Epileptic Seizure Detection on EEG Signal Using Statistical Signal Processing and Neural Networks

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Abstract: - Epilepsy is a common chronic neurological disorder that is depicted by frequent unproved seizures. Epilepsy acutely affects the customary activities of a human being. The divination of epileptic seizures assures a novel diagnostic application and a new approach for seizure control. Conventionally epilepsy is diagnosed using any one of the following technologies namely, Electroencephalogram (EEG), Magnetic resonance imaging (MRI), Positron emission tomography (PET) etc… The prime focus of this paper is on the discerning of epileptic seizure from the data that exists in the EEG signals. The seizure is identified with the aid of Statistical Signal Processing Technique, ICA and the ascertained signals are trained employing Artificial Neural Networks technique namely Back propagation algorithm. The proposed work hauled out a number of features from EEG segments and consequently these features were used to categorize the segments relating to the epileptic seizures.

Key-Words:-Epilepsy, Statistical signal processing, Independent component analysis, Electroencephalogram, Artificial neural networks, Back Propagation algorithm

1 Introduction

Epilepsy is a common term that incorporates different types of seizures. Epilepsy is characterized by senseless, recurring seizures that disturb the nervous system. Seizures or convulsions are temporary alterations in brain functions due to abnormal electrical activity of a group of brain cells that present with apparent clinical symptoms and findings [3]. Epilepsy may be caused by a number of unrelated conditions, including damage resulting from high fever, stroke, toxicity, or electrolyte imbalances [3]. The disease epilepsy is characterized by a sudden and recurrent malfunction of the brain that is termed "seizure." Epileptic seizures reflect the clinical signs of an excessive and hyper synchronous activity of neurons in the brain [1]. Approximately one in every 100 persons will experience a seizure at some time in their life [2].

Epilepsy and seizure are two dissimilar terms where in seizures are the symptoms of epilepsy and epilepsy is the causal propensity of the brain to create an unexpected rupture of electrical energy. Epilepsy can be segregated into two broad categories namely idiopathic epilepsy and symptomatic epilepsy. The former is a kind of epilepsy in which the cause for the epilepsy remains unmarked whereas in the latter case a concrete cause is identified. The symptomatic epilepsy is typically identified through any one of the subsequent symptoms: stroke, an eruption in brain, serious illness in the nervous system, severe damage to the skull etc…In general there are nearly twenty types of seizures. These types are again divided into two categories namely partial seizures and generalized seizures.

In partial seizures the electrical riot is restricted to a precise area of one cerebral hemisphere. Further down, the partial seizures are classified into simple partial seizures and complex partial seizures. The difference between the two seizures is, in simple partial seizures consciousness can be retained and in complex partial seizures consciousness is harmed or lost. Partial seizures might spread to cause a generalized seizure, where in the classification category is partial seizures secondarily generalized [16]. Generalized seizures distress both the cerebral hemispheres from the onset of the seizure. They generate failure of consciousness, either for a short time or for a longer period of time.

Besides the existence of numerous technologies for diagnosing epileptic seizure, such as

Electroencephalogram (EEG), Magnetic resonance imaging (MRI), Positron emission tomography (PET) etc. The EEG signals are widely used in the diagnosis and study of epileptic seizure. The reason for choosing the EEG over the other two is that the EEG signals record ample information regarding the function of the brain. Electroencephalogram (EEG) is illustrated as the representative signal containing information of the electrical activity generated by the cerebral cortex nerve cells. This has been the most utilized signal in clinical assessment of brain activities and the detection of epileptic form discharges in the EEG is an important component in the diagnosis of epilepsy [4].

The Electroencephalograph (EEG) signals involve a great deal of information about the function of the brain. EEG obtained from scalp electrodes, is a superposition of a large number of electrical potentials arising from several sources (including brain cells i.e. neurons and artifacts) [14]. However the potentials arising from independent neurons inside the brain, not their superposition, are of main interest to the physicians and researchers to describe the cerebral activity. Direct measurements from the different centers in the brain require placing electrodes inside the head, which needs surgery. This is not acceptable because it causes pain and risk for the subject. A better solution would be to calculate the signals of interest from the EEG obtained on the scalp [15].

In general Signal processing is the analysis, interpretation, and manipulation of signals [10]. The secondary fields of signal processing are Analog signal processing and Digital signal processing. The essence of this work is Digital Signal Processing. DSP includes the representation of signals as a series of numbers or symbols and the processing of these symbols with the assistance of various digital techniques. DSP includes several sub fields like: audio and speech signal processing, sonar and radar signal processing, sensor array processing, spectral estimation, statistical signal processing, digital image processing, signal processing for communications, biomedical signal processing, seismic data processing, etc [11].

