Early Diagnosis of Alzheimer's Disease Using a Combination of Images Processing and Brain Signals

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Abstract—Alzheimer's prevalence is on the rise, and the disease comes with problems like cessation of treatment, high cost of treatment, and the lack of early detection methods. The pathology of this disease causes the formation of protein deposits in the brain of patients called plaque amyloid. Generally, the diagnosis of this disease is done by performing tests such as a cerebrospinal fluid, CT scan, MRI, and spinal cord fluid testing, or mental testing tests and eye tracing tests. In this paper, we tried to use the Medial Temporal Atrophy (MTA) method and the Leave One Out (LOO) cycle to extract the statistical properties of the three Fz, Pz, and Cz channels of ERP signals for early diagnosis of this disease. In the process of CT scan images, the accuracy of the results is 81% for the healthy person and 88% for the severe patient. After the process of ERP signaling, the accuracy of the results for a healthy person in the delta band in the Cz channel is 81% and in the alpha band the Pz channel is 90%. In the results obtained from the signal processing, the results of the severe patient in the delta band of the Cz channel were 89% and in the alpha band Pz channel 92%.

Keywords—Alzheimer's disease, image and signal processing, medial temporal atrophy, LOO Cycle.

I. INTRODUCTION

ALZHEIMER'S disease is a type of brain dysfunction that gradually decomposes the patient's mental abilities. According to statistics, an outbreak has begun since 1990, with 11.2 million people affected, and in 2006 it was 26.6 million people, and in 2016 more than 31 million people were infected. The figure is expected to reach 10.86 million in 2050. The number of Alzheimer's patients in Iran, according to the Alzheimer's Association of Iran, has almost doubled over the course of 13 years [16]. In this disease, spherical protein structures are formed outside the neurons of some regions in the brain and of the proteinaceous structures of the nucleus in the cellular body of the neurons. These protein structures are called amyloid objects, due to some changes in the amount or structure of the proteins of these neurologic structures called amyloid plaques. Alzheimer’s treatment methods cannot be treated if they are aged, but can be slowed down, and can be cured if injured. Although there is still no cure for Alzheimer's disease, medications can slow down the progression of the disease and reduce the severity of memory impairment and behavioral problems. In general, the treatment is divided into two categories, drug and non-drug. At present, the process of further treatment means preventing the progression of the disease and controlling symptoms and psycho-behavioral disorders caused by it [11], [2].

II. ERP

The ERP test actually examines the brain's response to stimuli. This is while the brain reacts to stimuli in less than 1 second and allows for the evaluation of brain function in patients with cognitive impairment. In this method, by giving an appropriate stimulus (visual, cognitive, auditory ...) to the individual, the EEG signaling signal is derived from its perception of stimulation. ERP provides a millisecond record of nerve data processing. The most common way of extracting ERP is through the use of patterns in which two completely different triggers appear in a random sequence. One of these triggers is the standard stimulus [13], [14]. The other stimulus is considered as a target stimulus, and its emergence is far less unpredictable. Standard and objective stimuli can be in the form of sounds of varying frequencies.

A. P300

A specific type of ERP, or in the other words, is a component of ERP that appears in specific circumstances. According to a study, a P300 wave appears when the brain enters a brain signal during the processing of a series of common stimuli to a new stimulus (unusual stimulation). Of course, to generate the P300, it is necessary for a person to define a specific task that only responds to the stimulation of the target. For example, person is asked to count the number...
of provocations. Physically, this component has a positive polarity and a range of about 10 to 15 micro volts. To stimulate the audio, the P300 wave delay is on average about 300 ms, which is the reason for the selection of this name due to positive polarity and a delay of 300 ms. But, for other stimuli, for example, the visual stimulation of this time may increase to about 1000 ms. But overall, the average delay is between 300 and 1000 ms. This signal is recorded from the three channels on the mid-line head Cz, Pz, Fz. Research has shown that in comparison with these three channels, most P300 cases have the highest amplitude in the parental area Pz and the smallest domain in the frontal area Fz. Of course, it is important to note that age, gender, and many psychological characteristics such as intelligence and personality affect the amplitude and delay of this wave. In addition, variations in the size of this wave depend on the amount of information provided by stimulation. That is, whatever the task of the intellectual is required of the individual more on unusual stimuli the waveform of the P300 is extracted [8], [3].

III. METHOD AND MATERIALS

A. Down Sampling

There are several methods to remove the base line of the signal, but using a down sampling, we can calculate the average of several samples and reduce the signal itself to eliminate the signal line's base line. In this paper, the signals used have an initial sampling frequency of 1000 samples per second. Then, using down sampling, we took the sample rate to 10 Hz [14].

