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Analysis the EEG Signal to Detect Epilepsy Using Artificial Neural Network

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***Abstract* - According to the World Health Statistics, the epilepsy is a disease that suffer about one percent of people in the world. The EEG Signals as electrical activity of the brain use to detect type of epilepsy. Epilepsy will be detected by the recurrence of epileptic seizures in EEG signals. In most cases, it can not predict the onset in a short period, but requires a continuous recording of the EEG signal. Conventional way of recording tape that has been recorded for this method is mobile that keeps the EEG data for a very long time, even up to a week holds. Since conventional methods of analysis are very tedious and time consuming, EEG automatic seizure detection methods have been developed in recent years, but the error percentage of them is high. Therefore, this paper presents a method based on artificial neural network for detecting the epilepsy that results demonstrate, good accuracy of the proposed model.**

***Keywords* - Epilepsy, Artificial Neural Network, EEG Signal**

I. Introduction

Nearly a century, the science of the mind (psychology) has grown independently of the science of neuron (neuroscience). Regarding to that, psychologists were interested to mental functions, and how to learn and think. Aginest of them, neuroscientists were interested in how the brain grows its functionality [1]. If we would like to understand the various researches forgive upgrade the brain capacity in basic neuroscience must to study the basic neuroscience [2]. Nevertheless the study of brain can be improved, in the using biological processes.

Significant changes in the pattern of electrical activity of neuronal have been established the electrical potential across the cell membrane. Each cell can create the membrane potentials which are detectable only a few micrometers distance of cells, but a collection of brain cells that fire simultaneously, may have the potential to make microvolt degrees, that be detectable on the scalp and skin with arrangement of the electrodes. A regional variation in the electrical potential of the skull creates an electroencephalograph, which records the electrical activity of the brain [12]. The EEG signal of the nature human, contain harmonic frequencies of 1 Hz (one cycle per second) to 50 Hz [14]. The most obvious rhythm in adults are 9 to 10 Hz that is over the behind lobes [3].

A. The EEG signal

The EEG signal is a calm and objective indicator of dynamic brain activity, not only from a specific place, but described the overall atmosphere of the interior of activity [4]. The most common method of the classical EEG brain imaging was invented in 1929 by Hans Berger. The neuronal electrical activity is determinant in the top layer of cortical neurons. Electrodes where placed on the skin of a person's skull, measure the electrical activity of neurons [3].

Brain electrical activity recorded can not be observed from a sample of the results from the EEG signals directly, but can be studied and interpreted; and it can detect the abnormality. Usually the frequency spectrum of this signal contains useful information that has many applications [5].

II. Scope of the Research

Hippocrates recognized that epilepsy is an organic phenomenon (part) of the brain, but many of the old researchers seizures were the result of supernatural forces. The word epilepsy originating is from a Greek word (meaning the perch in the wrath of the forces of the world). In the late nineteenth century, Jackson identified the cases revealed epileptic seizures. Jackson designed the new definition of epileptic seizure, based on his observation that is called "Sudden charges abnormality, and abnormalities of nerve tissue". Furthermore, he concluded that this abnormality charged with the severity of the disease, and the effects of many factors occur at any age. He describes emphasizing the clinical onset of seizures, first of all, the appearance of cells under the theory of focal epilepsy; with subsequent release criteria.

Occasionally epilepsy is determined by the dys-charges (attack), abundant and abnormal cells according to the clinical record of the EEG [11]. Charges abnormality occurs when the nerve stimulation thresholds decrease excessive compensation in membrane threshold stabilizing mechanisms. Attack may be localized and limited to the starting location or spread to other areas of the brain. When the size of the area under charge abnormality is sufficient, occures the symptomatic seizures, otherwise asymptomatic and local electrical to be limited interference effects. The International classifications of epileptic seizures are divided into two major categories:

- Partial seizures (focal) seizure that starts a relatively small area of the brain. Simple partial seizures (focal): A simple partial seizure induced by focal cortical abnormality charges and is proportional to the area of brain function that is in charge of dyslipidemia and impaired consciousness without cause symptoms[13]. Simple partial seizures may be having signs or symptoms of motor, sensory, autonomic, and behavioral or mental.

