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Feature Extraction from Scalp EEG for Brain Tumor Detection using Wavelet-ICA Method

Shraddha Y. Tule[1], G. R. Padalkar[2]

PG scholar, MKSSS's Cummins College of Engineering, Pune[1]

Assistant Professor, MKSSS's Cummins College of Engineering, Pune[2]

Abstract: EEG i.e. Electroencephalogram is the recording of brain activity can be used to diagnose several diseases such as seizure disorders, strokes, brain tumors and other physiological disorders.EEG is affected severely by power line noise, breathing, muscle movements, body movements, loose contact of electrodes and eye movements. Various algorithms are proposed by many researchers for removing these artifacts from EEG, extracting features and classify it with different classification techniques for efficient analysis of the brain related diseases. This paper presents ICA method for removing artifacts and wavelet transform for eliminating high frequency noises. This paper also presents feature extraction of EEG using different statistical parameters.

Keywords: Electroencephalogram, Independent component Analysis, Artificial Neural Network

I. INTRODUCTION

EEG records electrical signals within brain that are caused by local electrical activities and can be measured by electrodes placed on scalp. Brain tumor or other disorders leads to abnormal activities in the recorded EEG signals. The early treatment given to tumor patients is either not given or delayed due to lack of early diagnosis and methods to detect the Brain tumor symptoms in the EEG signal [1].

There are several neuro-imaging techniques such as MRI or CT but they are not preferred because they are costly, invasive and involve risk of hazardous radiations. Hence, there is need of the easy, less costly and less risky technique for tumor detection from EEG.

EEG provides low spatial resolution but good temporal resolution wit millisecond range which leads EEG to be a valuable tool in research and diagnosis. The recorded EEG signals are often contaminated with several types of noises. These artifacts are needed to be removed from EEG for efficient detection of tumor.

This requires certain preprocessing methods to be used to remove artifacts. Many researchers applied different methodologies to remove noise such as kalman filter, Moving average method, Cubic spline method, PCA, ICA, wavelet transform, wavelet packet transform etc.

In this paper Independent Component Analysis ((ICA) is used to separate out de-noised EEG signal from noisy EEG along with wavelet transform for further reduction of the high frequency noise. Features of the resulting EEG signal calculated are two first order statistical features, namely the Mean Square Amplitude (MSA) and Mean Slope Rate (MSR), one second order statistical feature, namely the Mean-to-Maximum Ratio of Power Spectrum (mmrPS) and one third order statistical feature, namely the Peak Bispectrum (pBS).

II. MATERIALS AND METHODS

A .Materials

Input signal to the proposed system are from thirty two EEG Channels of the EEG acquisition system with electrodes placed on scalp according to the standard 10-20 electrodes system in digital format .The EEG recorded from 10 healthy patients and 10 brain tumor patients in awake state with their eyes closed at sampling rate of 750 Hz [1][2]. All EEG records are bandpass-filtered to 1-70 Hz frequency band and 50-Hz notch-filtered using the CLARITY Brain-Tech software for EEG analysis. But some artifacts such as eye movements, power line noise, body movements and muscle artifacts are still present [1][2][3].

B .Methods

The block diagram representation of the proposed system is as follows,

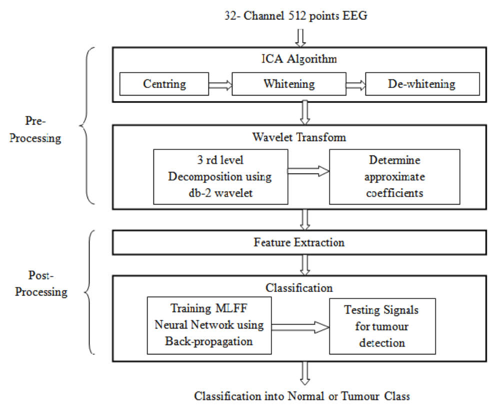

Figure 1.Block diagram

According to block diagram, firstly the independent components of the 32 channel EEG are calculated then wavelet transformed to get de-noised EEG signal, further statistical first and higher order features are calculated to track morphological and spectral variations in signal, these

