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Analysis and Implementation of an Artificial Learning System based on the Cognitive Process of the Human Brain

[1]Juan A. Rios C., [2]Carlos A. Ruiz, [3]Celedonio A. Meza

[1]Universidad del Valle de México S.C. San Juan de Dios #6 Col. Arboledas del Sur, CDMX.
[2,3]Escuela Superior de Ingeniería Mecánica y Eléctrica Unidad Culhuacan, IPN, Av. Santa Ana #1000, Col. San Francisco Culhuacan CDMX.

***Abstract* - This article presents the analysis and implementation of an artificial learning system that bases its functioning on the cognitive process of the human brain. The proposed system is able to learn and memorize, through training, some pattern and later it is possible to recognize it even when there are some variants in what it intends to use for recognition. The computational theory of artificial neural networks was used to design the system, in addition to the MATLAB© multitasking platform.**

Keywords: Learning, Human Brain, Cognition, Neural Network, Artificial System.

I. INTRODUCTION

In the first instance, we must define learning. Learning is a relatively permanent change in associations or mental representations as a result of an experience [1].

However, the concept of meaningful learning encompasses some other particularities. When talking about meaningful learning, there is a reference to the creation of new neural networks and synchronies between them, which allows to update the knowledge based on lived experiences. This process is carried out once the brain has been stimulated to think [2].

The learning process in the human brain has an initial place in neurons. Neurons are composed of a cell body, dendrites and axons and their main function is to process information, transport chemical and electrical signals in the destination direction. It is necessary to make an analogy of the composition of a human neuron with respect to the artificial neuron in order to give intelligence to the machines.

Next, the functions of each of the components of a human neuron are defined.

- ✓ Cell body: It is able to produce movement, however, they usually remain stable and stimulate the axons to be extended outward and form other connections with their similes.
- ✓ Dendrites: They are responsible for establishing synaptic contact (union with firmness) with the terminals of another neuron and thus send nerve impulses (orders of the brain) through the so-called neurotransmitters.
- ✓ Axon: It is who allows the transmission of information in the form of electrical stimulation and also serves as transport of chemical substances involved.

Now, what is the methodology that neurons follow to generate a learning process? To begin, learning is a process that requires the interconnection of a network of neurons since it is impossible for it to be generated in only one.

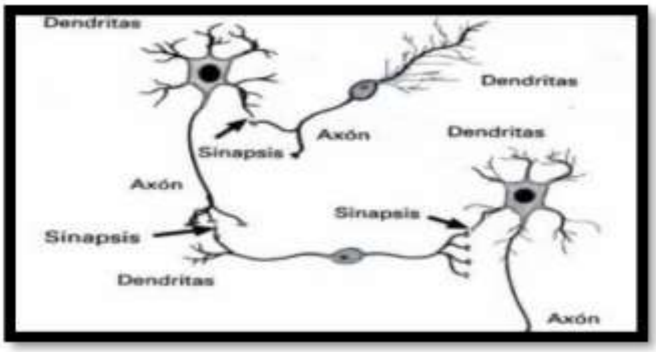

Figure -1: Connection of neurons

To be sure, there is no explanation of how learning occurs in the human brain. However, there is a hypothesis arising through experimentation.

The process begins when some kind of stimulus appears in the brain. This stimulus can be internal by means of a brainstorm produced by a reading or perhaps by the interpretation of the solution of a mathematical problem, it can also be based on a new experience such as learning to ride a bicycle. The human brain is able to detect when we are doing

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something new or something we already know how to do, if the latter occurs reinforcement is generated in the neural pathways. The process is as follows [3]:

1. The information is captured by our senses or, perhaps, can be activated by thought or memory (if we start from some previously acquired knowledge).
2. The information is oriented to the thalamus (filter that allows to delineate the path that sensory inputs must follow).
3. If the information is emergency, it will be sent to the amygdale and it will respond immediately.
4. After having been processed, the information is sent to the hippocampus where it will be retained in time (memory)
5. The hippocampus will be responsible for associating what is retained, through memories, with other areas of the cerebral cortex in order to generate long-term storage.