- A generalized seizure (local) is that the seizure bilaterally symmetrical and no starting position. Complex partial seizures (psychomotor seizures, temporal lobe), the major difference between simple and complex partial seizures is, there is disturbance of consciousness in complex but there is not in simple.

III. Artificial Neural Network

Study on Neural Network was started in 1943 by McCulloch and Pitts. Single layer networks were introdued in 1962 with activation functions of threshold by Rosenblatt that was called perception networks. In the 1960s, it was shown experimentally that the perception network has ability to solve the several problems, despite many of the complex problems can not be solved by this network. These limitations of the perceptron network with one hidden layer were published in a book by Minsky and Papert. Result of this book leds to the neural networks to be considered for less than two decades. In the 1986, publication of the back propagation algorithm by Rumelhart, Hinton and Williams led to new studies on the neural networks. The importance of this algorithm was the multi-layer neural network could be trained [10].

Multilayer Perceptron Neural networks are a kind of progressive networks consisting of an input layer, an output layer and desire hidden layer. Although, there is no limit to choose the number of hidden layers from aspet of theoretically, but usually one or two layers are considered for hidden layers. The perceptron neural network with four-layer has three hidden layers and an output layer with the ability to solve every problem with any complexity. Each layer is fully connected to the successive layers, as shown in Figure1. There are several parameters in the design of a neural network, for example, to select the required number of layers and number of neurons in each layer [9].

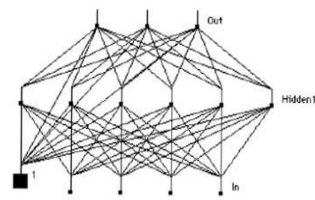

Figure 1. Schematic drawing of a multi-layer perceptron neural network

A. *Structure of the PN and EN Neural Network*

EN is a special type of back propagation neural networks. It's a two-layer back propagation network with a feedback connection from the output of the hidden layer to its input. This relevance feedback, make enable it to recognize and generate temporal patterns as well as spatial patterns [8].

PN is a kind of radial basis networks. This is a feed-forward network with two layers, the middle layer, called the radial basis layer and a competitive edge. These two layers use radial basis functions and competition respectively [6, 7].

IV. Materials and Methods

The population of this study is as follows.

A) Male and female undergraduate students who were enrolled at Tabriz University (Iran).

B) The number of patients in the nerves department of the Crescent Hospital who referred to the EEG.

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A. Using Calbod Software Framework for Data Collection

Sampling was taken in both healthy and patients in 12 channals and unipolar assembly with the lowest band 1.2 Hz to higher band 35 Hz. The channel number can be from 8 to 24and pole assembly van be changed from 1 to 8 in the lowest band 0.16, …, 3, 2 and highest band 10, ... 90. In this software were taken data in the four cases those are eyes open, eyes closed, breathing deeply and light conditions. Neurologist in charge can be used of the state is stimulated by the patient's illness or absence of these conditions. The possibility of using brain map is to display the number of alpha, beta, theta waves in the software.

Three sets of EEG data of normal and epilepsy patients have been used as experimental datasets for the proposed system based on neural networks. Each data set consists of 150 single-channel EEG segments, each lasting is 23 seconds. This part of the evaluation were selected and isolated such as visual artefacts due to muscle activity or eye movements.

The first data set is obtained from 50 healthy instances by placing surface electrodes standardized. Instants were fixed in a state of quiet wakefulness with eyes open. The second data set of EEG is obtained from epileptic EEG signals from 50 different patients during occur the epileptic seizures with intracranial electrodes. Part of epileptiform EEG is selected from all the bands of epilepsy attack. The Intracranial epileptic EEG classification system was chosen, because this is the most accurate of attacks.

