CHAPTER 1

INTRODUCTION

The rate of neurological and psychiatric disorders is increasing rapidly in our day to day life due to mental burden, neurological and behavioural disorders. Among the various neurological brain disorder, Epilepsy is a constant, persistent brain disorder which is characterized by abnormal electrical activity in the brain. Epilepsy is identified by recurrent seizures. A single seizure cannot be predicted as epilepsy, because it is a condition of two or more arbitrary seizures. The effects of an epileptic seizure can vary from short term loss to raging movements. The occurrence of an epileptic seizure can be observed from abrupt muscular movements and changes in the mental state.

Seizures can also result in the loss of consciousness. The origin of seizures may be due to high electrical discharges from a collection of brain cells. Various parts of the brain can be sources of hyper discharge in the brain cells. The period of seizures can differ from short lapses of muscle jerks to prolonged disturbances. This motivates the need for automated epileptic seizure detection. Thus this chapter discusses about the occurrence of epileptic seizure and its detection.
1.1 EPILEPTIC SEIZURES

Patients with seizures ought to have physical issues added to the psychosocial problems.

The types of seizure also includes focal seizure otherwise known as partial seizures and generalized seizures. The source of seizures may also be stress, insomnia, skipping of meals, exposure to heavy flashing lights, or higher consumption of alcohol. In focal seizures, the epileptic process initiates in a section of the brain and the individual may not be aware of the undergoing epilepsy.

These seizures mostly begin in the temporal and frontal lobes of the brain. These types of seizures can last only for a few minutes and may transform into generalized seizures. A specific type of focal seizure is known as Jacksonian seizure, where there may be short trembling movements. This seizure starts from a finger and then progresses towards the whole hand.

In generalized seizures, the epileptic seizure may occur in both halves of the brain. This type of seizure can also occur for a short duration that no one can notice. The types of generalized seizures are absence, atonic, myoclonic, tonic, and tonic-clonic seizure.

In tonic-clonic seizures the individual falls down, but during generalized seizure the individual does not fall down. In myoclonic seizure, the individual just shakes a part of the body.

Partial seizures are further segmented into simple partial seizures and complex partial seizures. The consciousness is sustained in simple partial seizures, while the consciousness is lost in complex partial seizures. The problems with epileptic seizure patients involve depression and memory loss.
Depression may occur when the patients are administered epileptic medicine. Epileptic seizures lead to temporary changes in behaviour and perception.

Hence in order to diagnose these disorders, Electroencephalogram (EEG) is utilized. EEG measures the signals from human brain. It is powerful source which provides a valuable insight of the brain dynamics. Accurate and careful analyses of these signals play a prominent role in diagnosis of brain diseases and many cognitive processes.

1.2 ELECTROENCEPHALOGRAM

The human brain is made up of more than 10 billion nerve cells, or neurons. These neurons present in the brain’s network tremendously form an information processing system. The Neurons present in the nervous system process and transmit information throughout the membranes with the help of electrical currents. Thus the information transmitted using this electric and magnetic fields are recorded from the surface of the scalp. In order to measure these electric fields produced by the movement of neurons, Small electrodes placed on the on the scalp. Thus, the potentials difference produced between these placed electrodes are amplified and recorded using electroencephalogram (EEG). At the same time, the small magnetic fields generated in the brain by the neurons are measured with the help of Magnetoencephalogram (MEG) (Niedermeyer & Lopes da Silva, 2004, Christiannini, & Shawe-Taylor 2000).

In general, EEG is used to detect Seizures. It is also identifies the disorders like Epilepsy, Brain Tumor, Stroke, Dementia etc. Thus it mainly deals with the anatomy of the brain and not only with the physiological level of the brain. Thus EEG plays a vital role in many applications such as Brain-Computer Interface (BCI), Brain Machine Interface (BMI) and Human-Computer Interaction (HCI).
Operating principle of EEG

EEG is nothing but a method which records and analyses the electrical activity of the brain. Electrodes are the sensor which is used to detect the brain activities are placed on/ under the scalp. The outputs of the electrodes are connected with electroencephalograph. It converts electrical impulses into the graphical movement (ie. vertical movement of a pen over a paper). Thus the brain waves detected using the electrodes are amplified and is recorded in database with the help of EEG machine. Thus the recorded signals represents the overall performance of the neurons present in the brain and based on the pattern of electrical activity produced in an EEG, the factors that affects the brain can be detected.

