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Research paper

A Survey on Epilepsy Detection and Classifications Using Automated Approaches

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Abstract

This paper discusses various methods for the automatic detection and classification of focal and non-focal EEG signals for the detection of Epilepsy disease. The feature extraction and classification methods which were used in many conventional Epilepsy classification methods are discussed in this paper. The machine learning algorithms requires number of input features from the images for improving the classification rate. The deep learning algorithms do not require any extracted features from the source EEG signals. This classification algorithm takes the signal as input features and produces the classification result. The classification rates of these deep learning algorithms are high due to its stability with input sources.

Keywords*: Epilepsy, Features, Classifications, Deep learning, Machine learning.*

1. Introduction

The signals from brain are captured by Electroencephalogram (EEG) sensor and these signals are known as EEG signals. These signals are used to analyze the different normal and abnormal patterns in brain regions. The normal EEG signal is known as non-focal signal and abnormal EEG signal is known as focal signal. This is important for the automatic detection and classification of focal and non-focal EEG signals for the detection of Epilepsy disease. Fig.1 shows the focal and non-focal EEG signals for Epilepsy disease detection and classifications.

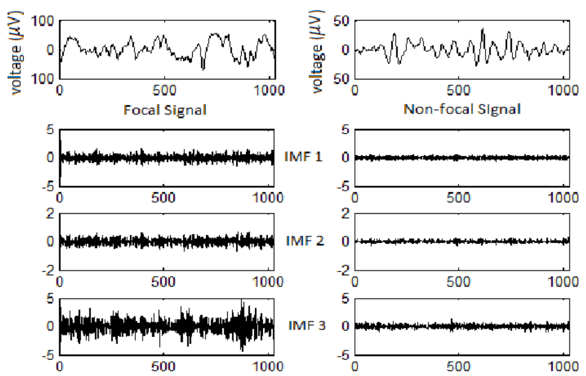

Fig.1: Focal and Non-focal EEG signals

In general, the noises and other disturbances which affect the classification are detected and removed using preprocessing stage. Then, the features are extracted from the preprocessed EEG signals using different feature extraction procedures. The extracted features are optimized by reducing the size of features for improving the EEG signal classification rate. The classified features produces two responses as Non-Epilepsy and Epilepsy signal based on the extracted feature set. The generic process for automatic detection of EEG signals for disease classification is illustrated in Fig.2.

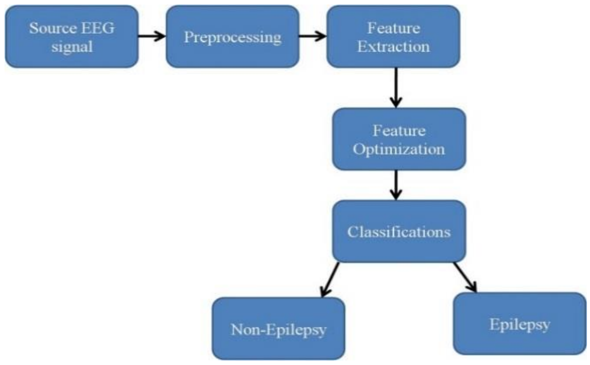

Fig.2: Generic Epilepsy detection system

2. Survey based on feature extraction

Features are the important behavior of the objects which are used to classify the single object from different set of multiple objects in a same signal. Generally, the features can be classified into either generic features or unique features based on the intensity variations in signal and its morphological behavior structures. The generic feature are classified into shape, size and morphological features based on the structure of the signal. This feature provides low classification accuracy due to its non-stability of its nature. The area, perimeter, width and height of the signals are called as morphological features (Shivnarayan et al. 2017). The EEG signals cannot be classified for Epilepsy disease detection using these feature set. Hence, the unique features are required for the detection and classifications of EEG signals for Epilepsy disease detection. These unique features are classified into binary features, Grey Level Co-occurrence Matrix (GLCM) features and texture features. Local Binary Pattern (LBP), Local Ternary Pattern (LTP), Local Derivative Pattern (LDP) and Local Tetra (LTR) are the binary features. These features produce or extract the feature values from the signal based on its nearby quantities of the signal (Diykh et al. 2016).

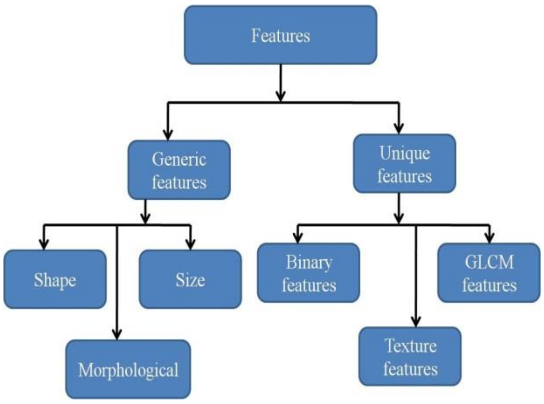

Fig.3: Feature extractions for Epilepsy disease detection and diagnosis

The intensity variations in EEG signals can be identified using GLCM features which can be extracted from GLCM matrix from EEG signals. Energy, entropy, auto correlation and cross correlation are the GLCM features which are used for the detection and classifications of EEG signals for disease detection and diagnosis process. Many conventional methods used GLCM features for the disease detection process. Next, texture features are also used for the classification of EEG signals in many conventional methods. Fig.3 shows the feature extractions for the detection and diagnosis of Epilepsy disease.

