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ALZTRAINING: A Prototype Training for Potentiate the Cognitive Abilities of a Person with Alzheimer's Disease in its Initial Phase

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Abstract

There are currently more than 46.8 million people in the world who suffer from some kind of mental dementia, and it is projected that in recent years this figure is growing exponentially [1]. The costs involved have increased from US $ 604 billion in 2010 to US $ 818 billion in 2015, which means an increase of 35.4 %, which is why the disease is characterized by high morbidity and economic impact a public health problem.
This paper proposes the implementation of techniques such as the artificial neural networks (RNA), which allow to develop an application that meets the needs of each user at-tempting to analyze the advance that has the disease at its early stage and identifying the brain areas that have been affected, all of this based on the use of Artificial Intelligence.

Keywords: Alzheimer Dementia, health, artificial neural networks

1 Introduction

In the last World Health Report (WHO) in 2015, entitled "The Global Impact of Dementia, an analysis of prevalence, incidence, costs and trends" [1] shows a series of data and conclusions that show the increasing increase of the cognitive and mental illnesses as well as the decrease of the quality of life of the world-wide population.
Currently WHO estimates that 46.8 million people live with dementia in the world and are projected to double this number every 20 years reaching in the year 2050 131.5 million, where countries with high resources will have a rate of growth of 56%), medium-income countries in the (185%), while low-income countries (239%) [1].

What is Dementia?

From the medical definition, dementia can be defined as a progressive and irreversible impairment of the mental faculties that causes serious behavioral disorders. The World Health Organization defines dementia as a syndrome due to a brain disease, usually of a chronic or progressive nature, in which there are deficits of multiple upper cortical functions... Which have an impact on daily activity of the patient [2].
Among the higher cortical functions that the patient loses are memory, understanding, judgment, speech, calculation, thinking, orientation, etc. Not all deteriorate simultaneously, but it is a continuous process in which more and more of the affected functions are perceived and with progressive deterioration, being generally the memory the first observation of alteration that perceives the patient or his relatives nearer [3]

What is Alzheimer's?

Alzheimer's disease is a neurodegenerative disorder, manifested as cognitive impairment and behavioral disorders. It is characterized in its typical form by a progressive loss of memory and other mental abilities, as the nerve cells (neurons) die and different areas of the brain atrophy [4].
It manifests itself as a very heterogeneous syndrome and therefore its origin and evolution are not identical in all the people who suffer it. [5].
Although scientists know that Alzheimer's disease involves a failure of nerve cells, the reason why this occurs is still unknown. However, [6] in his study "Risk Factors for Alzheimer's Disease," he has identified certain risk factors that increase the likelihood of developing Alzheimer's disease such as: age, sex, genetics, alcohol, Cranioencephalic Injuries, education and diet.

2 Methodology

In order to identify the parameters to be considered within the Artificial Red Neuronal, the criteria for the diagnosis of Alzheimer's dementia associated to DSM-IV (Diagnostic and Statistical Manual of Mental Disorders) [7] were analyzed. Where codes based on the type of onset and the predominant characteristics of Alzheimer's disease are established.

From them and the project proposed by [8] where they carried out a prospective study that evaluated an initial sample of 639 people undergoing a neuropsychological examination through the application of four tests that evaluated the cognitive capacity of patients: the MSSE Folstein, the GDS, the Hachinski scale and the verbal fluency test, through the results of these tests, it was determined that the parameters or input variables of the red neuron.

The inclusion and exclusion criteria of the sample, with the following elements were: [8]:

2.1 Inclusion Criteria

- Signature and date of informed consent.
- Age between 45-85 years.
- Schooling from minimum studies (3 years).
- Result MMSE Folstein.
- Clinical diagnosis of Alzheimer's disease likely according to DSM-IV criteria.
- GDS (Global Detection Scale) global scale score between 16 and 23 points.
- Treatment with acetylcholinesterase inhibitor drugs (IChE) for at least six months.
- The patient lives in his home with a responsible caregiver.

2.2. Exclusion Criteria

- Patients with severe behavioral problems: delirium, hallucinations
- Illiterate or functional illiterate.
- Patients undergo all other types of psychosocial treatment.