Many approaches have been proposed to extract information from EEG signals that can be used to develop algorithms to predict or detect epileptic seizures such as Wavelet transform [5], Recurrent Neural network [6], nonlinear systems [7], logistic regression [8], spectral densities of DWT coefficients [18], etc. Here, the epileptic seizure in an EEG signal is discovered by utilizing the ICA i.e. Independent Component Analysis, a prominent statistical signal processing technique.

2 Proposed Methodology

This paper mainly focuses on the detection of epileptic seizure from EEG signal. The work has two phases. First phase is to detect the seizure from recorded EEG signals and the second phase is to train the signals. Commonly the recorded EEG signal will be a mixture of other signals as well. The primary objective of this work is to detect the epileptic seizure. The epileptic seizures can be identified with the aid of some techniques of which we make use of ICA (Independent component analysis, a statistical signal processing technique). The ICA separates the epileptic seizure from the recorded EEG signal. The aforementioned steps constitute the first phase.

The second phase in our work is the training of the separated signals, for which we utilize ANN i.e. artificial neural network technique namely Back propagation algorithm. The initial step in the training process is to feed the epileptic seizure signal and other recorded EEG signal as an input to the neural network. The network needs to be trained in such a way that it should be capable of recognizing the epileptic seizure from the EEG signal.

2.1 Epileptic Seizure Detection Using Independent Component Analysis (ICA)

The seizure detection phase is the initial phase in our work and in this phase we detect the seizure affected part of signal from the recorded EEG signals by means of employing statistical signal processing technique. Signal processing is also engaged to deal with miscellaneous issues in EEG analysis such as data compression, detection and classification, noise reduction, signal separation, and feature extraction. The analysis of these signals is vital for the research and medical diagnosis and treatment as well. In our work we employ, Statistical Signal Processing Technique, in which the signals are regarded as either stochastic processes or random processes [12].And at this instant we can see about the ICA.

2.2. Independent Component Analysis (ICA)

In this paper, the epileptic seizure from the EEG brain signal is diagnosed with the aid of ICA, a sort of Statistical Signal Processing Technique. The ICA is highly employed in the interpretation of EM brain signal, since it determines the statistically independent components from a collection of deliberated signals. The objective of ICA is to separate the original signal from the mixture of recorded EM signals, assuming that original signals are statistically independent.

The ICA algorithm allows separating N independent sources from N sensors under the constraints that the propagation delays of the unknown "mixing medium" are negligible, and the sources are non-log and have probability density functions (pdf's) not too unlike the gradient of a logistic sigmoid. Therefore N scalp electrodes must record the EEG signal and the correlated signals are used to separate N unknown "independent brain sources" that generated these mixtures [13].By means of employing ICA to our input signal (EEG), we can extract the epileptic seizure from the mixture of EEG signals. The epileptic seizure can be discerned and extracted as well, from the registered EEG signal with the aid of Independent Component Analysis. This is followed by the training of the ascertained signal, applying ANN (Artificial Neural Networks). Figure 1 depicts the block diagram of seizure detection process from EEG signal using ICA and Neural Network training.

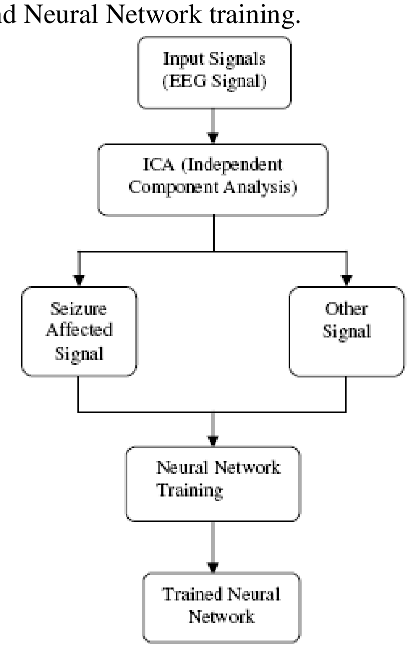

Figure 1. Block diagram of Seizure detection from EEG signal and Neural Network Training

3 Training Phase Using ANN

Once the epileptic seizure is separated from the EEG signals with the aid of Independent Component Analysis, the training process will have to be carried out. Artificial Neural Networks (ANN) comes in handy for the training purposes and so it is utilized here. Literally speaking, the Artificial Neural Networks (ANN) is the elemental electronic delineation of the neural framework of the brain. An Artificial Neural Network is an adaptive, most often nonlinear system that learns to carry out a function (an input/output map) from data [18]. The effect of the transformation is determined by the characteristics of the elements and the weights associated with the interconnections among them. By modifying the connections between the nodes the network is able to adapt to the desired outputs [19] [20].