The EEG signals are recorded by a 128-channels amplifier system using a common reference medium. Data (after a 12-bit analog to digital converter) is recorded on the memory of a computer system with a sampling rate of 173.61 Hz with band-pass filter configurations 40 to 0.53 Hz. All EEG signals were made between the hours of 17 to 20. The standard electrods have been located at 21 sites on the skull based on the standard international system 20-10 and fixed them on the head using special hat. Resistance electrodes are kept at 5 kHz and data recording done in the close eye, awake and resting, about 15 minutes.
The electrode assembly was arranged longitudinally polarized and removes unwanted waves ranging from 70 to 0.3 Hz by filtering device. After recording waves, each lasting was selected the terms of 23 seconds as part of instance. The terms of 23 seconds is selected by a neurologist from artifact-free sections.

To compare the performance of different brain areas in two persons, can be used comparison in different frequency bands.

B. Preprocessing on Dataset

To feature extraction must be done pre-processing on any epoch of data that steps are as follows:

A) Applying a median filter over any epoch.

B) To obtain median filter using subtracting the original epoch from smoting epoch.

C. Feature Extraction of Neural Network

The approximate entropy values are calculated for selected compounds as follows.

The values used in this experiment are M = 1, 2, 3 data sequence with a 10 percent increase SD from r = 0% -90%, N = 512, 256, 173, 2048, 1024. The approximate entropy values are calculated for each EEG signal epileptic and are given as inputs to the neural networks. The entire collection of EEG available data, more than 60% of the dataset are used for training and the rest are to test the performance of neural networks. Thus, the total number of data points used for training and testing are 238,740 and 159,160 respectively. Using these points, the frames were created in the varying sizes (173, 256, 512, 1024, and 2048). Figures 2 and 3 (a) and (b) show the approximate entropy diagram corresponding to N, equal to 512 and 1024 that samples have partial overlap between their epileptic EEG signals.

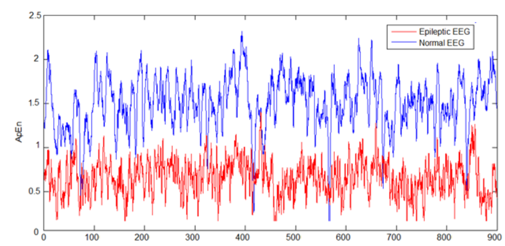

Figure 2(a). The approximate entropy diagrams that show the explicit resolution of the epileptic EEG signals

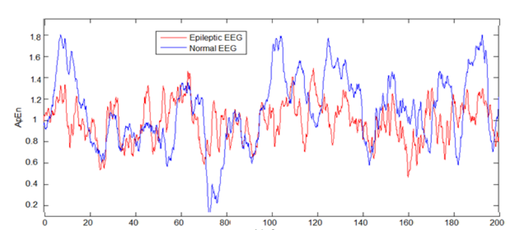

Figure 2(b). The approximate entropy diagrams that shows the explicit resolution of the epileptic EEG signals

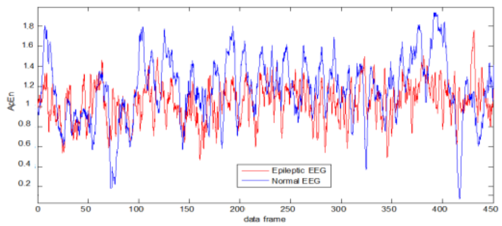

Figure 3(a). The approximate entropy diagram that shows a partial overlap between epileptic EEG signals

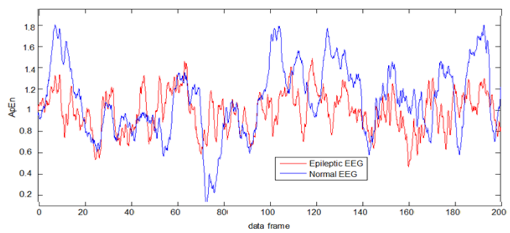

Figure 3(b). The approximate entropy diagram that shows a partial overlap between epileptic EEG signals

