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Wavelet-based EEG processing for computer-aided seizure detection and epilepsy diagnosis

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ABSTRACT
Many Neurological disorders are very difficult to detect. One such Neurological disorder which we are going to discuss in this paper is Epilepsy. Epilepsy means sudden change in the behavior of a human being for a short period of time. This is caused due to seizures in the brain. Many researches are going onto detect epilepsy detection through analyzing EEG. One such method of epilepsy detection is proposed in this paper. This technique employs Discrete Wave Transform (DWT) method for pre-processing, Approximate Entropy (ApEn) to extract features and Artificial Neural Network (ANN) for classification. This paper presented a detailed survey of various methods that are being used for epilepsy detection and also proposes a wavelet based epilepsy detection method.
Index Terms: Discrete Wavelet Transform, Approximate Entropy, Artificial Neural Network

I. INTRODUCTION

Seizure means an abrupt change in the electrical activity of a brain. These abrupt changes occur due to some chemical changes in the nerve cells. Seizure causes a sudden change in the activity of a person for that short period of time. The sudden change in activity may occur due to excitement or inhibiting of brain cells from transmitting messages. Usually in normal condition, the excited cells and the cells that inhibit are balanced but during seizure these cells imbalance. Seizures in themselves are not a disease but they may be the symptoms of any disorder in the brain.

Epilepsy is a common chronic neurological disorder that cannot be cured but can be controlled using medicines. Epilepsy seizures are the result of the transient and unexpected electrical disturbance of the brain. Various researchers have found that around 50 million cases in the world are positive and are struggling with epilepsy. people worldwide have epilepsy, and nearly two out of every three new cases are discovered in developing countries. Epilepsy is more likely to occur in young children or people over the age of 65 years; however, it can occur at any age. The detection of epilepsy is possible by analyzing EEG signals.

Electroencephalogram (EEG) has established itself as an important means of identifying and analyzing epileptic seizure activity in humans. In most cases, identification of the epileptic EEG signal is done manually by skilled professionals, who are small in number. In this paper, we try to automate the detection process.

II. RELATED WORK

Automatic seizure detection has been the area of interest for many researchers since seventies. These researches were started primarily in order to overcome the shortcomings of visual analysis of EEG data such as time consumption while analyzing and disagreements among certain neurologists on ictal and inter-ictal activities. Therefore, the researchers tried to find out the automatic way of detecting these activities. Some methods for Inter-ictal spike detection have been proposed by Ravi Mishra and Madhulika Pandey in [4] which classified these methods into six different categories as follows:

- Mimetic technique: This technique uses digital filters and frequency domain approach for automatic generation of EEG reports.
- Template matching algorithms: In digital image processing template matching is a technique that is used to find out small parts of an image that matches the template image. There are various template matching techniques. Some of which include Navie Template Matching (NTM), Image Correlation Matching (ICM), Pattern Correlation Images (PCM), Grayscale-Based Matching (GBM) And (Edge-Based Matching) EBM. [5]
- Parametric approaches: In this method underlying densities are known but the values of parameter might be unknown.
- Artificial Neural Networks: Artificial Neural Networks (ANN) are used in texture analysis, pattern recognition, segmentation, color representation, and image compression.

- Knowledge based techniques : A knowledge base technique uses a database or a public library of related information about a particular subject.

Dr. D. Najumnissa and Dr. T. R. Rangaswamy proposed in [6] proposed an Eliptic seizure detection technique using wavelet transform and Adaptive Neuro-Fuzzy Logic. In this research, they tried to increase the diagnostic importance of EEG using Wavelet transform coefficients and Adaptive Neuro Fuzzy Inference System (ANFIS). For the analysis of seizure in EEG signals, 50 subjects out of which 20 normal and 30 seizures were used. Here the EEG signals were first decomposed into time and frequency domain using wavelet transform technique and then the statistical features were calculated to describe their distribution. An Adaptive Neuro Fuzzy Logic based system was used for the classification of epileptic seizure. For this the ANFIS systems were trained initially to detect epileptic seizures and then classify them. Further, BPN algorithm is used to study and compare the datasets. Average True Positive Rate and True Negative Rate weare found to be 97% and 99% respectively. The presented ANFIS classifier combined the neural network adaptive capabilities and the fuzzy logic qualitative approach.