It is worth mentioning that, although for each patient the development of the disease is different, this research method allows to analyze together that the characteristics are common, and in this way to train the neuronal red, all thanks of the effectiveness to the offered advice by a group of students from the University of Applied and Environmental Sciences (UDCA), and the specialist in Clinical Neurology Doctor Daniel Hedmont.

To test the effectiveness of the red neuron, we used the data set of the study named MoCA and MMSE scores in patients with mild cognitive impairment and dementia in a memory clinic in Bogotá conducted by [9], where 248 patients, who are no longer part of the training data of the network, but who, on the contrary, will obtain a type of estimation exercise based on the results of the cognitive estimation project carried out with individuals suffering from mild cognitive impairment [10]

3 Design

3.1 Artificial Neural Network Design

Based on the results obtained by [11] in his study entitled Methodological approach to the use of artificial neural nets for the prediction of results in medicine and taking into account the established by the same author [11] where he states that the structure most used within of the unidirectional supervised networks, is the so-called Multilayered Perceptron (MLP).
It was determined that this would be the type of architecture implemented in this project because the type of problem that is studied is of nonlinear type.

3.2 Application Design

The objective presented in this paper is at the forefront with the current interest in the development of software products related to the health of users. Such is the growth of this sector that even Google offers an API [12] for the creation of applications aimed at promoting healthy habits in an easier, faster and efficient way.

Therefore the proposed application makes use of the textual information and user profile hosted on its mobile phones. Currently there are several mobile applications for the help of people with Alzheimer's. However, none of them considers automatic learning [11] and proposes training routines. This is undoubtedly a great advantage of the application over existing ones, since it minimizes the need to configure different parameters that can be complex. In this way it facilitates the use of the application both to patients, who are usually elderly and have not internalized the use of the phone, as well as their caregivers, who will simply receive notifications when appropriate.

4 Architecture

4.1 Application Architecture

Because the mobile application will be used by the patient with Alzheimer's, there are considerations to take into account when designing and defining the architecture of the application. The first and most important requirement is that given the patient's health condition, he will not be aware that he has an application running on his mobile device, therefore, he will not understand how to use it, so the application must identify the habits of the patient and specify an hour to perform the exercises (parameters that are initially configured by the caregiver).
In addition, it must be taken into account that the user interfaces must be intuitive and user-friendly. As for authentication when the patient logs in, the mobile application must be automatically synchronized with the web page and the caregiver's mobile app.

This information is transmitted using the data network of the device, or connection to WiFi for later being sent to a server. In addition, the server stores the data in a database in order to maintain a history of the patient's daily progress, which are shown in a table. The architecture diagram of the application is shown in Figure 1.

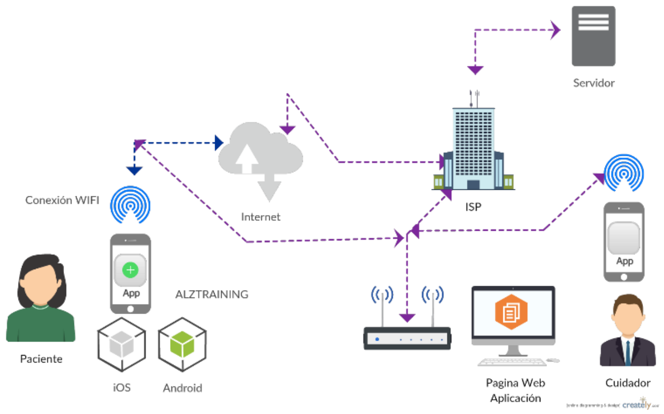

Fig 1. Application Architecture

The architecture proposed above establishes a general framework of operations, in which particularly the following devices are involved:

- Patient Device: It is the main component and it is a mobile application that resides in the patient's device.
- Caregiver device: Again it is a mobile application that in this case resides in the caregiver device. Through it, the caregiver can follow up on the progress of the patient can also configure the application remotely indicating the desired times. The application is responsible for receiving and processing the settings giving them the appropriate treatment.
- Website: This is a website where the caregiver will have access to all the graphs and reports available to the patient's condition, and will also have the option to perform all the tasks that he / she programs from the mobile application.