Jessica J.Falco et al. (2018) classified EEG signals for detecting Epilepsy disease using feature extraction process and classification approach. The authors classified the seizures into normal and abnormal using extracted texture features from the source EEG signals. The authors obtained 87% of classification rate for classifying the source EEG signals into normal or abnormal signals based on the extracted feature set. Li et al. (2018) used multi scale radial basis algorithm for the detection of source EEG signals into normal and Epilepsy disease signal. Time and frequency features were extracted from the preprocessed EEG signals and then these time-frequency features were optimized suing modified particle swarm optimization algorithm. These optimized set of time-frequency features are then classified using SVM classification approach. Further, multi scale radial functions were used on the classified features for improving the disease classification rate. Priyanka et al. (2017) developed an automated technique in order to detect and classify the source EEG signals into normal or abnormal signal patterns based on the features. The authors used neural network classifier method to classify the source EEG signals into Ictal, Inter-ictal, Pre-ictal. These three stage classification method produced reasonable results for the detection of Epilepsy disease. The authors obtained 96% of classification ratio using these processes.

3. Survey based on Classifier

The features from the EEG signals are used to classify the data for the detection of Epilepsy disease (Manolakis et al. 2000). Hence, it is necessary to classify these extracted features for the detection of Epilepsy disease using classifiers. Generally, classifiers are categorized as following;

1. Machine learning
2. Deep learning

The extracted features are classified using machine learning algorithms and machine learning algorithms are classified into Support Vector Machine (SVM), Neural Networks (NN) and Adaptive Neuro Fuzzy Inference System (ANFIS) classifiers.

The machine learning algorithms requires number of input features from the images for improving the classification rate. The SVM classifier trains the input features and produces the output pattern with minimized error. These generated errors will not be again trained for the classification. Hence, the classification ratio is low by using this classification algorithm. In order to eliminate these problems in classifications, NN classification algorithm is used for classifying the source EEG signals for the detection of Epilepsy disease. The NN classification algorithm is again split into radial NN and Feed Forward Back Propagation NN (FFBPNN). The training error is low in Feed Forward algorithm due to its feedback propagation of error patterns into input path. The training period is high using feedback NN algorithms. Hence it is not suitable for large dataset. In order to overcome this problem, ANFIS classification is used for automatic EEG signal classifications. The fuzzy logic rules are integrated with feed forward back propagation algorithms to strengthen the classification responses for the detection of Epilepsy disease.

Deep learning algorithms are classified into Convolutional NN(CNN) and Deep NN (DNN) classifiers. These deep learning algorithms do not require any extracted features from the source EEG signals. This classification algorithm takes the signal as input features and produces the classification result. The classification rates of these deep learning algorithms are high due to its stability with input sources.

Fig.4 shows the different classifiers for Epilepsy disease detection and diagnosis using source EEG signals.

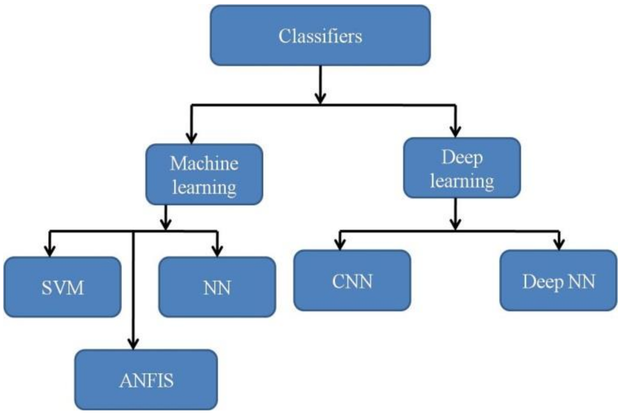

Fig.4: Classifiers for Epilepsy disease detection and diagnosis

Gupta et al. (2018) developed a computer assisted model for detecting the abnormal EEG signals for Epilepsy disease detection using linear modeling approach. The authors constructed linear regressive model for extracting the features from the source EEG signals and these signals formed linear regressive patterns for the classification problems. Gaussian random classification algorithm was used in this paper for classifying the extracted features for the identification of Epilepsy disease. The authors obtained 89.1% of classification accuracy using these Gaussian random models. Li et al. (2017) decomposed the source EEG signals using Discrete Wavelet transform based complex wavelet decomposition method for decomposing the EEG signals into multi slices. Then, the energy features were extracted and computed from each sub band of decomposition layer and then these decomposed features were trained by non-linear classification algorithm for the detection of Epilepsy disease. Corsini et al. (2016) predicted and analyzed the EEG signals for the classifications of linear and non-linear EEG signals for detecting and classifying the Epilepsy disease. The authors developed constrained blind source separation algorithm for detecting the abnormal patterns in source EEG signals. The classified signals were further used for diagnosis the Epilepsy disease in future surgery in order to save the life of patient.

Table.1 shows the comparisons of EEG signals classification methodologies with respect to its classification accuracy.

Table.1: Comparisons of EEG signals classification Methodologies

Authors	Methodologies	Accuracy (%)
Gupta et al. (2018)	Linear modeling approach	89.1
Li et al. (2017)	Complex wavelet decomposition method	81
Corsini et al. (2016)	Constrained blind source separation algorithm	79.9
Priyanka et al.(2017)	Neural network classifier method	96
Jessica J.Falco et al. (2018)	SVM	87

4. Conclusions

This paper discusses various conventional methods for the detection and classifications of source EEG signals for the identification of Epilepsy disease. The feature extraction and classification methods which were used in many conventional Epilepsy classification methods are discussed in this paper. The experimental results of the conventional methods were also discussed in this paper

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