Analogously, we can consider neural networks as adaptive probabilistic systems, which, like the human brain, are classified as self-associative memories. The previous term is referred to the learning action that the human has to understand a situation or learn from it. The natural process of cognition allows the human to perceive and memorize patterns to later reconstruct them generating a self-association between what has already been memorized and what is presented to him / her. Neural networks are tools that allow us to recreate this cognition process in order to implement intelligence in machines. Neural networks basically have two components [4]:

- ✓ Artificial neuron
- ✓ Interconnections

An artificial neuron is an elementary processor since it is responsible for manipulating the input information to subsequently produce an output. An interconnection is the physical space that allows the synapse (union) between one neuron and another in order to exchange information.

An artificial neural network has three stages of processing:

- ✓ Input Layer (Receive Sensor)
- ✓ Hidden Cloak (Processing)
- ✓ Output layer (Execution)

In the input layer the data that will be processed is received, they are the initial parameters to be considered. The middle layer is called hidden because it is where the processing calculations are made and is not seen by the users. The output layer is the one that generates a response dependent on the input commands, that is, it is where the input stimuli affect a certain action.

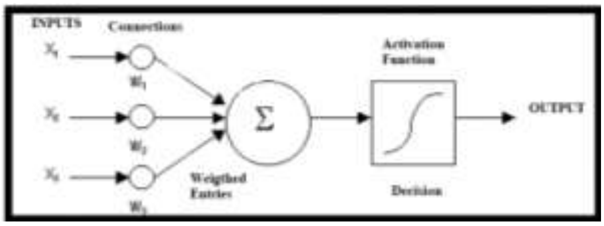

Figure -2: Generic diagram of an artificial neuron

Mathematically they are considered as an interconnected structure that is capable of fulfilling a control function by means of an activation function. As a result of this activation function, we can measure the significant learning at the first iteration or at the "n" times using a convergence criterion. When the convergence criterion is met, we can conclude that the learning of the neural network was significant, otherwise there is no such learning.

The diagram in figure 1 shows an artificial neuron that simulates the constituent parts of a human neuron. At the entrance we can see the signals that emulate the dendrites (sensors that are activated every time there is a stimulus), then come the connections that serve to assign a weight to each input signal in order to give them a priority; then they are joined to build the body of the neuron and then go on to a decision stage in which an activation function will be responsible for validating what the neuron has learned about what it is intended to evaluate.

The implemented algorithm complies with the aforementioned characteristics and with a considerable stability criterion because the training allows a successful recognition at the exit.

The algorithm is governed by a principle of human memory, with the passage of time the memory suffers deterioration, but even so, well-learned knowledge remains intact. Analogously with human behavior, even if there are external factors that try to deteriorate the optimal functioning, the algorithm is able to adapt and continue to show significant learning.

Hopfield's neuronal network theory is recurrent and completely connected. It works as a non-linear associative memory that can internally store patterns presented incompletely or with noise (interference signals). In this way it can be used as an optimization tool. The state of each neuron can be updated an indefinite number of times, independently of the rest of the neurons in the network.

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The Hopfield network consists of a set of N interconnected processing elements that update their activation values asynchronously and independently of the rest of the processing elements. All elements are both input and output. The activation values are binary.

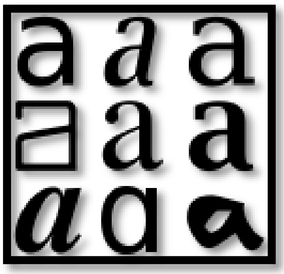

Figure -3: Different ways of representing the letter "a" lowercase

Figure 2 shows the different ways of expressing the letter "a" in lowercase but, however, the interpretation is the same no matter how it is written. The above, the brain processes and compares to a universal pattern through a cognitive process, since it has always seen different ways of expressing the same letter in the print media. The algorithm that was implemented in this article allows the above, to recognize through artificial learning regardless of the possible variants that may appear.

Next, the steps to follow for the implementation of the algorithm in the MATLAB© platform are detailed.

