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Automated Epileptic Seizure Prediction for Brain Disorder People

[1]A. Sivasangari, [2]P. Ajitha
[1]Sathyabama University,
Chennai, India.
sivasangarikavya@gmail.com
[2]Sathyabama University,
Chennai, India.
hannahgracelyne @gmail.com

Abstract

The seizure prediction accuracy of existing methods is having more false alarms per patient. They needed more computational time. Prediction of epileptic seizure by analyzing EEG signals is a challenging task due to inconsistency of EEG signal such as patient age, sex and seizure type. There is a need to improve the seizure prediction with more accuracy and lower false alarms. The proposed seizure detection is based on EEG signal, electro thermal activity of human body and body movements using accelerometer. The main aim of the proposed work is to predict the occurrence of epileptic seizure accurately and develop an automated algorithm to remove the artifacts of signal as much as possible without distorting the original signal.

Key Words: Epilepsy, seizure, continuous wavelet transform.

1. Introduction

Epilepsy is a brain disorder which causes people to have recurring seizures. The seizures happen when neurons in the brain send out the wrong signals. In epilepsy, the normal pattern of brain activity is disturbed, causing strange sensations, emotions and loss of consciousness. The original EEG signals and their corresponding sub bands are used to classify healthy, Interictal (seizure free) and Ictal(during a seizure) groups from each other. Electroencephalogram (EEG) signals are mainly used for analyzing the brain functions and diagnose diseases and brain disorder. Long term monitoring of epileptic patients is not feasible, duo to the inconvenient manner of seizure detection based on video and EEG monitoring. The visual scanning of EEG signal is time consuming process and may be inaccurate.

Continuous wavelet transform is used for preprocessing and feature extraction. The high pass and low pass filtering can be used to filtering the EEG signal from artifacts that produce the detailed and approximation of signal. The resultant EEG signal which contains many data points can be compressed into few features. The wavelet entropy value is calculated for measuring the similarity between the different fractions of the signal. The entropy at each decomposition values is calculated. The extracted features dimensions should be reduced due to the use of classifier. The principal component analysis is used for feature dimension reduction. The SVM classifiers are used to differentiate all groups of EEG signal from each other. The data can be classified into three classes such as normal EEG, Epileptic subjects during seizure free interval and epileptic subjects during seizure interval. The remote user will get the alert message using GPS. Epilepsy is one of the neurological disorders that affect the motor system in a brain and affect the normal interaction with the environment. Epilepsy patients suffer recurrent seizures, which are caused by excessive neuronal activity in the brain. EEG is used for monitoring the brain activity. Sudden and abrupt seizures that cause shortly lapses of consciousness can have significant impact on the daily life of sufferers. Thus, epileptic seizure detection would help these people to have a normal life

It is very difficult to separate seizures from artifacts and classify them into healthy or epileptic subjects during seizure free interval or epileptic subjects during seizure course. The methodologies to extract effective features still remain as a important challenge for detecting seizure intervals. The visual infection of experienced medical experts is required for confirming the seizure intervals which is a heavy task. It is necessary for automatic detection technique to recognize the seizure interval for epileptic patients. The main goals of the proposed work are listed as follows:

- To design an automatic and accurate seizure detection system with immediate warning.
- To provide higher prediction accuracy and lower number of false alarm in seizure prediction.

- To reduce the time delay and increase the classification score.
- To make the seizure analysis process easier for the clinicians and also to improve the performance of the seizure detection.

2. Related Work

Electroencephalogram (EEG) is most usually utilized as a part of epilepsy discovery since it incorporates valuable physiological data of the cerebrum. Be that as it may, it could be a test to recognize the inconspicuous yet basic changes incorporated into EEG signals. Highlight extraction of EEG signals is center inconvenience on EEG-based mind mapping examination. Asmaa et al (2016) extricated ten components from EEG flag in light of discrete wavelet change (DWT) for epilepsy location. These various components enabled the classifiers to accomplish a decent exactness when use to order EEG to motion to identify epilepsy.

Helen et al (2013) proposed the most imperative systems that could be executed in equipment for checking an epileptic patient. Many examinations demonstrated that, Electroencephalogram (EEG) is the most imperative flag utilized by doctors in surveying the cerebrum exercises and diagnosing distinctive mind issue. This investigation depends on various EEG datasets that were gotten and portrayed by analysts for examination and finding of epilepsy. Butterworth bandpass channels are executed and used to preprocess and disintegrate the EEG motion into five distinctive EEG recurrence groups (delta, theta, alpha, beta, and gamma). Vijith et al (2016) proposed to assess the non straight elements like Estimated Entropy, Test Entropy and Hurst Example in epileptic and typical EEG and have acquired clear segregation between them. These elements separated amid interictal stage EEG are potential parameters for investigating the likelihood of epilepsy finding from interictal stage EEG. SVM classifier was actualized for the non direct elements separated from EEG. Order parameters of classifier in light of non straight elements were computed.