Regarding the design requirements, it is determined that the creation of Friendly Interfaces is very important since "The friendliness determines if the program is going to target a specific sector or if it can reach the mass market and, of their potential for generalization in learning "[13], therefore the following friendliness techniques will be applied according to what is expressed by [13]:
Combination of different communicative codes: Visual (iconic), verbal, auditory. The goal is to achieve optimum redundancy in the communication process to bridge the stresses and response times, further increasing the signal strength.
Organization and structuring of the interface at hierarchical levels: To overcome the limitations of working memory and perceptive space (pulldown menus, pop-up menus, graphical structuring, etc.)

Creation of aids: Textual, graphic and procedural, simulating the advice of an expert.

4.2 Automatic Synchronization

As for the automatic synchronization process, it is proposed to work with the REST architecture [14] since according to the investigation by [15] "Mobile applications must consider the characteristics of the application execution environment available to the phone, to ensure the proper functioning of it."

4.3 Artificial Neural Network Architecture

As it was named in the section Design of the Neuronal network the type of network selected was the MPL (Multilayered Perceptron) due to the performance of the same in the study reported by [11]. It should be mentioned that although the RNA construct, implemented in this article was based on the results obtained by [11], they pursue very different objectives.

Usually the network architecture (MPL) consists of only two layers of neurons, the input and output neurons, it was necessary to incorporate other layers of neurons (See section Implementation). The justification of this decision is presented in Fig. 2, since the decision ability of the multi-layer perceptron networks, cover different regions in the plane depending on the number of selected neurons.

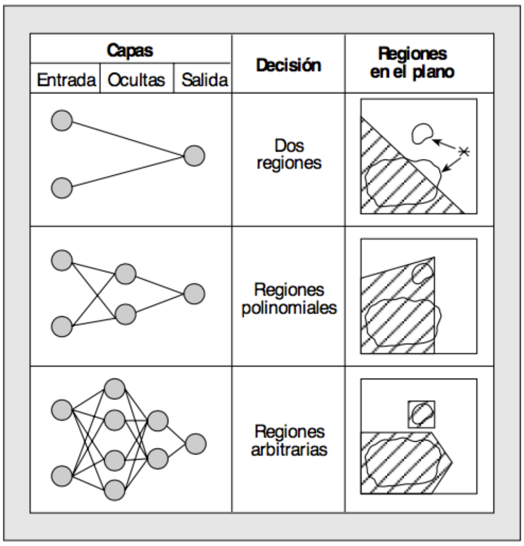

Fig. 2 RNA / MPL Decision Capacity. Source: [11]

In order to determine the number of layers and neurons that made up the architecture proposed in this article it was necessary to carry out an iterative process, validating the learning capacity of the network, all this process is detailed in the following section.

5 Implementation

5.1 Training process

In the first place, a data entry process was carried out with 200 data. This set of data determined the input set characterized by the variables described in the section (Methodology), because the proposed RNA has a type of supervised learning it was necessary to specify the targets to be pursued by the network according to the conclusions drawn by [8].

Network connections are randomly initialized and progressively self-adjust as you train with the available data, so that it learns to gradually recognize all cases in the dataset used for your training. The learning ends when, after a variable number of iterations, 100% of the cases are correctly classified, or a maximum value of hits is reached, which does not increase with more iterations [16].
In this way, we get the network to learn to recognize patterns in all sorts of ways, increasing and improving its classifier potential [16].

5.2. Network Inputs

The inputs of the network are the following variables, evaluated in the 200 people:

- Height [Between 100 and 180 cm]. Weight [Between 50 and 100 kg].
- Sex [F or M].
- Age [Between 55 and 70 years]. Occupation [See Image]. Alcohol Consumption [SI-NO]. Tobacco consumption [SI-NO]. Coffee consumption [SI-NO].
- Physical Activity Level [SI-NO]. Level of studies [See Image].
- Proficiency in a language other than the mother tongue [SI-NO]. Family history of illness. neurodegenerative diseases [SI-NO].
- GDS test result [4].
- Result Test MMSE -Fosltein [Between 18 and 24 points].