B. Notch Filter

One of the most important disturbances that may occur for the brain signal is the city's electricity frequency, which is used to remove this filter from filtering called Filter Notch. This filter is a non-alternating filter with a very low band, which often passes through the frequencies without weakening and only severely reduces the specific range precisely to eliminate the single-frequency component.

C. Band Pass Filter

This filter is used to isolate frequency bands. This separation is carried out in the form of a five-frequency signal of the brain, an in order to improve the quality and accuracy of the next steps, the cut off frequency of this filter is considered from 0.01 to 45 Hz.

D. Elman’s Neural Network

Elman’s Neural Network is a network with a general structure for modeling the phenomena that depend on their past, which is helped by a recursive learning algorithm and time-varying time patterns. This algorithm has two layers called hidden layer and output layer, for the Elman network to work well during the process, there should be more neurons in its hidden layer than other networks.

E. Leave One Out

This method is the extreme mode of PVC and KCV. In this method, K is assumed to be equal to the total number of available samples. So, at each step, a sample is set aside and then the rest of the data are used to build and teach the model, and then use the excluded data for the test. This method is very good, but it is very time consuming because the model learning task should be done with the number of elements in the main set. This is the best option in cases where the total sample size is low [10].

IV. FEATURES

A. Sharp Filter

Sharpening is a technique for enhancing the transparency of an image. The transparency of an image depends on the resolution and sharpness of the edges of an image. The resolution of an image is not dependent on something; in fact, the size of the image file depends on its pixel count, and if all other factors are the same, the higher the resolution, the more pixels the image will be, so you can get sharper [5]. The resolution of the edges is a little more complicated, which includes the contrast level at the edges of the image. The edges that are more contrast are more obvious to the human vision system. In this paper, the Sharp filter is used to increase the transparency of the image, which makes the image more transparent and also increases the accuracy of the image edges, which results in obtaining more accurate numbers in the MTA [6], [15], [11].

B. MTA

A measure of the diagnosis of patients with mild cognitive impairment and Alzheimer's disease is defective individuals, which is very useful for evaluation [7], [12], [5], [11].

| TABLE I |
| THE RESULTS ARE FROM THE MTA |
| Person 1 | column | 322/85 | 322/55 | 324/28 | 323/2 |
| Row | 404/4 | 403/01 | 402/84 | 401/61 |
| Person 2 | column | 314/51 | 314/01 | 309/03 | 304 |
| Row | 417/5 | 416 | 414 | 398 |

Fig. 1 Display CT scan images of patients

V. RESULTS

According to the table statistics, the highest frequency power in the Fz channel is the EEG signal for the patient (second man) and the lowest for the healthy person (second man). Also, in the Cz channel, the highest value was obtained for the patient (first woman) and the lowest for the patient.
(second woman), and for Pz channel, the highest frequency power for the healthy person (second woman) and the lowest for the healthy person (first man) is [4], [9].

<table>
<thead>
<tr>
<th>Gender</th>
<th>Person</th>
<th>Sick Channel</th>
<th>All</th>
<th>Delta</th>
<th>Theta</th>
<th>Alpha</th>
<th>Beta</th>
<th>Gamma</th>
</tr>
</thead>
<tbody>
<tr>
<td>Man 1</td>
<td>Normal</td>
<td>Fz</td>
<td>2055.5</td>
<td>1653.2</td>
<td>41.8064</td>
<td>5.1412</td>
<td>2.2390</td>
<td>0.2473</td>
</tr>
<tr>
<td>Man 1</td>
<td>Patient</td>
<td>Cz</td>
<td>1808.2</td>
<td>1454.9</td>
<td>36.8071</td>
<td>4.5172</td>
<td>2.2390</td>
<td>0.2473</td>
</tr>
<tr>
<td>Man 1</td>
<td>Patient</td>
<td>Pz</td>
<td>1808.2</td>
<td>1454.9</td>
<td>36.8071</td>
<td>4.5172</td>
<td>2.2390</td>
<td>0.2473</td>
</tr>
</tbody>
</table>

VI. CONCLUSIONS

In this paper, after the extraction of features from CT scan images and brain signals in three channels after delta, theta, alpha, beta and gamma bands, the data were classified using Alman's neural network. According to the comparison of the results obtained from image and signal processing, the percentage of accuracy obtained from the neural network in the patient's image is mild Alzheimer's, 81% and in the severe patient 88%.

According to the statistical characteristics of the brain signal, the highest percentages in the Pz channel of alpha band in the severe and mild patients were 92% and 90%, respectively.

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