

Figure 6. Mae and Mse

Source: Own Elaboration

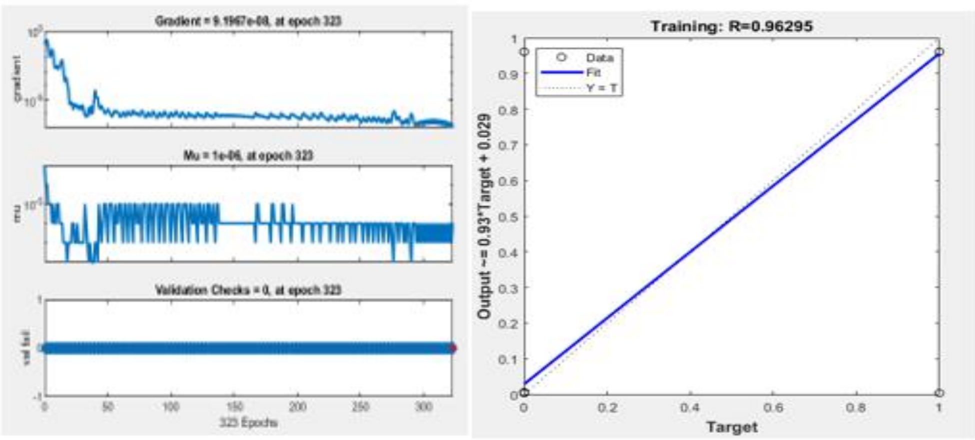

Figure 7. Learning rate and R= 0,96

Source: Own Elaboration

7. ANALYSIS AND DISCUSSIONS

Now we proceed to observe the behavior of the validation and training errors of the architectures with a hidden layer with traingda and trainlm, because these networks have the smallest mae and mse, also analyzing the number of neurons.

Table 4. Number of Neurons, mse and mae traingda

ONE LAYER HIDDEN		
# NEURONS	**MSE**	**MAE**
5	0.021	0.42
7	0.021	0.42
9	0.018	0.46
13	0.012	0.45

Source: Own Elaboration

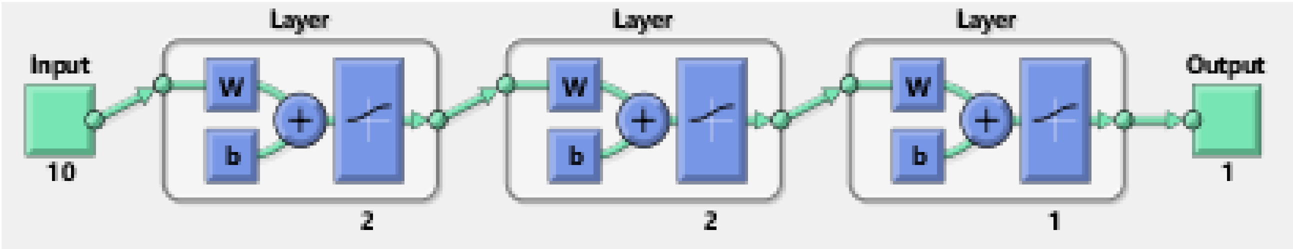

Figure 8. Architecture [2 2 1]

Source: Own Elaboration

Table 5. Number of Neurons, mse and mae trainlm

UNA CAPA OCULTA		
# NEURONS	MSE	MAE
5	0.017	0.42
7	0.007	0.42
9	1.24e-9	0.44
13	1.08e-8	0.45

Source: Own Elaboration

Where it can be corroborated that the best architecture with algorithms of traingda and trainlm is that of [2 2 1].

From the information provided in table 4, on the architectures trained with the traingda algorithm, the following graphs are generated:

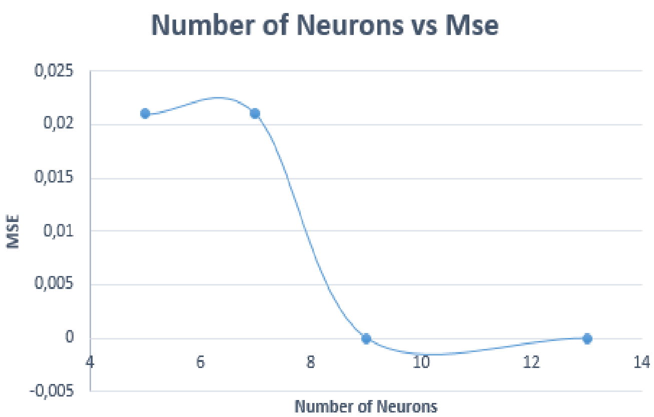

Figure 9. Numbers of Neurons vs Mse

Source: Own Elaboration

In Figure 9 it was observed that as an increase in the number of neurons is generated, the mse decreases proportionally.