II. PROJECT DEVELOPMENT

An artificial learning algorithm [5] must be able to eliminate the impulsive noise type "salt and pepper" (so named because, as well as salt and pepper, are extra elements to what is intended to analyze). Specifically, the algorithm must calculate the correlation that exists between the analysis training patterns and that will be stored in a data matrix called the weight matrix.

The weight matrix hosts the weights of the data to be learned, analogously to the human brain, we can say that it is the memory that holds something that has already been learned and that allows us to recognize or perform something already learned.

Next, the equations to be followed are shown according to the generic diagram and the analogy with a human neuron shown in Figure 1.

1. The weight matrix is defined by:

$$w_{ij} = \begin{cases} \frac{1}{N}\sum_{i=1}^{M} C_i^s \cdot C_j^s & cuando \quad i \neq j \\ 0 & cuando \quad i = j \end{cases} \qquad (1)$$

2. The states of the network are initialized, that is, each of the neurons is initialized with the corresponding state, analogously, initiates the synapse process.

Iterations are carried out until the results are visualized through a convergence (stability criterion) using:

$$y = f_n(w_{ij} \cdot X^T) \qquad (2)$$

It is observed if there is a convergence when the condition is:

$$y(n-1) = y(n). \qquad (3)$$

If the previous condition is successful, the learning has ended. Otherwise, (2) must be iterated until it is fulfilled (3). It is like when the human wants to learn something that he does not master, he practices until he is already capable and once he reaches that point he will not forget (convergence criterion).

III. RESULTS

Below is an example that implements the built algorithm in which it is requested to design an artificial learning network that allows to memorize two patterns (making an analogy to meaningful learning) so that, later, a test with "contaminated" patterns is made but that the system is capable of recognizing what is being tested. The patterns to train are the following:

A = [-1 -1 1 1]   B = [1 1 -1 -1]

In the proposed example, the illuminated frames can be represented with a "-1" and the empty frames with a "1". This notation is called a bipolar notation since we have the same digit, but with a different sign.

Step 1: We calculate the weight matrix, the weight matrix will have 16 values for this example since we have four elements per input pattern and the resultant is a quadratic.

$$W_{ij} = \begin{bmatrix} w_{11} & w_{12} & w_{13} & w_{14} \\ w_{21} & w_{22} & w_{23} & w_{24} \\ w_{31} & w_{32} & w_{33} & w_{34} \\ w_{41} & w_{42} & w_{43} & w_{44} \end{bmatrix}$$

There is a particularity, according to equation 1 if the subscripts are equal, therefore:

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$$w_{11}, w_{22}, w_{33}, w_{44} = 0$$

To calculate the remaining values we know that N = 4 since each learning pattern has 4 elements, in addition, the first pair of parentheses corresponds to elements 1 and two respectively of the first pattern and the second pair corresponds to elements 1 and 2 respectively but now of the second pattern. Next, the calculations are detailed:

$$w_{12} = \frac{1}{4}\big((-1)(-1) + (1)(1)\big) = \frac{1}{2}$$

$$w_{13} = \frac{1}{4}\big((-1)(1) + (1)(-1)\big) = -\frac{1}{2}$$

$$w_{14} = \frac{1}{4}\big((-1)(1) + (1)(-1)\big) = -\frac{1}{2}$$

$$w_{21} = \frac{1}{4}\big((-1)(-1) + (1)(1)\big) = \frac{1}{2}$$

$$w_{23} = \frac{1}{4}\big((-1)(1) + (1)(-1)\big) = -\frac{1}{2}$$

$$w_{24} = \frac{1}{4}\big((-1)(1) + (1)(-1)\big) = -\frac{1}{2}$$

$$w_{31} = \frac{1}{4}\big((1)(-1) + (-1)(1)\big) = -\frac{1}{2}$$

$$w_{32} = \frac{1}{4}\big((1)(-1) + (-1)(1)\big) = -\frac{1}{2}$$

$$w_{34} = \frac{1}{4}\big((1)(1) + (-1)(-1)\big) = \frac{1}{2}$$

$$w_{41} = \frac{1}{4}\big((1)(-1) + (-1)(1)\big) = -\frac{1}{2}$$

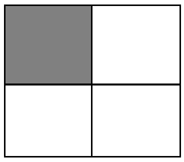
$$w_{42} = \frac{1}{4}\big((1)(-1) + (-1)(1)\big) = -\frac{1}{2}$$