V. Experimantal Results

Figure 4, 5, 6 shows the EN for some M, R, N values that can provide a high overall accuracy in the range of 99 to 100. The EN values for other compounds are same with last accuracy. The accuracy of the model is in the range of 99.45 to 100 percent that this is acceptable for clinical trials. The PNN for only a small number of 3-combinations offers accuracy in the range of 98 to 100 percent. Regarding to the results it can be concluded that EN is generally better than PNN (Preseptron Neural Network) in the all compounds. The Feedback structures and Incremental processes used in the EN can be considered among the possible reasons for the better performance. The overall accuracy obtained by the proposed method is 99.6%. Although the use of the artificial neural networks increases the computational complexity, but the high accuracy obtained with this system can overcome the disadvantages, because in each model, detecting any attack automatically, with high accuracy, is the first priority. It should be noted that applying a simple threshold model, it would be inefficient because only certain combinations of the parameters specified in the resolution clearly shows epileptic EEG signals. On the other hand, artificial neural networks are good for almost all combinations. For example, a simple threshold system, as shown in Figure 4, would be inefficient for approximate entropy values, because can be clearly observed the partial overlap between epileptic EEG signals. In contrast, the accuracy achieved in this case using EN, for both cases (512 and 1024) is 100 percent. While the accuracy of the PNN for the 512 and 1024, are 84.52 and 77.42 percent respectively. These results were confirmed and support using neural networks. Our experimental results are based on only 5 different instances. The approximate entropy values of optimal parameters obtained based on these data may not be generally good. So using a linear discriminant with known values of the parameters of the approximate entropy take not good result in the situations where are involved the large numbers of instances. This problem was not created using the proposed method based on neural networks, because this system has done independent over the values of the parameters used in the approximate entropy. We know that the approximate entropy have suitable characteristics such as epileptic pattern recognition as well as the power has low computational. Thus, an automated system using approximate entropy as input parameters is the best choice for real-time detection of epileptic seizures. The system offers based on the two types of EEG, such as EEG signals of the are normal people and patient instances. The system should be strengthened using match it with other EEG states such as sleep EEG signals.