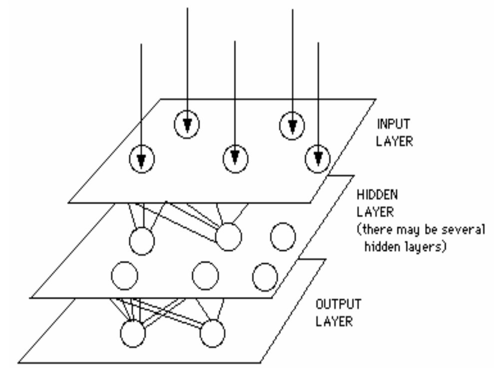

Figure 2. Architecture of Artificial Neural Networks

The seizure affected parts of the brain can be exactly identified once the recorded EEG signals are trained employing Artificial Neural Networks. In ANN there are several techniques for training the input data. In our work we used Back propagation algorithm for training our input (EEG) signals

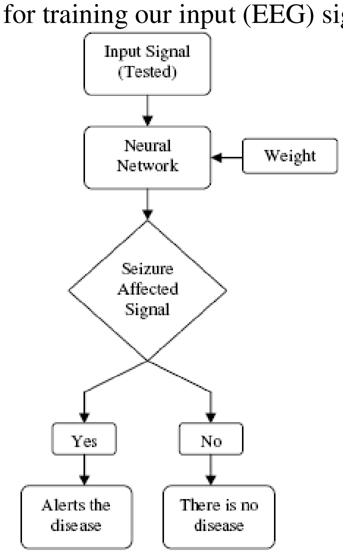

Figure 3. Block diagram of Neural Network Recognition

3.1 Back Propagation Algorithm

In this paper for training the EEG signals we utilize Back propagation algorithm. One of the most

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commonly used supervised ANN model is back propagation network that uses back propagation learning algorithm [21]. Back propagation algorithm is well-matched for pattern recognition problems. The back propagation neural network is essentially a network of simple processing elements working together to produce a complex output. These elements or nodes are arranged into different layers: input, middle and output [22]. The advantages of Back propagation algorithm are, it is simple and its speed is also reasonable. The working procedures of back propagation algorithm are as follows:

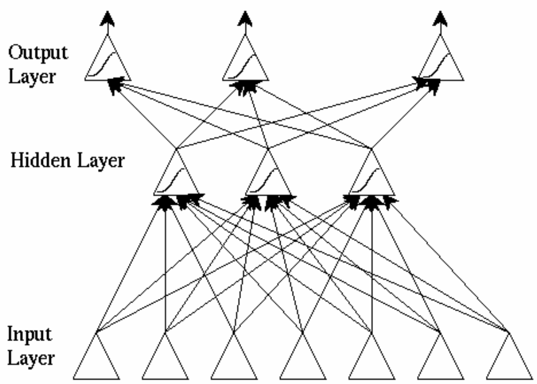

Figure 4. Architecture of Back Propagation neural network

In a back-propagation neural network, the learning algorithm has two stages. Initially, a training input pattern is presented to the network input layer. The network propagates the input pattern from layer to layer until the output pattern is produced by the output layer. If this pattern is dissimilar from the preferred output, an error is intended and then propagated backward through the network from the output layer to the input layer. The weights are customized as the error is propagated.

In our work we primarily present our input signal i.e. EEG signals to the neural network, which in turn compares our input signal with the trained signal, by considering the weight factor. If the input signals (EEG signal) contain epileptic seizure then our trained network produces an alert signal to indicate the occurrence of the disease. The utilization of Back propagation shows better results in the detection of seizure from EEG signal.

4 Experimental Results

The main objective of this paper is to detect the epileptic seizure from the recorded EEG signals. Initially we acquire the EEG signals from the brain. Normally the recorded signals constitute a mixture of other signals as well. And for separating the seizure from the recorded signals we used ICA which in turn separates the seizure from the recorded signals. And next we perform training in which we employ Back propagation algorithm. For training we give the EEG signals as an input and the network is trained in such a way that, it should be capable of detecting the seizure (alone) from the EEG signal. And our algorithm produces better results in the detection of seizure from the EEG signal.

5 Conclusion

The predominant purpose of this paper is the identification of epileptic seizure from the annals of the EEG brain signals. The desired signals are elicited from the recorded signals with the aid of Independent Component Analysis. Further, the signals are trained availing ANN (Artificial Neural Networks) technique namely Back propagation algorithm. For testing our results, we acquire EEG signals from the brain and separate the seizure from the signal by means of employing the Independent component analysis As the next step of our work we utilized Back Propagation algorithm for training in which the trained network detects the epileptic seizure from the EEG signal. The utilization of Back propagation algorithm shows better results in the detection of seizure from EEG signals. Thus the exertion of ICA and ANN proffers encouraging results in the detection of epileptic seizure from the recorded EEG signals.

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