$$w_{43} = \frac{1}{4}\big((1)(1) + (-1)(-1)\big) = \frac{1}{2}$$

The resulting weight matrix will be:

$$W_{ij} = \begin{bmatrix} 0 & \frac{1}{2} & -\frac{1}{2} & -\frac{1}{2} \\ \frac{1}{2} & 0 & -\frac{1}{2} & -\frac{1}{2} \\ -\frac{1}{2} & -\frac{1}{2} & 0 & \frac{1}{2} \\ -\frac{1}{2} & -\frac{1}{2} & \frac{1}{2} & 0 \end{bmatrix}$$

Step 2: The learning test is carried out. In this test, "contaminated" or "distorted" values will be checked but the algorithm will be able to recognize which of the two trained values (learned) correspond to the test one. For example, we will try:



Prueba = [-1 1 1 1]

As we can see, the test pattern has a majority of elements similar to the training pattern "A", so the algorithm must show that this stop corresponds to the input pattern "A". Let's see the test; according to equation 2, we must multiply the test matrix by the weight matrix previously calculated (to multiply matrices we must do row by column):

$$[-1\ 1\ 1\ 1] * \begin{bmatrix} 0 & \frac{1}{2} & -\frac{1}{2} & -\frac{1}{2} \\ \frac{1}{2} & 0 & -\frac{1}{2} & -\frac{1}{2} \\ -\frac{1}{2} & -\frac{1}{2} & 0 & \frac{1}{2} \\ -\frac{1}{2} & -\frac{1}{2} & \frac{1}{2} & 0 \end{bmatrix} =$$

$$= \left[0 + \frac{1}{2} - \frac{1}{2} - \frac{1}{2} \quad -\frac{1}{2} + 0 - \frac{1}{2} - \frac{1}{2} \quad \frac{1}{2} - \frac{1}{2} + 0 + \frac{1}{2} \quad \frac{1}{2} - \frac{1}{2} + \frac{1}{2} + 0\right] =$$

$$= \left[-\frac{1}{2} \quad -\frac{3}{2} \quad \frac{1}{2} \quad \frac{1}{2}\right]$$

Step 3: We evaluate the resulting matrix through an activation function (analogously with the human brain we speak of a synapse). The activation function that we will use will be the step function, graphically:

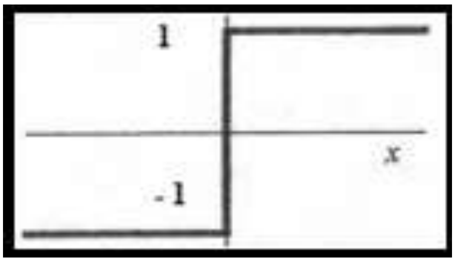


Figure -4: Step activation function. If the values of the resulting matrix are greater than or equal to zero, a "1" will be thrown, otherwise a "-1".

Evaluating the resulting matrix, we have:

$$y = fn\left(\left[-\frac{1}{2} \quad -\frac{3}{2} \quad \frac{1}{2} \quad \frac{1}{2}\right]\right)$$

$$y = [-1 \quad -1 \quad 1 \quad 1]$$

That as we see corresponds to the initial state that belongs to the value "A". That is, the pattern that we introduced as evidence recognized it as an "A". Now it is feasible that we implement the algorithm in the MATLAB© platform.