5.3. Weighting of Variables

According to what has been reported in the literature, there are several factors associated with the development of EE, each with a different impact level. However, the author of this paper proposes the following weights, based on the criteria studied by [17]:

- Most relevant criteria (between 10% and 15%)
- MMSE result (15%)
- GDS result (10%)
- Gender Female (10%) Age (10%)
- Relevant criteria (between 8% and 6%)
- Positive Alcohol Consumption (8%)
- Negative activity level (8%)
- Family history of neurodegenerative diseases (8%)
- Profession (6%)

- Level of studies (6%)
- Profession (6%)
- Normal criteria (between 2% -5%)
- Tobacco consumption positive (5%)
- Positive coffee consumption (5%)
- Mastery of another language other than maternal (5%)
- Weight (2%)
- Height (2%)

5.4. Structure of RNA

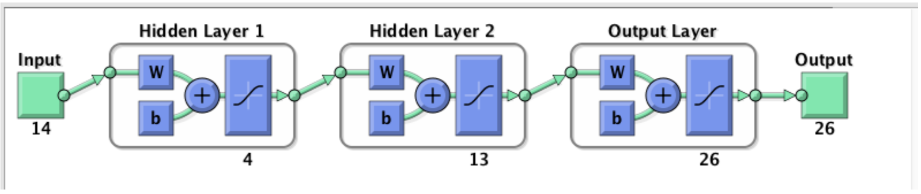

Fig 3. Structure of the ANN. Source: Authors

Within the proposed structure, it was established:
Layer 1: 4 Neurons
Layer 2: 13 Neurons
Layer 3: 1 Neurone (Configuration established by Matlab)

5.5 Training Results

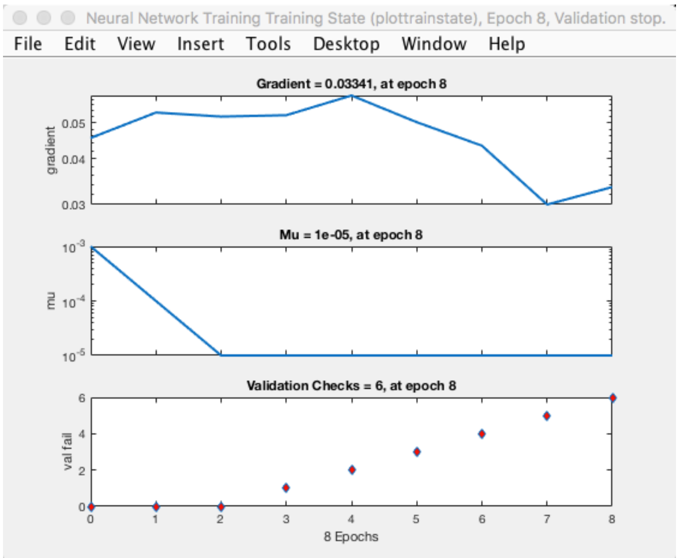

Fig 4. Structure of the ANN. Source: Authors

Figure 4 shows the performance of RNA during the training process over 8 seasons. The results show that the network succeeds in finding a logical relationship in the 2 epoch however in the following epochs it tends to move away from the ideal value by which the gradient obtained in the 8 epoch is 0.03341

5.6 Training

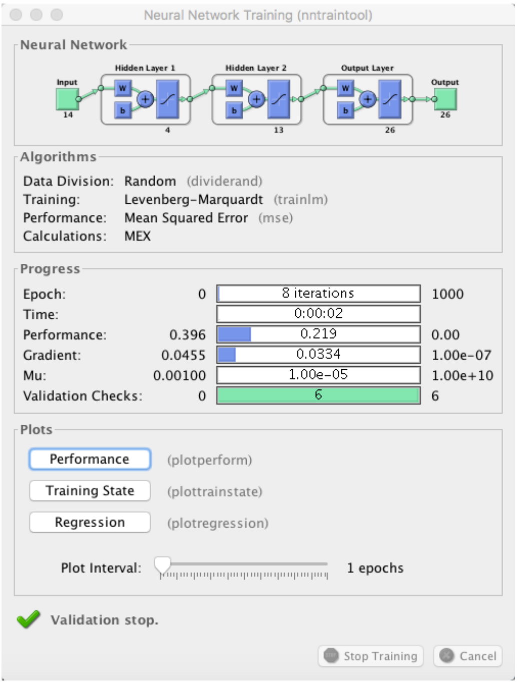

Fig 5. RNA Enhancement. Source: Authors

Fig 5. Shows the general configurations of RNA, this result is obtained when training any RNA, through the toolkit provided by Matlab called nntool.