1.3 EEG AS A TOOL FOR EPILEPSY

Epilepsy is a disease of the brain caused by spontaneous, intermittent and abnormal electric burst activity in the brain. EEG is one of the main diagnostic tests for epilepsy and an effective clinical tool for monitoring, diagnosing and prognosis of neurological disorders. The onset of a clinical seizure is characterized by sudden changes in the morphology of EEG, but some abnormality in EEG patterns may occur due to different conditions (Bickford et al. 1973).

Compared with other measurement methods, EEG is a clean and safe technique for monitoring the brain activity and neurobiological disorders as it provides a visual display of the recorded waveform (Sanei 2007).

Generally, the electrodes (flat metal discs) are placed on the scalp and the EEG is used to detect the epileptogenic activity by determining the consequent abnormalities. The electrode obtains the electrical potentials from the brain and records them on the EEG machine for further processing.
The recorded EEG data gives a continuous graphical exhibition of the spatial voltage distribution over time. This motivates the need for automated epileptic seizure detection. The manual analysis by a small team of professionals after EEG recording necessitates the automated seizure analysis (Gotman et al. 2016).

The epileptic seizure prediction must be implemented in real-time to meet the requirements of large amounts of EEG data. When the EEG processing is not instantaneous, it may result in delays and the EEG classification accuracy may decrease.

1.4 AUTOMATED EPILEPTIC SEIZURE DETECTION

Epileptic seizure detection in EEG signals can be achieved by employing soft computing techniques. First, the EEG signals are separated into their respective sub-components using various feature extraction methods such as Wavelet and FastICA. Then the epileptic seizures are detected using BPNN. The feature extraction tool splits the input EEG signal into subcomponents based on the statistical independence of the non-Gaussian source signals. These separated components serves as a training input to the BPNN and is utilized to identify the presence of seizure (Cristianini & Technologies B 2001).

Thus an ANN consists of various processing elements to determine the presence of epilepsy. The algorithm present in the neural network possesses highest classification accuracy. The different types of algorithm implemented for training the Artificial Neural Network are stated as follows: Gradient Descent Algorithm (GD), Scaled Conjugate Gradient (SCG), One Step Secant (OSS), Powell-Beale Restarts (PBR), Gradient Descent with Adaptive (GDWA) learning rate, Fletcher-Powell Conjugate gradient (FPCG) and Levenberg Marquardt (LM) Back Propagation. These
training algorithm involves initialization of weights, information feed forwarding, Back Propagation of errors, and updation of the weights etc.

The accuracy of the epileptic seizure classification is enhanced using Fourier Transform and ICA. In this proposed methodology, ICA is used as a preprocessing step. The features in the EEG signals are extracted based on parameters, namely, Correlation Dimension, Lyapunov Exponents, and Standard Deviation. ICA determines the features of the EEG data.

The accuracy of the automated epileptic seizure detection is further enhanced by performing feature selection based on Genetic Algorithm (GA), Hybrid PSO and ACO algorithm. Feature selection is used to improve the classification accuracy by removing the redundant and irrelevant data.

An epileptic seizure detection application is developed based on Parallel Computing in order to reduce the computational cost of the detection algorithms.

1.5 OBJECTIVES OF THE RESEARCH

The objectives of the present research include

- The development of an automated epileptic seizure detection method with high processing speed.
- To employ GA based ANN technique to classify the EEG signals.
- To design a phase that detects the presence or absence of seizure using hybrid PSO techniques.
- To accomplish performance analysis of the Artificial Neural Network with ICA.
1.6 MOTIVATION OF THE THESIS

Epileptic seizures have important public health implications. It is one of the most physically and emotionally destructive neurological disorders affecting population of all ages. Any possibility of alerting a patient and/or his attending staff to an impending epileptic seizure, or anticipating the onset of seizures will have obvious clinical importance. In the recent years, with the advance signal processing techniques and invasion of this expertise into the field of neurology, considerable effort is invested in detecting and forecasting epileptic patterns.