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features are applied to an Artificial Neural Network to classify the given EEG into either normal or in tumor class.

a) EEG Pre-processing

For de-noising and to find the statistically independent components of the EEG Independent component analysis (ICA) method is applied. Thirty two independent components from single EEG signal are obtained and wavelet transformed to remove high frequency noises [2] [3]. ICA removes artifacts from EEG for better diagnosis of tumor from it. It separates the mixed signals into statistically independent components. It assumes that all signals in mixed signal are statistically independent and have non-Gaussian distribution. After applying ICA, the resulting independent components which have same properties as source signal such as independence and non-Gaussian distribution and having the low complexity can be selected as source signal and used for the further process of tumor detection [3][4][5]. ICA is used for blind source separation problems. In Blind source separation problem, signals from different sources are mixed and then de-mixed by multiplying them with the de-mixing matrix calculated by ICA algorithm to yield the different statistically independent components that are same as the signals from different sources [2][4][6].

ICA methodology is as follows:

$$X=AS \qquad (1)$$

Equation (1) represents the ICA equation [2].

Here, X is the mixed signal, A is the mixing matrix and S represents the independent components i.e. each row of S contains one independent component. In this problem A and S are unknown and are needed to find them using ICA [2][3].

ICA algorithm is as follows [2][3][7]:

1. Centering (Remove mean of EEG signal).
2. Whitening (multiply the source signal with random mixing matrix).
3. Find an orthogonal de-mixing matrix w i.e. estimation of A with singular value decomposition.
4. Find Y i.e. estimation of S by multiplying X with W.

Therefore, the estimation of source signal S can be calculated using the above ICA algorithm.

The independent components received after ICA is wavelet transformed up to third level decomposition using Daubechies (db2) wavelet to remove high frequency noise [2].

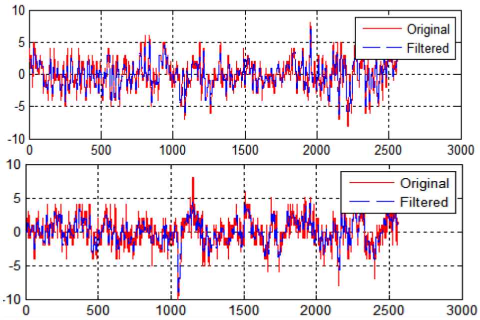


Fig 2 Result of wavelet-ICA analysis

Above figure 2 shows the wavelet-ICA output along with the original signal for two channels of EEG .It shows that the noises in the original EEG (Peaks of waveform) are removed by combined ICA and Wavelet method

b) EEG Post-processing (Feature Extraction)

EEG post processing includes feature extraction of de-noised EEG and classifying it into normal or tumor case using Artificial Neural Network.

Several statistical features of EEG are calculated are listed as follows [1]:

First order Features:

- The Mean Square Amplitude (MSA_i) of an ith component, x_i (n) of a 32-component IC set was calculated as follows [1]

$$MSA_i = \sum_n [x_{i2}(n)]/length(x_i(n)) \qquad (2)$$

- The Mean Slope Rate (MSR_i) for an ith component, x_i (n) of a 32-component IC set was calculated as follows [1]

$$MSR_i = mean\{\sum_k [x_i[k]x_i[k+1]] / [t_k - t_{k+1}]\} \qquad (3)$$

Higher order Features:

- The Power Spectral Density (PSD) is the Fourier transform of the autocorrelation sequence of the signal. Maximum-to-Mean\Ratio of Power Spectrum ($mmrPS_i$) of an ith component, x_i(n) of a 32-component IC set was computed as follows[1].

