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Features Extraction of Eeg Signal Using ICA

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Abstract— We have seen lot of work was already done on DWT as features extractor. So here in this paper we proposed ICA (Independent Component Analysis) as feature extraction technique for EEG i.e. *Electroencephalogram* Signals. The most important thing in this that the features are extracted from the Real Time EEG signals. The Signals are recorded through the RMS Machine in real time from different patients. Then those signals are used for the further process of extraction of features. We found that it's tough to handle the real time EEG data and also ICA is another good features extractor.

***Keywords**- ICA (Independent component analysis), RMS Machine and Software, EEG Signals, Real Time Data*

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I. INTRODUCTION

There are lots of feature extraction methods available like parametric and non-parametric feature extractions methods [1]. These two methods further classified into several methods but DWT is the very famous and repetitively used method, so we want to tend our work into different direction that's why we choose parametric feature extraction method, specifically ICA (Independent Component Analysis) for EEG Signals.

Further going into details of the ICA or anything else we would like to introduce that we have taken the Real Time Data i.e. EEG signals of patients using RSM Machine and the RMS software. First of all we need to acquire the EEG signals using 32 electrodes which placed on the head of the patient. All these electrodes record the brain activities which are present or appear in the form of electric pulses. All these electric pulses are recorded using the RMS machine and plotted physically in the RMS Software. The recording of the EEG signals are done nearly for 30 to 35 minutes. The reason behind this much of time duration is find the consistency of the brain signals, because all these signals are the mixture of artifacts, abnormalities, normal movements, etc.

II. SIGNAL ACQUISITION & PRE-PROCESSING

For proper and correct EEG Signal acquisition, the most important thing is the placement of electrodes on the head. The placement of the electrodes is shown in fig.1. The positioning of the electrodes is in 10/20 % system between Nasion-Inion points. The marking is done as for Frontal pole (Fp), Central (C), Parietal (P), occipital (O), and Temporal (T).

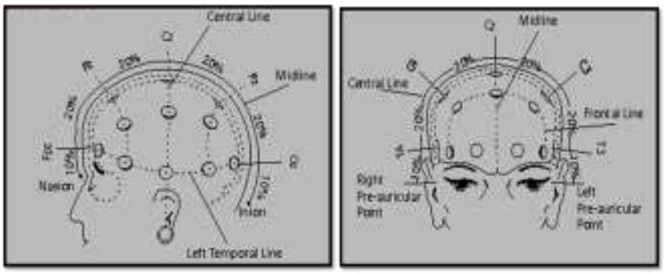


Fig.1

These electrodes start acquiring the brain signals with the help of RMS machine on to the software on the computer. In this the electrodes acquire the electrical impulses generated by the brain which will be monitored by the intermediate RMS machine and then it will be transferred to the RMS software.

This software shows the 16 signals instead of 32 as there are 32 electrodes present. The reason behind this is that, the EEG signals are weak so that system a step forward and allow us to see the differences between the two electrodes or we can say that the software will shows the signals between the region or the region covered by the two electrodes, this will increases the strength of the signal and make it easy to recognize. Following fig. 2 shows how the EEG signals appeared on the RMS software on the computer screen.

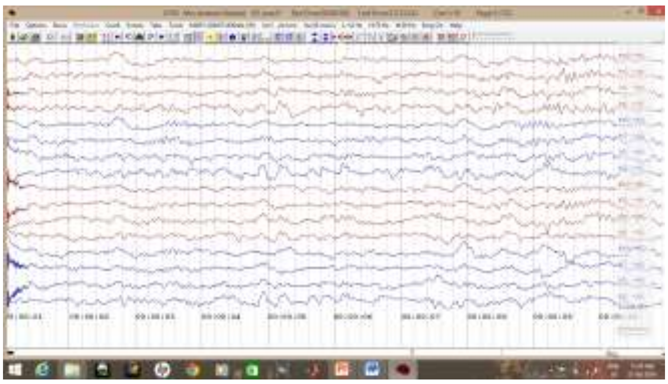


Fig. 2

Here the first and the most important part is finish i.e. signal acquisition. Thus in this way we got a database of Real Time EEG Signals of various patients.

Now the pre-processing, for any of the further procedure we need the voltage values of the signals which is recorded by the software which is shown us in the visual format. There is a provision given by the RMS software itself that it can export the voltage level values of EEG signals to excel sheets. Total 16 channels are exported page wise in single excel file. Now these excel files are used for our main feature extraction purpose.

