EEG signal based seizure classification using key point based LBP: A review

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Abstract : Epilepsy is a brain disorder, which can affect any person at any age. It is characterized by recurrent convulsions over a time period. Epilepsy and seizure disorders are not the same; in other words all the seizures are not epileptic fits. Epilepsy is characterized by unprovoked seizures due the involvement of the central nervous system. It is due to the process of 'epileptogenesis' where normal neuronal network abruptly turns into a hyper-excitable network, affecting mostly the cerebral cortex. It is therefore highly unpredictable and its risk is higher. Other than this non-epileptic seizure disorders could be due to several measurable causes, such as stroke, dementia, head injury, brain infections, congenital birth defects, birth-related brain injuries, tumors and other space occupying lesions. For all these types of defects preventive measures can be adopted according to the various causes. Diagnosis of epilepsy based on the visual inspection of EEG signals can be slow and inefficient and may take a long time, especially for long-duration EEG signals. The advanced signal processing technique based methods may be more suitable for fast, reliable and automatic diagnosis of epilepsy from EEG signals. There has been a lot of work done using various signal processing techniques in order to determine features for analysis, classification, and detection of epileptic seizures from EEG signals. In this paper will give a review about the epileptic and non epileptic seizure classification using key point based Local Binary Pattern (LBP) of EEG signals to get more accurate results than the previous results.

***Keywords* – Epilepsy, EEG, Local Binary Pattern, Scale Invariant Feature Transform.**

I. INTRODUCTION

The electroencephalogram (EEG) signals are generally used for diagnosis of epilepsy which affects nearly 50 million people around the world. Diagnosis of epilepsy based on the visual inspection of EEG signals can be very slow and inefficient and may take a long time, especially for long-duration EEG signals. The advanced signal processing technique based methods may be more suitable for fast, reliable and automatic diagnosis of epilepsy from EEG signals. The disorder is associated with abnormal neuronal activity which may lead to seizures. Electroencephalography (EEG) is a common tool employed for two clinical functions: 1) epileptic seizure detection and 2) epilepsy diagnosis through identification of EEG markers or abnormalities. At present, these two functions are performed manually based on a visual examination of EEGs by highly trained neurologists. In the environment of epilepsy monitoring units, seizure detection is also performed by automated computer models. However, such models are less reliable resulting in frequent false alarms and missed detections and therefore require close human supervision. This method exploits the time-domain features like spikes and amplitude of the signal for epileptic seizure detection using EEG. Another category of approaches for automated diagnosis of epilepsy using EEG signals is based on time-frequency domain and non-stationary signal decomposition techniques. In this project, we are introducing a new method for automated diagnosis of epilepsy using EEG signals. The key feature of our approach is that it involves computation of LBP only at a set of stable key-points, which are detected through a multi scale analysis of the EEG signal. Our method involves detection of key-points at multiple scales in EEG signals using a pyramid of difference of Gaussian (DoG) filtered signals. Local binary patterns (LBP) are computed at these key-points and the histogram of these patterns are considered as the feature set, which is fed to the support vector machine (SVM) for classification of EEG signals.

II. LITERATURE REVIEW

1. Ashwani Kumar Tiwari, Ram Bilas Pachori, Vivek Kanhangad, and B. K. Panigrahi in " Automated diagnosis of Epilepsy using key point based local binary pattern of EEG signals", IEEE transactions on biomedical and Health informatics (2016). In this paper, they proposed a methodology for EEG based automated diagnosis of epilepsy. This method involved detection of key-points at multiple scales in EEG signals using a pyramid of difference of Gaussian (DoG) filtered signals. Local binary patterns (LBP) are computed at these key-points and the histogram of these patterns was considered as the feature set, which is fed to the support vector machine (SVM) for classification of EEG signals[1].
2. Rajeev Sharma, Ram Bilas Pachori, "Classification of epileptic seizures in EEG signals based on phase space representation of intrinsic mode functions", Expert system with application, Elsevier,(2015). In this they have proposed the method based on the phase space representation (PSR) for classification of epileptic seizure and seizure-free EEG signals. The EEG signals are firstly decomposed using empirical mode decomposition (EMD) and phase space has been reconstructed for obtained intrinsic mode functions (IMFs). For the purpose of classification of epileptic seizure and seizure-free EEG signals, two-dimensional (2D) and three-dimensional (3D) PSRs have been used[2].
3. M. Peker, B. Sen, D. Delen, "A Novel Method for Automated Diagnosis of Epilepsy using Complex-Valued Classifiers", IEEE Journal of Biomedical and Health Informatics, (2013). In this paper they proposed a new method for the diagnosis of epilepsy from EEG signals based on complex classifiers. In this study, first the features of EEG data are extracted using a dual-tree complex wavelet transformation (DTCWT) at different levels of granularity to obtain size reduction. In subsequent phases, five features (based on statistical measurements-maximum value, minimum value, arithmetic mean, standard deviation, median value) are obtained by using the feature vectors, and are presented as the input dimension to the complex-valued neural networks (CVANN). The evaluation is conducted using

the k-fold cross-validation methodology, reporting on classification accuracy, sensitivity and specificity. The proposed method is tested using a benchmark EEG dataset and high accuracy rates were obtained. The stated results show that the proposed method can be used to design an accurate classification system for epilepsy diagnosis [3].