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```
clear all
clc
F=input('¿Cuántos valores deseas
entrenar?: ');
for i=1:F;
    MM(i,:)=input('Escribe el patrón entre
corchetes: ');
end
[M,N]=size(MM);
Acu=zeros(N,N);
for P=1:F
    Z=MM(P,:);
    h=length(Z);
    for i=1:h
        for j=1:h
            if i==j
                W(i,j)=0;
            else
                W(i,j)=Z(i)*Z(j);
            end
        end
    end
    Acu=Acu+W;
end
MatFin=Acu*(1/N)
A=[-1 -1 1 1];
B=[1 1 -1 -1];
R=input('Introduce el patrón que deseas
evaluar en corchetes: ')
Y=R*MatFin;
g=hardlims(Y)
if g==A
   disp(' El estado reconocido es A ')
elseif g==B
   disp(' El estado reconocido es B ')
else g~=A&g~=B
    disp('El estado es falso')
end
```

Figure -5: Program encoded in the MATLAB © platform that represents the cognitive process of the human brain

The program has three parts: the first is the learning phase in which we tell the algorithm what it is going to learn artificially, the second part consists of the calculation process of the weight matrix, remember that the matrix it helps us to reinforce what we are learning and, finally, the third part is the process of recognizing a test pattern. When executing the algorithm, we obtain the following:

```
¿Cuántos valores deseas entrenar?: 2
Escribe el patrón entre corchetes: [-1 -1 1 1]
Escribe el patrón entre corchetes: [1 1 -1 -1]

MatFin =

         0    0.5000   -0.5000   -0.5000
    0.5000         0   -0.5000   -0.5000
   -0.5000   -0.5000         0    0.5000
   -0.5000   -0.5000    0.5000         0

Introduce el patrón que deseas evaluar en corchetes: [-1 1 1 1]