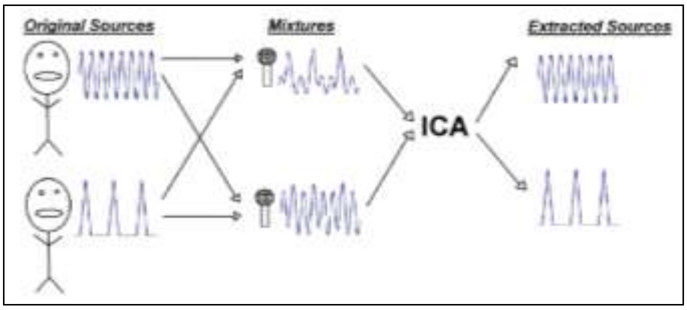
III. Feature Extraction

Feature extraction is a process is separating the features or we can say that separating the points which are differ from the general things, which makes that particular thing unique from the others or its kind. Here we have chosen ICA for feature extraction method. It's a bit tough task to extract features from the EEG signal as none of the signals are similar to each other. Every signal is unique in itself, hence we don't have any of the signals which we can take as a reference and say that the particular signal has the particular features. Hence, we opted for ICA i.e. Independent Component Analysis.

A. ICA – Independet Component Analysis

ICA defined as it is the method of decomposition of the independent statistical component. Oja & Hyvarinen [3] considers ICA as latent variable model.

ICA has the concept of Blind Signal Separation Technique. To explain this term, here we have an example of cocktail drink. Let's consider that we have a cocktail of two drinks, we want to separate them from each other but we did have the information of the drinks. In such a case we need a standard or any random mask or filter. After first filtration, we've got a bit information about the drinks, the as per the result we need to do some updates or changes in the filter, again after filtration we got some more features again we need to update or do the changes in filter and again do filtration till we get the two drinks separated completely. At the end of all this, we've got the perfect filter or mask which definitely separate those two drinks in future. All the points or components of this mask are known as the Features.



B. Bell-Sejnowski ICA Algorithm

The basic Bell-Sejnowski ICA algorithm [2] is written for the two known but considered as unknown sound signals. They mixed both the signals and with the help of random signal they separated both the signals, as they've noticed that at the end of the procedure they've got the mask for those filters to separate out in the future.

Hence considering this piece of work, we have started writing the same algorithm for the 16 channel unknown variable EEG signal.

- ✓ Here we have taken the EEG signals consist of 16 channel data in it. All these 16 channels we consider as a 16 separate signals i.e. {s1,s2,s3,………s16}.

- ✓ Now we combined them all with each other and formed a single signal. Let's say "s".

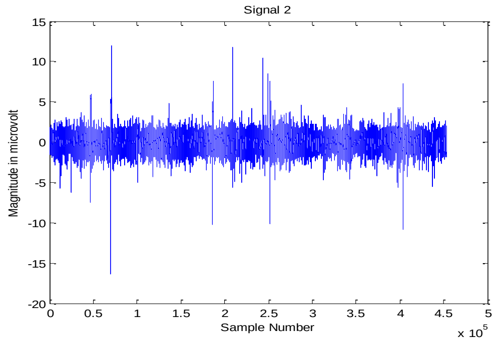


Fig. Combined EEG Signals

- ✓ Now we considered a random matrix A of 16x16. As the number for signals are 16 hence the matrix is of 16x16. If the signals are 2 then it would have been 2x2 matrixes.

- ✓ Then we have mixed the EEG signal with the random 16x16 matrix to form a cocktail.

$$X = s * A$$

- ✓ Now we have to separate this out and for that we need a mask, which will try to separate them, as the mask at the initial stages is known and the random matrix is also known we'll definitely get the remaining unknown entity.

$$Y = W * X$$

Where, Y is the original signal which we'll get back after all the separation procedure.

W is the mask used to separate. This is mask is known as the ICA Gradient Accent. This is the mask consist of Entropy and Entropy Gradient.