In [7] Yusuf U Khan, Omar Farooq and Priyanka Sharma proposed automatic detection of seizure in Pediatric EEG. Here, they classified the normal and seizure EEG signal by using linear classifiers. They used hyper-plane technique to separate the data of different classes. For two class problems (seizure and non-seizure) the feature vector depends on the side of hyper plane. The separating hyper plane is the boundary for which the distance between two classes is maximum and inter-class variance is minimum. Here the data is classified individually for each patient and the final result is obtained by averaging these individual results. The performance of the system is evaluated on the basis of latency, sensitivity and false detection rate.

Fenglin Wang, Qingfang Meng, Yuehui Chen, and Yuzhen Zhao in [8] proposed a novel method for feature extraction in EEG, that can be applied to both inter-ictal EEG and ictal EEG. In this paper they initially constructed a node set of Time Series Complex Network (TSCN) and then an edge set is constructed depending on similarity between the nodes. Further, the Cluster Coefficients (CC) and the Cluster Coefficient Distribution (CCD) of each node in the TSCN are calculated and lastly the partial sum of cluster coefficient distribution is calculated.

III. THEORY OF TECHNIQUES

A. Discrete Wavelet Transform (DWT):

Transformation of a signal means converting it from one form to another. There are a lot of transforms available but most transform represent signal in time domain. But many a times the signal is also required in frequency domain if time domain analysis alone is not sufficient. So, the transform that represents a given time domain signal into its frequency domain is known as the Fourier Transform. The Fourier Transform gives the signal in only in frequency domain. But, often it is required to represent the signal in both frequency and in time domain. So, the solution to this problem is to use Wavelet Transform (WT). The WT transforms the signal, both in frequency and in time domain. The wavelet transforms are of following types: discrete, continuous, stationary and non-decimated.

In DWT a signal is first decomposed into two different versions using a HPF and a LPF. The filters used must be such they should satisfy the admissibility condition. Then we take either the output of low pass filter or high pass filter and again decompose it into two different parts. Likewise, we go on decomposing the signal up to a certain pre-defined level. Now, we get a lot of decomposed signals like D_0, D_1, D_2, D_3, D_4 etc. and now if we plot these decomposed signals on a 3-D graph then it will show what frequency band exist at which time and what is the amplitude at that frequency and time.

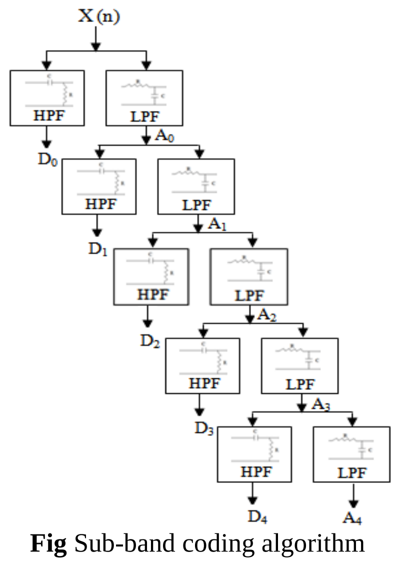

Fig Sub-band coding algorithm

B.Approximate Entropy (ApEn):

Approximate entropy (ApEn) indicates the amount of regularity or the predictability of fluctuations in a given data. [9]. Approximate Entropy has three parameters m, r and N, where the run length m, and tolerance window r are the inputs and must be specified and N represents the no. of points in the series.

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IV. PROPOSED SYSTEM

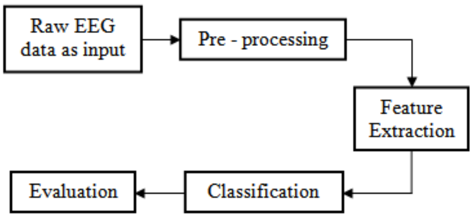

Fig. shows the block diagram of proposed epilepsy detection system. Here, the raw data i.e. the EEG signals will be given as input. Then these raw signals will be pre-processed using Discrete Wavelet Transform (DWT) and will be decomposed into different levels. Features are then extracted from these decomposed signals using Artificial Neural Network (ANN) and are then classified using Support Vector Machine (SVM). The Ant Colony Optimization algorithm (ACO) is used to optimize the classified vectors.

V. CONCLUSION

Different methods are proposed in different papers to detect Epilepsy. From these papers it is seen that epilepsy detection is a very tough task. The traditional method uses epilepsy detection using manual observation but it has a lot of disadvantages such as time consuming, laborious, requires skilled interpreters, and is prone to subjective judgment and error. Further, manual way of epilepsy detection is not suitable to detect subtle features. Therefore, the researchers are trying to design a CAD tool that can be used to efficiently analyze the EEG signals. Here, we have also proposed a method for epilepsy detection using DWT, ApEn, ANN and SVM

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