5.7 RNA Performance

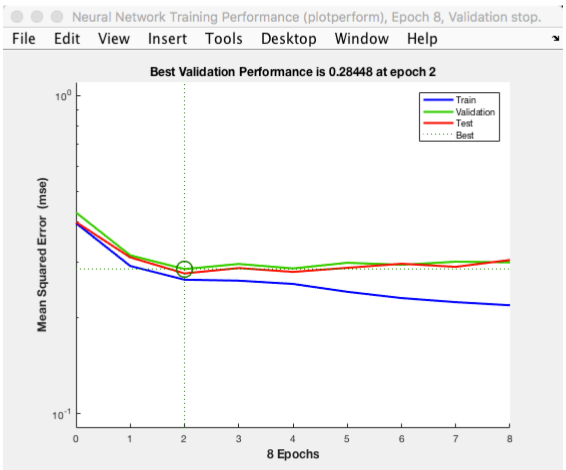

Fig 6. Performance of RNA. Source: Authors

Figure 6 shows how consistent the proposed model is by comparing the performance of training data against validation and test data. From this it is evident that the validation and test data converge to a very close value, becoming the best validation achieved in period 2, with a performance of 0.28448. This relationship remains constant throughout the 8 seasons.

5.8 Regression Training

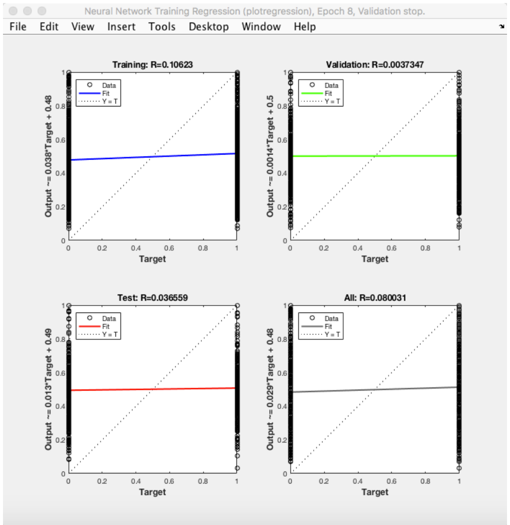

Fig 7. Regression Training. Source: Authors

Figure 7 shows the performance of the target data during the training and validation phase. For the first part of the process, the output value is given by the expression output = 0.038 * Target + 0.48 and you get a R = 0.10623 while the same data during phase are determined by the following expression: output = 0.0014 * Target + 0.5, which shows that the process is is effective since an R = 0.0037347 is obtained.

On the other hand during the test phase an output = 0.013 * Target + 0.49 ratio was obtained, and an R = 0.035559 which demonstrates a deterioration with respect to the validation stage. With regard to the overall behavior of the target data we obtain the expression output = 0.029 * Target + 0.48 and an R = 0.080031.

5.9 Error Obtained

With regard to the calculation of the error, a risk function, corresponding to the expected value, was obtained using the mean quadratic error (ECM), obtaining an error of 0.0364 (3.64%).

6 Conclusions

According to the results presented in the previous section and according to the one

posed by [11] it is verified that the RNA that performs better is the multilayered Perceptron (MLP). However, in future work, the modification of the parameters in terms of training function, type of learning and adaptation function can be considered.
On the other hand, the error obtained in the model presented was the 0.0364 (3.64%), however this value could be reduced if we take into account such variables as the level of arterial hypertension (HTA), displeasures, cholesterol level, obesity index, risk factors that were neglected for the construction of the current model.
In terms of the tests evaluated, this section could be expanded taking into account the Hachinski Scale and the verbal fluency scale.

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