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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 disfunction 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 of 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 proteome of the neural cells and the imbalance and changes in the amount or structure of the proteins of progesinin, apolipoprotein, synoclain, and amyloid peptide that it is caused. One of the most important proteins involved in the development of Alzheimer's disease is the amyloid precursor protein (APP). This protein is expressed in the cells of the nervous system, and it interacts with the cells, contacts, and connects to the extracellular matrix and cellular skeleton. The APP protein is processed by three types of proteolytic enzymes. Symptoms of this disease begin with the loss of the power to maintain information, especially temporary memory, in aging, and gradually end with loss of recognition of time, depression, loss of speech, hearing loss, and eventually death from respiratory distress. Death occurs after five to ten years of symptoms, but the disease has started about 20 years before the symptoms began to appear. The disease is caused by the loss of synaptic neurons in some areas of the brain and necrosis of brain cells in different regions and by creating spherical protein structures called elderly 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 [1], [2].

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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

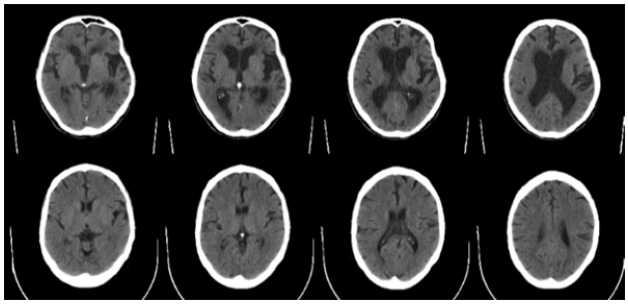

Fig. 1 Display CT scan images of patients

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 II
MAXIMUM FREQUENCY OF EACH BAND AND CHANNEL

Gender	Person	Sick	Channel	All	Delta	Theta	Alfa	Beta	Gamma
			Fz	2055.5	1653.2	41.8064	5.1412	2.2390	0.2473
Man	1	Normal	Cz	73.4775	59.0136	1.4892	0.1844	0.2670	0.0089
			Pz	2.0911	1.6766	0.0443	0.0126	0.1164	0.00035
			Fz	1808.2	1454.9	36.8071	4.5172	1.9589	0.2176
Man	2	Normal	Cz	98.7364	79.3905	1.9980	0.2467	0.3235	0.0119
			Pz	16.3596	7.6972	0.1992	0.0255	5.4291	0.0073
			Fz	1841.7	1481.8	37.4849	4.6086	2.0001	0.2219
Man	3	Normal	Cz	92.8629	75.5807	1.9099	0.2334	0.3057	0.0113
			Pz	35.5988	5.8054	0.1459	0.0182	11.6977	0.0243
			Fz	1925.3	1552	39.2569	4.8328	2.1120	0.2321
Man	1	Patient	Cz	59.2212	46.9799	1.2005	0.1472	0.2394	0.0828
			Pz	85.6473	4.2580	0.1096	0.0437	27.8158	0.0333
			Fz	2260.4	1810.5	45.7878	5.6295	2.4457	0.2707
Man	2	Patient	Cz	11.2813	9.0032	0.2283	0.0275	0.2677	0.2677
			Pz	56.7272	44.9177	1.1307	0.1416	1.9406	0.0068
			Fz	2006.5	1614,8	40.7802	5.0159	2.1734	0.2415
Man	3	Patient	Cz	6.1211	4.9430	0.1229	0.0154	1.0012	0.0168
			Pz	3.5154	2.8369	0.0712	0.0087	0.8801	0.0066
			Fz	1907.5	1534.0	38.7877	4.7877	2.9264	0.2314
Woman	1	Normal	Cz	112.8378	90.9861	2.2957	0.2835	0.6354	0.0344
			Pz	223.5897	10.1123	0.2570	0.1122	72.4290	0.1258
			Fz	1890.5	1509.1	38.2024	4.6930	4.6666	0.2248
Woman	2	Normal	Cz	116.7774	97.8505	2.4640	0.3042	11.1993	0.1343
			Pz	333.7712	6.1868	0.1546	0.1660	112.0935	0.1813
			Fz	1857.7	1494.9	37.8151	4.6451	2.0201	0.2236
Woman	3	Normal	Cz	75.5989	61.2239	1.5467	0.1899	0.2892	0.0092
			Pz	11.3077	9.0093	0.2305	0.0281	1.3147	0.0039
			Fz	1833.4	1477.4	37.3491	4.5944	1.9840	0.2209
Woman	1	Patient	Cz	135.2910	107.3968	2.7180	0.3350	0.2242	0.0161
			Pz	5.6683	4.2079	0.1060	0.0140	1.4152	0.0034
			Fz	1845.3	1475.5	37.3537	4.5881	1.9987	0.2209
Woman	2	Patient	Cz	4.5466	3.8892	0.0973	0.0121	0.0898	0.00057
			Pz	9.5747	7.5313	0.1951	0.0223	0.4725	0.0011
			Fz	1910.9	1532.3	38.7657	4.7651	2.0719	0.2295
Woman	3	Patient	Cz	10.4490	8.0267	0.2084	0.0255	0.0231	0.0012
			Pz	7.1776	6.0886	0.1558	0.0190	0.4416	0.0020

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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