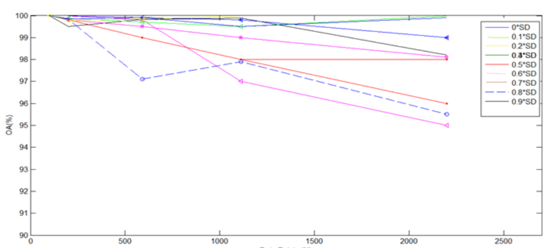

Figure 4(a). The overall accuracy of the neural networks with M=1

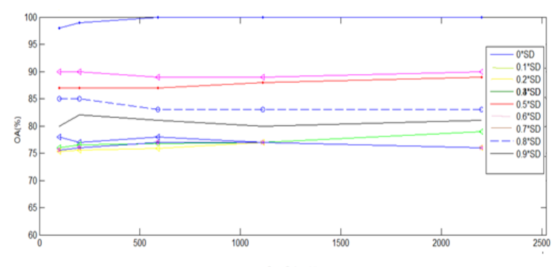

Figure 4(b). The overall accuracy of the neural networks with M=1

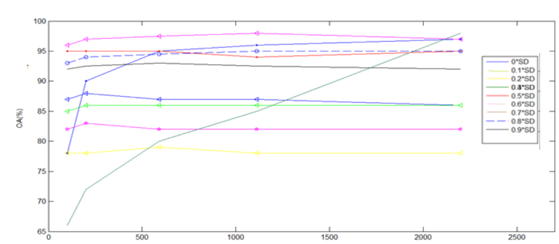

Figure 5(a). The overall accuracy of the neural networks with M=2

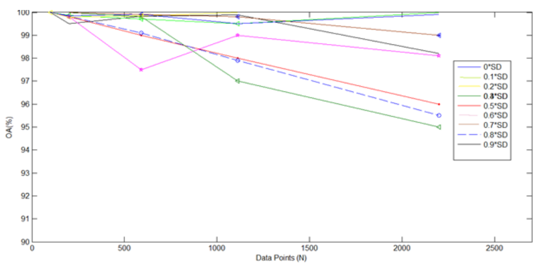

Figure 5(b). The overall accuracy of the neural networks with M=2

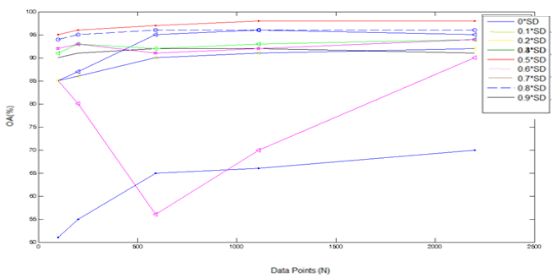

Figure 6(a). The overall accuracy of the neural networks with M=3

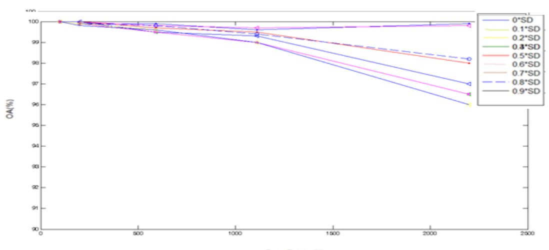

Figure 6(b). The overall accuracy of the neural networks with M=3

VI. Conclusion

In this paper, the artificial neural networks were used to demonstrate for data separation in different seizure activity. In terms of computational cost and powerful feature that called approximate entropy was used to diagnose epilepsy. The experimental results show that this system can achieve the overall accuracy of nearly 100%. Since the proposed model that is based on the low computational characteristic is the most appropriate choice for real-time detection of epileptic seizures based on the recorded tapes of the EEG signals.

References

[1] DashBozorgi, Z. (2002) "Innovative teaching methods based on the functions of the right hemisphere and both hemispheres", the M.S. Decertation, Alzahra university.
[2] Dietrich,A.(2004).The cognitive neuroscience of creativity, Psychonomic Bulletin & Review,11:1011-1026.
[3] Sadok, B. and Sadok, V. (2003) "Synopsis of Psychiatry, Behavioral Sciences-Clinical Psychiatry", Shar-e-Aftab Press, Tehran Iran.
[4] Vahedi, H. (2005) "Comparison of the quantitative EEG signal in the patients with PTSD", The M.S. Decertation, The University of Tabriz.
[5]Petsche, H. (1996). "Approaches to verbal, visual and musical crativity by EEG coherence analysis", Intrnational Journal of Psychophysiology, 24(1-2):145-59.
[6] Pincus S. M. and Goldberger, A. L. (1994) “Physiological time series analysis: what does regularity quantify”, Amer. J. Physiol., 266:H1643–Hl656.
[7] Richman, J. S. and Moorman, J. R. (2000) “Physiological time-series analysis using approximate entropy and sample entropy,” Amer. J. Physiol., 278: H2039–H2049.
[8] Kim, W. S., Yoon, Y. Z., Bae, J. H. and Soh, K. S. (2005) “Nonlinear characteristics of heart rate time series: Influence of three recumbent positions in patients with mild or severe coronary artery disease,” Physiol. Meas., 26:517–529.
[9] Demuth, H. and Beale, M. (2000) "Neural Network Toolbox", (for use with Matlab), Natick, MA: MathWorks.
[10]Huang, C. J. and Liao, W. C. (2003) “A comparative study of feature selection methods for probabilistic neural networks in cancer classification,” 15th IEEE Intern. Conf. Tools with Artif. Intell. (ICTAI’03), Sacramento, CA, Nov. 3–5, pp. 451–458.
[11] Rechy-Ramirez, E.J. and Hu, H. (2011) "Stages for Developing Control Systems using EMG and EEG Signals: A survey TECHNICAL REPORT" CES-513 ISSN 1744-8050.
[12] Boos, C. F., Pereira, M. C. V., Argoud, F. I. M. and Azevedo, F. M. (2010) "Morphological descriptors for automatic detection of epileptiform events", 32nd Annual International Conference of the IEEE Engineering in Medicine and Biology Society, pp. 2435-2438.
[13] Kumar, S. P., Sriraam, N., Benakop, P.G. and Jinaga, B.C., (2010) "Entropies based detection of epileptic seizures with artificial neural network classifiers", Expert Systems with Applications, 37(4):3284-3291.
[14] Sanei, S. and Chambers, J. A. (2007) "EEG Signal Processing", Wiley-Interscience.