$$MMR = mmrPS_i = max\{P_i(f)\}/mean\{P_i(f)\} \qquad (4)$$

- The bispectrum is defined as-

$$B(f_1, f_2) = FFT\ [R_{xx}(m_1, m_2)]$$

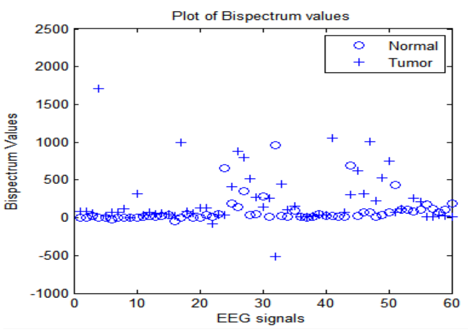
where, Rxx(.) is the third-order cumulant of x(n) and

$$R_{xx}(m_1, m_2) = E\{x(n)x(n+m_1)x(n+m_2)\}$$

The bispectrum can be calculated as follows

$$B(f_1, f_2) = X(f_1)X(f_2) \qquad (5)$$

The Peak Bispectrum (pBS) of an it h component, xi(n) of a 32-component IC set was computed as the maximum value of the Bispectrum[1] . These features of all patients EEG data are calculated and are given as input to the neural network for classification.



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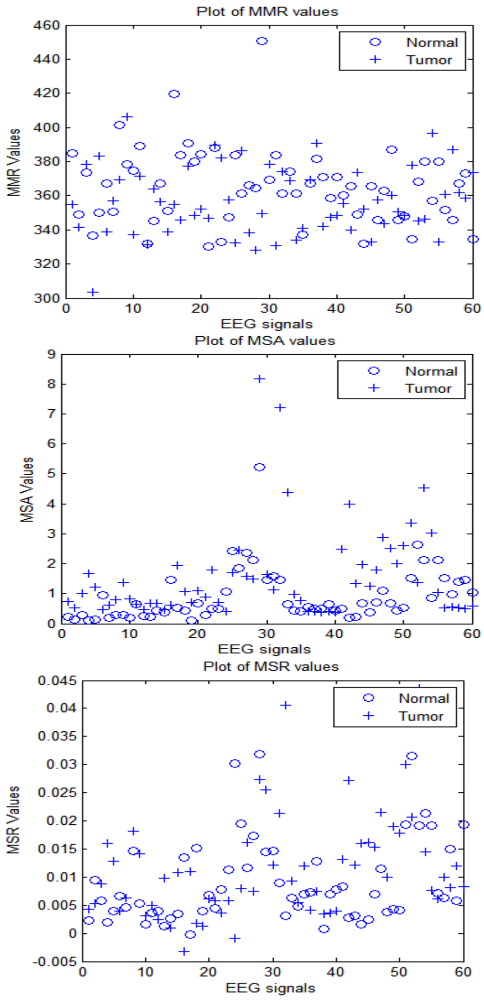

Figure 2. Feature values for Normal and Tumor EEG

Above figures shows the plots feature values calculated for 32-channel normal and abnormal (tumor) EEG.

III. FUTURE WORK

Artificial Neural network is the network of bio-logical neurons that are functionally connected to central nervous system. The statistical features obtained from above proposed methodology can be given as input to backpropogation neural network for classifying classify the input EEG into Normal o Tumor class. For training of ANN, the features from all healthy and tumor patients are used for updating weighs in ANN structure that minimizes the mean square error between actual output and desired output.

IV. CONCLUSION

For De-noising of EEG the algorithm used in this paper is Independent Component Analysis method. This method gives accurate results compared to other algorithms.ICA analyses multichannel EEG records by separating data recorded at scalp into independent components.ICA is a generally applicable, computationally efficient and effective method for removing variety of artifacts from EEG recordings.

Analysis of EEG for tumor detection requires its statistical features that can be compared with the standard reference signal belongs to particular class either normal or Abnormal .In this paper several statistical features are calculated for normal EEG and Abnormal (Tumor contained) EEG and also according to figure 2, it shows differences in features for both the classes which can be given as input to neural network or other classifier for classification.

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