Rajendra et al (2015) designed a automated diagnosis of epilepsy by using entrophy. Epilepsy is a neurological issue caused by repeating seizures and can be surveyed by EEG signals. The EEG flag is nonlinear nature and has higher entomb and intra observer inconstancy. In this way, mechanized recognition of epileptic EEG signs may demonstrate to be valuable in the observing and treatment of epilepsy patients. The nonlinear and riotous nature of the EEG signs can be assessed proficiently utilizing entropy highlights. It displays the level of changeability and many-sided quality present in the EEG signals. This complete audit introduces the utilization of different entropies to segregate ordinary, interictal and ictal EEG signals. The execution of all the entropies inferred that RE, SampEn, SEN and PE are exceedingly discriminative components to characterize typical, interictal and ictal EEG signals.

The electroencephalogram (EEG) flag is imperative in the analysis of epilepsy. Long haul EEG recordings of an epileptic patient contain a colossal measure of

EEG information. The discovery of epileptic movement is, in this manner, an extremely requesting process that requires a nitty gritty investigation of the whole length of the EEG information, typically performed by a specialist. This work depicts a mechanized characterization of EEG signals for the location of epileptic seizures utilizing wavelet change and measurable example acknowledgment. The basic leadership prepare is included of three primary stages: (an) include extraction in view of wavelet change, (b) highlight space measurement decrease utilizing disperse grids, and (c) characterization by quadratic classifiers. The proposed system was connected on EEG informational indexes that have a place with three subject gatherings: a) sound subjects, b) epileptic subjects amid a without seizure interim, and c) epileptic subjects amid a seizure. A general order precision of 99% was accomplished. The outcomes affirmed that the proposed calculation has a potential in the order of EEG signs and identification of epileptic seizures, and could along these lines additionally enhance the analysis of epilepsy.

Nabeel et al (2014) proposed a technique for programmed identification of epileptic seizure occasion and onset utilizing wavelet based elements and certain factual components without wavelet decay. Ordinary and epileptic EEG signals were ordered utilizing direct classifier. The execution of classifier was resolved as far as specificity, affectability, and precision. The general precision was 84.2%. On account of seizure onset recognition, the database utilized is CHB-MIT scalp EEG database. Alongside wavelet based elements, interquartile run (IQR) and mean outright deviation (Frantic) without wavelet deterioration were removed. Idleness was utilized to think about the execution of seizure onset location. Classifier gave an affectability of 98.5% with a normal idleness of 1.76 seconds.

3. Proposed Model

In our existing work, we developed wearable MEMS (Micro electro mechanical) predicated sensors are superseding their older technology with multi-axis integration. The existing device embeds a 3-axis accelerometer and a 3-axis gyroscope. A fall detection algorithm is applied to recognize falls from activities of daily living (ADL). When there is, a dangerous movement approaching fall the early fall alarm will admonish/warn the aged/end user to stop the movement. When the fall transpires/happens, the fall alarm will ring and send message to the guardian's cell phone for help. We filed patent for this elderly people monitoring. Our proposal will extend the service for epilepsy patients. Epilepsy is a chronic neurological disorder characterized by sudden occurrence of excessive neuronal discharges which affects most of the people. Epileptic patients are suffering from seizures which cause damage to the neural tissues. It also results in many injuries such as fractures, burns, accident and death. Many methods have been developed for seizure prediction. These methods extract various features from EEG signal and train the classifier to find the seizure appearance. Selecting effective features is very important for seizure

detection. The proposal consists of seizure detection and seizure classification. EEG recording are mixed with different forms of artifacts that generated from other than the brain. These artifacts may increase the false positive rate during seizure detection. The proposed method consists of four stages. The first stage-0 is used to generates the reference seizure from an available seizure type labeled in seizure database. The reference seizure can be generated by using various parameters such as gender, age, number of seizures, length of EEG (hrs) and seizure interval.