4. K. Samiee, P. Kovacs, and M. Gabbouj, "Epileptic Seizure Classification of EEG time-series using rational discrete short time Fourier transform", IEEE Transactions on Biomedical Engineering, (2015). This approach is based on an adaptive and localized time-frequency representation of EEG signals by means of rational functions. The corresponding rational Discrete Short Time Fourier Transform (DSTFT) is a novel feature extraction technique for epileptic EEG data. A Multilayer Perceptron (MLP) classifier is fed by the coefficients of the rational DSTFT in order to separate seizure epochs from seizure-free epochs. The effectiveness of the proposed method is compared with several state-of-art feature extraction algorithms used in off-line epileptic seizure detection. The results of the comparative evaluations show that the proposed method outperforms competing techniques in terms of classification accuracy. It also provides a compact representation of EEG time-series [4].
5. Semih Altunay, Ziya Telatar, Osman Erogul, "Epileptic EEG detection using the linear prediction error energy", Expert system with Application, Elsevier, (2010). In this a method is proposed to detect epileptic seizures over EEG signal. For this purpose, a linear prediction filter is used to observe the presence of spikes and sharp waves on seizure EEG recordings. Linear prediction analysis calculates a coefficient set for each window, which can best model the applied time series signal. Modeling success is observed on the prediction error signal. The presence of spikes and other seizure-specific sharp waves on the signal reduces the modeling success and increases the prediction error of the filter. It is clearly observed that, the energy of prediction error signal during seizures is much higher than that of the seizure free intervals, which indicates the energy value and can be used to locate the seizure interval. The method is applied to 250 distinct EEG records, each of which has 23.6s duration. The results of the proposed algorithm are evaluated with the ROC analysis which indicates 93.6% success in detecting the presence of seizures [7].
6. S. Ghosh-Dastidar, H. Adeli and N. Dadmehr "Principal component analysis-enhanced cosine radial basis function neural network for robust epilepsy and seizure detection", IEEE Trans. Biomed. Eng. (2008). The fractional linear prediction model based error energy and energy computations of EEG signals together with support vector machine (SVM) has been suggested for automated classification of epileptic seizure EEG signals. Artificial neural network (ANN) classifier utilizes these features for classification of normal and epileptic seizure EEG signals. The ANN classifier is also used with principal component analysis (PCA) based approach for classification of epileptic seizure EEG signals for diagnosis of epilepsy [9].
7. Y. Kaya, M. Uyar, R. Tekin and S. Yldrm "1D-local binary pattern based feature extraction for classification of epileptic EEG signals", Appl. Math. and Computation, Elsevier, (2014). In this an approach for the feature extraction of raw Electroencephalogram (EEG) signals by means of one-dimensional local binary pattern (1D-LBP) was presented. The proposed method was consisted of two stages: feature extraction by 1D-LBP and classification by classifier algorithms with features extracted. On the classification stage, the several machine learning methods were employed to uniform and non-uniform 1D-LBP features. The proposed method was also compared with other existing techniques in the literature to find out benchmark for an epileptic data set. The implementation results showed that the proposed technique could acquire high accuracy in classification of epileptic EEG signals[11].
8. L. Guo, D. Rivero and A. Pizos, "Epileptic seizure detection using multiwavelet transform based approximate entropy and artificial neural networks", J. Neurosci. Methods, Elsevier, (2010). This paper presents a novel method for automatic epileptic seizure detection, which uses approximate entropy features derived from multiwavelet transform and combines with an artificial neural network to classify the EEG signals regarding the existence or absence of seizure. The high accuracy obtained for two different classification problems verified the success of the method. Artificial neural networks have been used as the most common classifier for classifying EEGs. In this paper, a novel epileptic seizure detection method is proposed. The method consists of three steps. Initially, multiwavelet transform is used to decompose the EEG signal to several subsignals. Then, the approximate entropy feature is extracted from each sub-signal. Finally, the extracted features are used as input to an artificial neural network, which discriminates the EEGs according to the specified classification problems. This study explores the capability of applying approximate entropy derived from multiwavelet transform to classify EEG signals. The original EEG signal is firstly decomposed into several sub-signals through 4-level multiwavelet transformation with repeated-row preprocessing as discussed in[17].