g =

    -1    -1     1     1

 El estado reconocido es A
```

Figure -6: Execution of the algorithm implemented in the MATLAB© platform

In figure 6 we can see the execution of the cognition processing algorithm of the human brain. At the beginning we request the patterns that we want to learn artificially, and then calculate the weight matrix that will serve us for the recognition and finally we evaluate some "X" pattern so that the algorithm creates the synapse and tells us which pattern it corresponds to. It should be mentioned that "g" is the resulting matrix after the activation function. To run the algorithm more conveniently towards the user, a graphical user interface (GUI) was designed. Figure 7 shows the main window.

Figure -7: Graphical User Interface (GUI) implemented in the MATLAB© platform

The graphical interface consists of a section to introduce the learning patterns, a section to introduce the test patterns and the section where the result is shown. There are two ways to enter the data, both learning patterns and test patterns, you can be directly writing the data matrix or converting a file to an array and loading it directly with the "Select File" button. The file that is loaded is a document composed of "1's and" -1's "in .txt format and can be an image, a text or audio samples that we intend the system to learn. Figure 8 shows an example of the use of the interface. We will use the example that was developed earlier.

Figure -8: Example of use of the interface, recognizes the "A" pattern

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Figure 9 shows the GUI process that allows recognition of the learned pattern "B".

Figure -9: Example of use of the interface, recognizes the pattern "B"

Another important point is to validate mathematically what is the correlation between the learned pattern and the pattern that will be used as a test. For the above, we use the calculation of the correlation coefficient and follow the following procedure:

1. The arithmetic means are calculated; we know that:

$$A = [-1 - 1\ 1\ 1]$$
$$A' = [-1\ 1\ 1\ 1]$$

The arithmetic mean for the original pattern A and for the test pattern A 'will be calculated by evaluating the average of the data shown for the original patterns, then the calculation is shown:

$$\bar{A} = \frac{(-1) + (-1) + (1) + (1)}{4} = 0$$

$$\bar{A'} = \frac{(-1) + (1) + (1) + (1)}{4} = \frac{1}{2} = 0.5$$

2. The next step is to calculate the covariance of the data.

$$\sigma_{AA'} = \frac{\sum AA'}{Número\ de\ Datos} - (\bar{A}\bar{A'}) \quad \text{.......... (4)}$$

$$\sigma_{AA'} = \frac{[(-1)(-1) + (-1)(1) + (1)(1) + (1)(1)]}{4} - (0)(0.5)$$

$$\sigma_{AA'} = 0.5$$

3. We calculate the deviations for each pattern, both for the learning and for the test.

$$\sigma_A = \sqrt{\frac{(\sum A)^2}{Número\ de\ datos} - (\bar{A})^2} \quad \text{.......... (5)}$$

$$\sigma_{A'} = \sqrt{\frac{(\sum A')^2}{Número\ de\ datos} - (\bar{A'})^2} \quad \text{.......... (6)}$$

$$\sigma_A = \sqrt{\frac{[(-1)^2 + (-1)^2 + (1)^2 + (1)^2]}{4} - (0)^2} = 1$$

$$\sigma_{A'} = \sqrt{\frac{[(-1)^2 + (1)^2 + (1)^2 + (1)^2]}{4} - (0.5)^2} = 0.8660$$

4. We calculate the correlation coefficient:

$$r = \frac{\sigma_{AA'}}{\sigma_A \sigma_{A'}} \quad \text{.......... (7)}$$

$$r = \frac{0.5}{(1)(0.8660)} = 0.57$$

We can see that the correlation coefficient is 0.57, a result that indicates a partially strong correlation of the test pattern with the original pattern. The above is logical because the test pattern is NOT exactly the original pattern, that is, it has variants.

IV. DISCUSSIONS

To validate the significant learning of the artificial system, it is important to perform the test method based on the objectivity and subjectivity of them, according to Jensen [4] the objective tests that are performed on the system are all those that we can demonstrate scientifically, in particular, a test of the degree of objective difference (ODG) and subjective tests with merely qualitative, is subjected to explore visually that there is a correlation between the elements of analysis.

The correlation factor depends directly on the amount of noise and / or distortion that shows the pattern to be recognized with respect to the previously learned and trained pattern. As mentioned by James [5], it is important to consider the false positive probability and the false negative probability, both of which must be minimized by increasing the number of training and test iterations and meeting the convergence criterion; that is to say, that the recognized pattern is blurred almost exactly until it is related to the learned one.

According to the software model presented by Rivera [7], it shows an algorithm in which the activation weights of artificial neurons are comparable with respect to each other. In the algorithm proposed by the research proposed in this paper

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the weights of the neurons are independent of each other and are based on the constituent elements of the patterns to learn what would find a greater precision for the recognition process.

V. CONCLUSION

The implementation of the algorithm proposed in this article shows a convergence in terms of character learning based on neuronal training and established patterns. The tool designed in this article allows the recognition of characters "contaminated" by noise, so it is possible to use the system for the authentication of digital signatures, the recognition of other patterns such as the comparison of spoken portraits, etc. Neural networks are able to simulate the behavior of the human brain; However, I believe that an alliance with a digital watermarking system is possible, which will allow it to be strengthened and to increase the capacity of pattern authentication.

REFERENCES

[1] Ormrod J. E., "Human Learning", *Pearson Prentice Hall,* 4ta. Ed., Madrid, España, pp. 1-11, 2005.

[2] Dee Fink L., "Creating Significant Learning Experiences", *Jossey-Bass*, USA, 2003.

[3] Beck Christina, "Curious about the Sciences", *Max Planck Society*, Vol. 22, Germany, 2010.

[4] Jensen. E., "Learning and Brain", *Narcea Ed.*, Madrid, Spain, 2004.

[5] James A. A., "Neural Networks", Alfaomega, USA, 2007.

[6] Pérez A. E., "Novel Discrete Compactness-Based Training for Vector Quantization Networks: Enhancing Automatic Brain Tissue Classification", *Advances in Artificial Neural Systems*, vol. 2013, no. 4, pp. 1–7, Jan. 2013.

[7] R. Rojas, "Neural Networks" *Springer-Verlag*, Berlin, no. 10, pp. 1–27, 1996.

AUTHOR'S BIOGRAPHIES

Juan Ríos, Executive Degree, Universidad del Valle de México.
Qualification: Computer Science Engineer, Master on Computer Science.
Areas of interest: Computational systems, digital watermarking, cryptography, computer networks.

Carlos Aquino, Professor, Instituto Politécnico Nacional.
Qualification: Telecommunication Engineer
Area of interest: Digital Signal Processing.

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