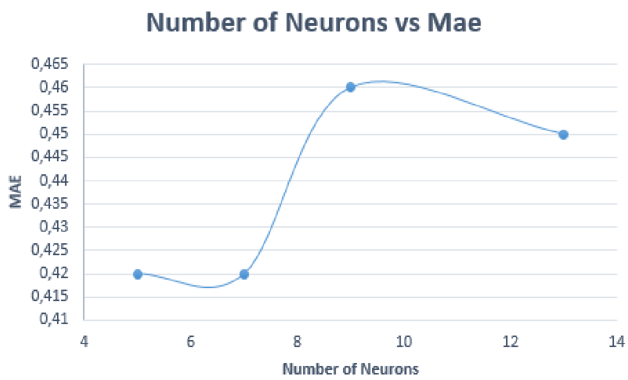

Figure 10. Numbers of Neurons vs Mae

Source: Own Elaboration

In the illustration 10 it was observed that a progressive increase of neurons generates a considerable increase in the mae, from which it can be inferred that, by annexing more than 7 neurons in the network, reliability of its classification is lost. Now we proceed to carry out a study of the data given in table 5 by means of the trainlm training algorithm, having:

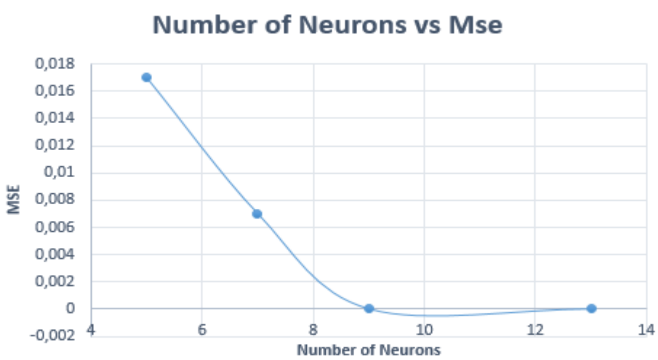

Figure 11. Numbers of Neurons vs Mse

Source: Own Elaboration

In Figure 11 it can be seen that the mse decreases considerably when more neurons are attached.

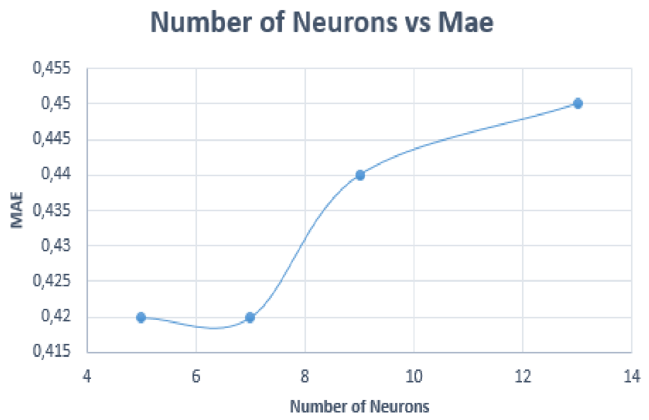

Figure 12. Numbers of Neurons vs Mae

Source: Own Elaboration

In Figure 12 it was observed that after 7 neurons, the validation error grows, which makes the network less sensitive to the classification of patients and increases the error considerably.

8. CONCLUSIONS

- The best architecture of the multiple simulations obtained was with Levenberg-Marquadt in [2 2 1] because it gave a better regression coefficient: 0.96, compared to the traingda architecture that gave a coefficient of 0.95, in addition to having a lower mse, which infers a better behavior in the trained data.
- From illustrations 9 and 11, it was observed that as an increase in the number of neurons is generated, the mse always tends to decrease in value, which is correct as it demonstrates that no architecture generated any type of over-training.
- From illustrations 10 and 12, it was observed that after increasing 7 neurons, the validation error mae grew considerably, which generates a loss in the sensitivity of classification of the network.
- It was observed that the behaviors of a training algorithm based on gradient descent methods are useful for classification cases and have a similar response to the generator methods through Levenberg Marquadt.
- It was observed that the Levenberg-Marquadt method is faster when training neural networks, because it generates larger jumps than the gradient descent methods, however it has the possibility of showing incorrect results, due to its ease of falling to a minimum local.

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