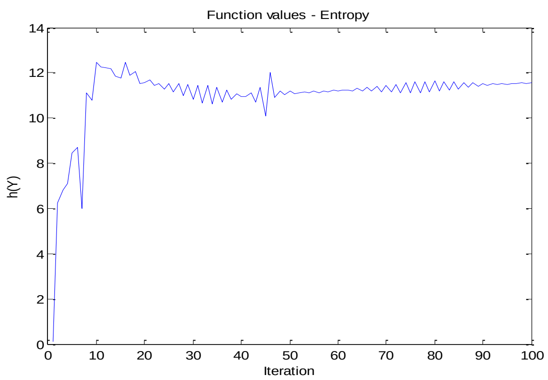


Fig. Entropy of the processed signal

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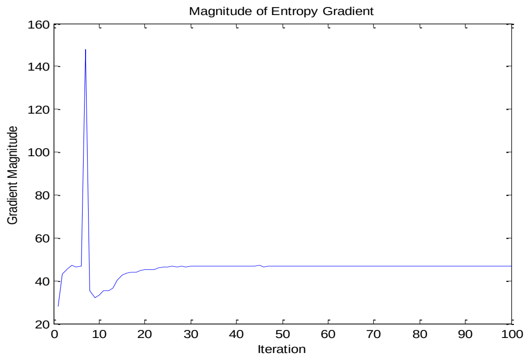

Fig. Entropy Gradient of processed signal

The resultant formula of our ICA Gradient accent is shown below-

$$\mathbf{W}_{new} = \mathbf{W}_{old} + \eta \left(\mathbf{W}^{-T} - \frac{2}{N} \sum_{t=1}^{N} \tanh(\mathbf{y}^{t}) \, [\mathbf{x}^{t}]^{T} \right)$$

When above formula is used as a mask it will try to separate out the mixture, due to which Entropy and Entropy Gradient gets affected which results in W i.e. value of the mask gets updated and this procedure is continues till the total signal is processed. This Wnew finally consist of all the features of the signal.

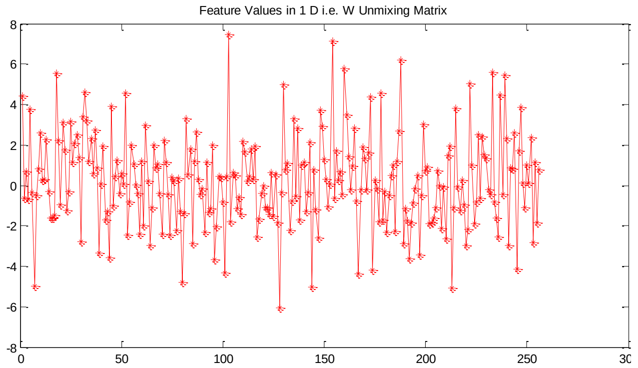

Fig. Extracted Features of the EEG Signal

All the prominent points visible in the above figure are the features of the considered EEG signal.

- ✓ For getting the estimated signal values at every eteration we need to reverse the procedure but with the new values or new extracted signal.

s_estimates = Y * inverse(A*W)

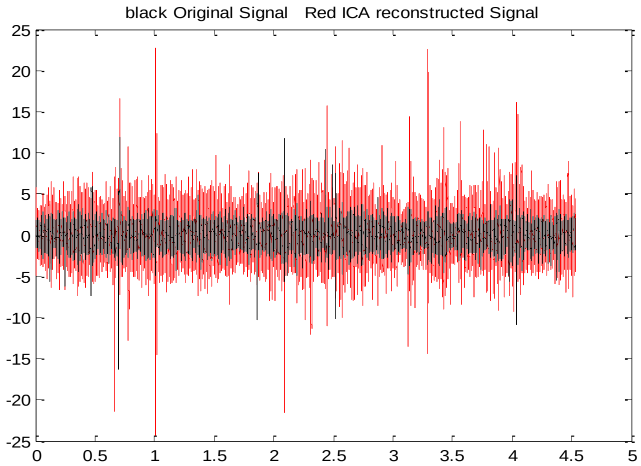

Fig. ICA Reconstructed Signal

In the Above figure it's clearly seen that the black is the Original signal and red one is the reconstructed signal i.e estimated signals.

IV. CONCLUSION

Thus in this way, we have constructed an algorithm for 16 channel EEG signal from the trivial algorithm. It's Also observed that the efficiency of extraction of features depends upon the sampling rate. As we have got the best results for feature extraction using ICA, we can use this in the further processes that are for the classification of the Eeg signals as per the deceases which can be detected by observing the EEG Signals.

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