In preprocessing stage, the raw EEG signal is sampled at F_s Hz. The incoming signal is divided into non overlapping segments with size N. The four-level decomposition using continuous wavelet transform (CWT) is applied in EEG signal. EEG signal is decomposed into higher resolution components a1 (30-60Hz) and lower resolution components bl(0-30Hz). After four levels of decomposition, the components retained are b2 (0-4Hz), b3 (4-8Hz), b4 (8-15) and b5 (15-30Hz). Reconstruction of these five components using inverse CWT corresponds to EEG subbands delta, theta, alpha, beta and gamma. The similarity based thresholding is applied for separation of artifacts from seizures. Two levels of threshold can be used for detection. If it has to be a seizure, then denoising is not performed that segment. The coefficients values are greater than the threshold value. If the coefficient value is between lower and higher threshold limit, then denoise the segments. The seizure detection task is performed in EEG data points. The EEG signal data points, can be compressed into few features that can discriminate between different classes. After getting the data points from an EEG signal, feature dimension reduction is performed.

The first step is to decide whether the obtained vector belongs to an ictal (epileptic) EEG or an EEG which is not ictal. If the EEG is not ictal, the next step is to choose between a normal EEG and an interictal EEG. The extracted features should be distinguished between normal and deviating cases. The feature dimension scheme is combined with feature extraction process in order to reduce redundancy and dimentionality of feature vectors. The proposed work uses principal component analysis for feature dimension. N vectors of n-dimentional features Y_i=i=1,..N. In this case, n represents the number of extracted features after applying CWT of EEG signal and N is the number of EEG data segments. The use of entropies can be utilized as a part of the flag preparing to isolate the valuable flag from repetitive data. It can be utilized to naturally recognize ictal sections that are hard to limit outwardly additionally, it can be utilized to separate central and non-central EEG signals. It represents the information of randomness and is defined as the entropy of fuzzy set whose elements have different degrees of membership. Membership functions vary in the unit interval of 0 and 1. Fuzzy entropy is defined as

$$H[A]=\int_{-\varepsilon}^{\varepsilon} S(Cr\{A \geq t\})dt \qquad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where A is the fuzzy variable, Cr is the credibility measure.