III. PROPOSED METHODOLOGY

The methodology proposed in this paper is based on local binary pattern of EEG signal. The key feature of our approach is that it involves computation of LBP only at a set of stable key-points, which are detected through a multi scale analysis of the EEG signal. The conventional LBP based methods for EEG signal classification compute LBP at every sample value of the EEG signal. The Fig. 1 below shows the methodology for the classification of signal.

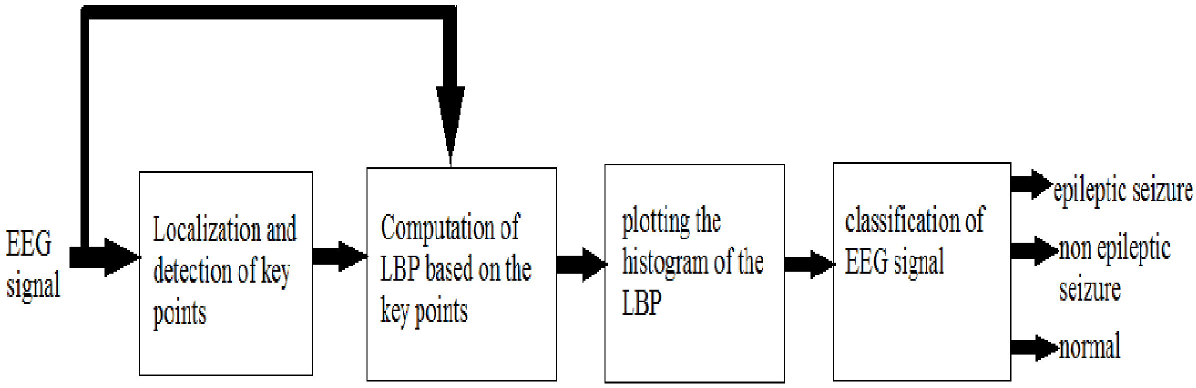

Figure 1: Block diagram of proposed methodology for classification of EEG signal.

1. **Detection of key points**
   For detecting the key points in an EEG signal SIFT (Scale Invariant Feature Transform) algorithm is used. SIFT is a method for extracting distinctive invariant features from images that can be used to perform reliable matching between different views of an object or scene. The features are invariant to image scale and rotation, and are shown to provide robust matching across a substantial range of affine distortion as discussed in[22]. The key-point detection technique employed in the above titled work involves convolving the EEG signal with a set of Gaussian filters to smooth the signal progressively, which is achieved by incrementing the scale (standard deviation) of the Gaussian function. This process generates a set of Gaussian smoothed signals. A pyramid of difference of Gaussian (DoG) filtered signals are then generated by computing the differences of adjacent signals in the set of Gaussian smoothed signals. Maxima and minima (extrema) in each level of this pyramid forms the set of key-points. These key-points are identified by comparing a sample value in the DoG filtered signal with its two immediate neighbors and 3 neighbors each in the two adjacent (upper and lower) levels in the pyramid. The detection of key-points is performed in each of the levels, except for two signals at the top and bottom of the DoG pyramid[1].

2. **Computing Local Binary Pattern (LBP) based on detected key points**
   After detecting key-points in the EEG signal, the next is to obtain a feature representation that carries sufficiently high discriminating ability for reliable classification of EEG signals. For this purpose LBPs are computed at the detected key-points in the DoG filtered signals as well as at the corresponding points in the original EEG signal. The decimal equivalent of this code is the LBP.

3. **Plotting the Histogram of LBP for feature extraction**
   Histogram of LBP is used as the feature set for classification of EEG signals. that each of the detected key-points has an associated level (or scale) in the DoG pyramid. Therefore, EEG signals are computed separately for key-points detected in the top and bottom level of the DoG pyramid(due to the lack of signals at the upper or lower levels for these signal using LBPs computed at the points corresponding to the key-points. Finally, the two sets of LBP histograms are of levels in the pyramid) to 4. Therefore, we have to compute LBP histograms at two levels.

4. **Classification of EEG signal**
   The last step is the classification of the EEG signals that is whether the signals are epileptic seizures, non epileptic seizures or normal seizure. In this we are using SVM Classifier for the classification of EEG signal. Support Vector Machine (SVM) is a supervised machine learning algorithm which can be used for both classification and regression purposes. It is mostly used for classification challenges. There are some kernel functions with which the classification can be done they are linear, nonlinear, polynomial, radial basis function (RBF), and sigmoid.

IV. CONCLUSION

In this paper we have discussed the different methods used by the authors for the classification of Epileptic EEG signals. In our case we are using SIFT algorithm as it is provides higher accuracy for feature extraction. It can compare hundred of samples at a time and gives higher accuracy. A single feature can be correctly matched with high probability against a large database of features from many images. SIFT is a fast and efficient method for feature extraction and comparison.

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