The detection of abnormality should be achieved at an early stage, so that proper and timely action may be taken to avert the impending seizure. An automated analysis and a reliable universal forecaster of seizures can be proving to be very efficient in prognosis of epilepsy. Moreover, by automating the detection of these types of neurological abnormalities, the burden of work on the neurologist can be significantly reduced, response time to the illness can be effectively improved, and suitable medical treatment can be administered within proper time. Also, an automatic seizure detection system if used in the diagnosis of epilepsy, can act as a second opinion tool apart from visual inspection of EEG by the physician.

Therefore the development of accurate computer aided diagnostic system for classification of brain disorders is strongly desired. There is a significant interest in the research community for development of reliable EEG-based automated tools. With the advancement of new signal processing techniques and mathematical algorithms in EEG analysis, supporting methods in medical decision and diagnosis can be developed to avoid tedious analysis of voluminous records and obtain clarity about the brain pathology. This thesis, therefore, investigates and develops a number of promising automatic
computer aided diagnostic system for use in these automatic neurological event detection systems. This doctoral thesis, in particular, tries to narrow the gap that exists between present methodology of EEG signal analysis and practical implementation for the benefit of medical fraternity and common man. Main focus lies on developing a system to transform the subjective qualitative diagnostic criteria into a more objective quantitative prognosis criterion and to analyze hidden dynamics of the EEG time series for extracting more information about pathological versus normal status of the EEG signals.

1.7 PROBLEM DEFINITION

The importance of epileptic seizure detection is going on increasing due to higher statistical occurrence of epileptic seizures in our normal day-to-day life activities. During seizures, symptoms such as loss of consciousness and movement disturbances, and sensation can temporarily occur. The epileptic seizure event must be appropriately detected to avoid its unexpected occurrences in the future. Hence in order to make this process as efficient as possible, this work proposed a various computational intelligence methods for epileptic seizure detection.

1.8 CONTRIBUTION OF THESIS

The present work deals with various issues in the automated epileptic seizure detection. A vast background analysis of the materials and methods corresponding to the general epileptic seizure detection methods.

A broad survey of the existing techniques related to automated epileptic seizure detection.

Some of the contributions of the present research work are,
A study on the applicability of various computational intelligence methods has been performed for automated epileptic seizure detection along with the detection results.

FastICA is employed for feature extraction from the EEG signals and the concept of ANN is applied for the detection of epileptic seizures in the EEG signals. The best training algorithm for the Neural Network (NN) is obtained by testing various training algorithms for the best detection accuracy. EEG dataset is collected from a recording laboratory with the help of a neurophysiologist.

1.9 THESIS ORGANIZATION

Chapter 1 lays the foundation as to how and why EEG signals are clinically significant for analysis and classification of epilepsy. The chapter deals with the facts about EEG signals, epilepsy and correlation between EEG signals and epilepsy.

Finally, motivation, outline and objectives of the present research work are outlined.

Chapter 2 presents a comprehensive literature review of the methods existing for epilepsy.

The goal of Chapter 3 covers GA based ANN Classification on EEG Signal dataset and was collected from the hospital. In this method, the raw data obtained from the patient is subjected to feature extraction. Then the resulted vectors are used to train the classifiers. At last the classifiers were tested with the data not seen during the training to evaluate their classification accuracy. From the results, it is evident that the GA based ANN classifier produces high classification accuracy.
Chapter 4 This Chapter discusses the designing of architecture of hybrid PSO algorithms implemented for seizure detection in EEG signals.

In Chapter 5 an EEG signal classification method based on Artificial Neural Network with ICA is addressed.

Chapter 6 summarizes the conclusions achieved from the work presented in the previous chapters and future scope of the problem is discussed.

1.10 SUMMARY

This chapter introduces the statistics and occurrence of epileptic seizure, which lays the motivation for the research. The problem due to epileptic seizure is highlighted; the reason for seizure occurrence and their symptoms are discussed. The period of a seizure may vary and the different types of seizures were highlighted. The role of EEG in epileptic seizure detection is highlighted; EEG is a tool for confirming the presence of the seizure and examining the neurophysiologic states of the brain. There are various types of EEG tests depending on the conformity of the epileptic seizure. Standard EEG tests involve placing electrodes on the scalp to detect the epileptogenic activity by noting the unusual spiky waveforms. An automated epileptic seizure detection method is developed using artificial intelligent technique.