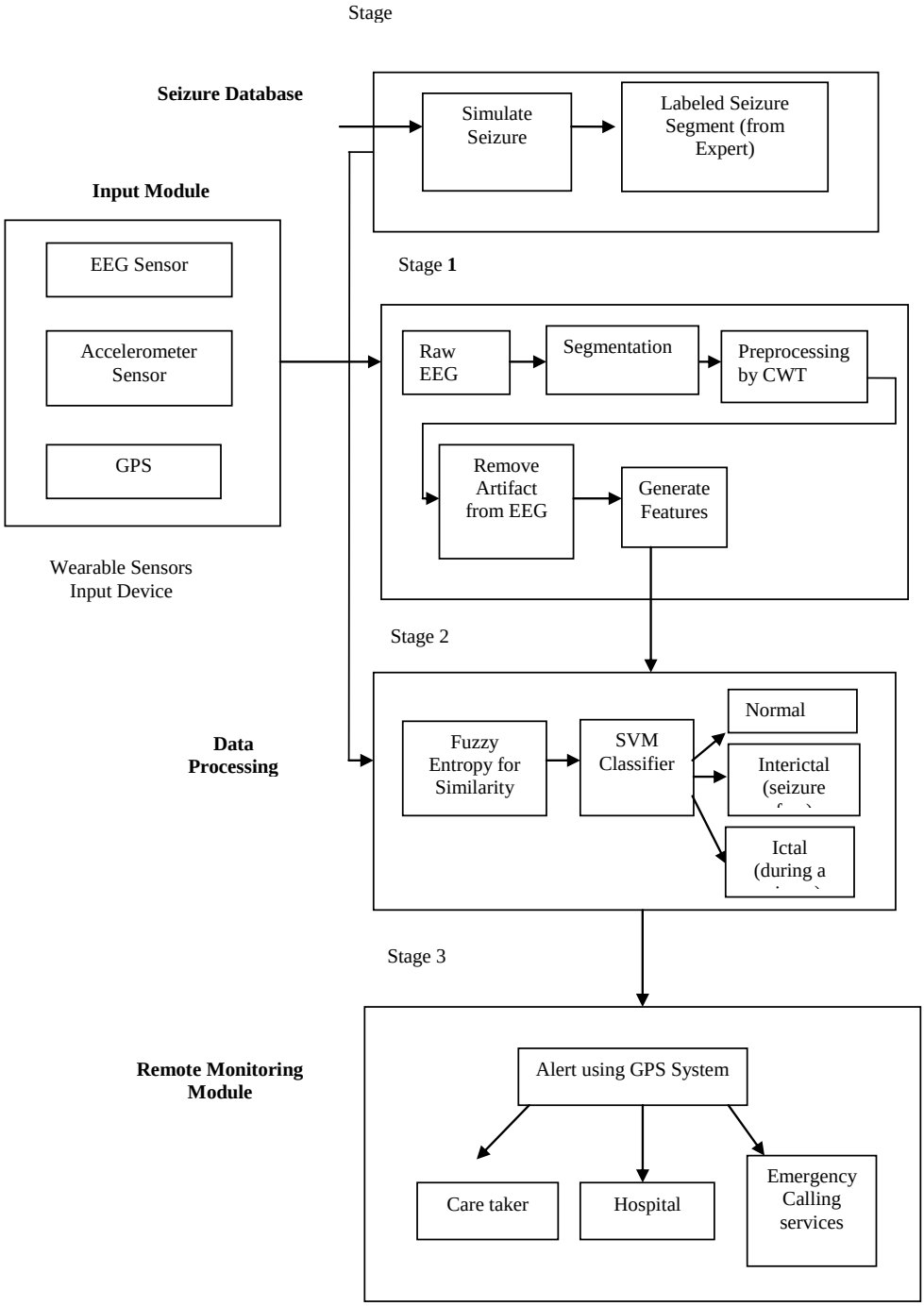

Figure 1: Proposed Work Flow Diagram

Fuzzy entropy measures ambiguous uncertainties from the highly irregular signals whereas deals with the measure of probabilistic uncertainties. The advantage of this entropy is that, it is insensitive to noise; and is highly sensitive to changes in the information content. Support vector machine (SVM) depends on the rule of basic hazard minimization. SVM takes in an ideal isolating hyper plane from a given arrangement of positive and negative illustrations. SVM can be utilized for design arrangement. For straightly distinct information SVM finds an isolating hyper plane which isolates the information with the biggest edge. For straightly indivisible information, it maps the information in the information space into a high measurement space.

$$x \in R^{1} \rightarrow \Phi(x)\, R^{H} \qquad \text{……..(2)}$$

with portion work Φ(x), to discover the isolating hyper plane. SVMs are assessed as prominent devices for gaining from the given information. A case for SVM piece work Φ(x) maps 2-Dimensional information space to higher 3-Dimensional component space. SVM was initially created for two class characterization issues. Each SVM isolates a solitary class from all the rest of the classes. SVM by and large applies to straight limits. SVM can delineate information vector into a high dimensional element space. By picking a non-direct mapping, the SVM develops an ideal isolating hyper plane in this higher dimensional space. In case an upcoming seizure is forecasted, alarms will be raised to notify the concerned users; otherwise, the system keeps monitoring the health condition of the respective subject.

4. Performance Analysis

In experimental analysis, we used EEG time series database. The experimental results are done by using MATLAB. The EEG data set of each patient is divided to records of one hour. Records that consist of seizure and non seizure classes respectively. In this paper, the CWT is used for EEG signal decomposition. The results are evaluated in terms of classification accuracy, sensitivity and specificity.

$$sensitivity = \frac{TP}{TP + FN}$$

$$specificity = \frac{TN}{TN + FP}$$

Where TP – True positive

TN – True Negative

FN – False Negative

FP - False Positive

In order to classify ictal and seizure free ECG signals, the generated features are feed in to SVM classifier. The comparison of classification performance

from different methods for the same data set is listed below.

Table I- Comparison

Methods	Accuracy
Time frequency Analysis	97.73
HMS Analysis	98.80
Dual-tree Complex Wavelet Transform	99.15
Wavelet Transform and K Nearest Neighbor	97
Proposed work	99.19

The classification algorithm classified normal, interictal and ictal EEG data sets with an accuracy of 100%, 98% and 98%. The total accuracy is 99%. The proposed algorithm proved that accuracy is high and has used for real clinical setting.

Table II- Parameters

EEG Data sets	Statistical Parameters		
	Sensitivity(%)	Specificity(%)	Accuracy(%)
Normal EEG	100	100	100
Interictal EEG	97	98.9	98
Ictal EEG	97	98.9	98

5. Conclusion

This paper proposes an efficient classification framework based on CWT for feature extraction, Fuzzy entropy measures and SVM for the automatic detection of epileptic seizures. Experimental results of the proposed method outperform the existing results with an average accuracy of 99.19. The SVM classifier has superior classification result compared to other classifiers. This effective framework needs to be tested by clinical trials with EEG signal in future.

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