



Analysis of EEG Signals using EEGLAB

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Abstract— *Advancements in biomedical signal processing techniques have led Electroencephalography(EEG) signals to be more widely used in the diagnosis of brain diseases and in the field of Brain Computer Interface(BCI). BCI is an interfacing system that uses electrical signals from the brain(eg: EEG) as an input to control other devices such as a computer, wheel chair, robotic arm etc.EEG has got diversified applications in field of biomedical engineering.To study human physiology with respect to EEG,bioelectric potential of brains is recorded with help of electrodes. These raw signals are firstly processed with help of mathematical tools in order to make them more and more informative. In this paper we will present a brief idea about EEGLAB software which is used for analysis of EEG signals.The basic functions which are used for preprocessing of EEG signals will also be discussed.*

Keywords— *Electroencephalography(EEG), ICA, ERP*

I. INTRODUCTION

Modern electroencephalography(EEG) devices provide us a convenient way to monitor human brain activities in real-time as recently, EEG devices become wireless and portable. The convenience of the EEG technology has boosted further development of EEG- based applications such as brain computer interface(BCI), neurofeedback systems and brain function training and performance training systems [1].

BCI systems create a communication channel between the brain and computer by acquiring, analysing and classifying neural activities under certain simulation and generate control signals for real world applications in areas including clinic, security, military, law enforcement, and telecommunications. An EEG signal represents an electrical activity of brain with its amplitude ranging from 0 to 200 micro-volt and the frequency varies, for Delta waves(up to 4 Hz), Theta waves(4 Hz $\hat{=}$ 8 Hz), Alpha waves(8 Hz $\hat{=}$ 12 Hz), Beta waves(13 Hz $\hat{=}$ 30 Hz) and gamma waves($\hat{>}$ 30 Hz)[2] These EEG signal frequency bands are associated with the neural activity and tend to change under different emotional environment.

Thus by capturing these variations and analysing them, it is possible to characterise the correlated emotional state [3].Electrical activity of brain is highly random in nature and may contain useful information about the brain state.They are basically non-linear and non-stationary in nature. However, it is very difficult to get useful information from these signals by observing them directly in the time domain. Hence, advanced signal processing techniques are necessary for investigation and analysis [4].In this paper preliminary signal processing of acquired EEG shall be done using EEGLAB in MATLAB workspace. Independent Component analysis(ICA), sometimes referred to as blind signal separation or blind source separation , is a mathematical tool that can be used for artifact removal to obtain clean EEG signals. ICA method could be used in situations, where large number of noises need to be distinguished. The main facility of ICA is possibility to separate the artifacts from EEG signals into isolated components [5]. This is an extension of Principal Component Analysis (PCA), which had been used in EEG research for years.

II. EEG LAB SOFTWARE

An EEG Lab is an interactive MatLab toolbox for processing continue and event related EEG, MEG and other electro physiological data incorporating independent component analysis (ICA), time/frequency analysis artefact Rejections ,event related statistics and several useful modes of visualisation off averaged and single trial data. EEG Lab provides an interactive graphic user interface allowing users to flexibly and interactively process their high density EEG. EEG Lab offers a wealth of matters for visualising and modelling event related brain dynamics both at the level of individual EEG lab 'Datasets' and across a collection of datasets brought together in an 'EEG lab' study set. The main features of EEG lab are as follows[6]

1. Graphics user interface
2. Multi format data importing
3. High density data scrolling
4. Defined EEG data structures
5. Open source plug in facility
6. Interactive plotting functions
7. Semi-automated artifact removal
8. Event and channel location handling
9. ICA and time/frequency analysis

For analysis of EEG signal, EEGLAB is interactive menu-based and scripting software for processing EEG signal data based under the Matlab interpreted programming script environment.. EEGLAB make use of common methods of electroencephalographic data analysis including independent component analysis (ICA) and time/frequency analysis. EEGLAB has become a most widely used platform for sharing and applying new techniques for biological signal processing and analysis of the EEG data.

III. EEG SIGNAL PRE-PROCESSING

One of the main problems in the automated EEG analysis is the detection of the different kinds of interference waveforms (artifacts) added to the EEG signal during the recording sessions. These interference waveforms, the artifacts, are any recorded electrical potentials not originated in brain. There are four main sources of artifacts emission:

1. EEG equipment.
2. Electrical interference external to the subject and recording system.
3. The leads and the electrodes.
4. The subject her/himself: normal electrical activity from the heart, eye blinking, eyes movement, and muscles in general.

Previous works have shown that the most severe of the artifacts are due to eye blinks and eyeball movements. A movement of the eyeball and the eyelids causes a change in the potential field because of the existing potential difference of about 100 mV between the cornea and the retina. Data preprocessing EEGLAB allows reading of data,event information, and channel location files in several different formats including binary,Matlab,ASCII, and Neuroscan. Standard data analysis functions available in EEGLAB include data filtering, data epoch extraction, baseline removal,data resampling and extraction of data epochs time locked to specified experimental events from continuous or epoch ed data. EEGLAB also includes methods allowing users to remove data channels,epochs, and /or components dominated by non-neural artifacts, by accepting or rejecting visually-cued.Continuous data and data epochs of any number of channels can also be scrolled(both vertically and horizontally).[7]

IV. INDEPENDENT COMPONENT ANALYSIS

All ICA algorithms have proven capable of isolating both artifactual and neurally generated EEG whose EEG contributions, across the training data, are maximally independent of one another. ICA is widely used in the EEG research community to detect and remove eye, muscle, and line Noise artifacts and also to separate biologically plausible brain sources whose activity patterns are distinctly linked to behavioral phenomena. EEGLAB contains an automated version of the infomax ICA algorithm with several enhancements. ICA finds a coordinate frame in which the data projections have minimal temporal overlap. The core mathematical concept of ICA is to minimize the mutual information among the data projections or maximize their joint entropy.

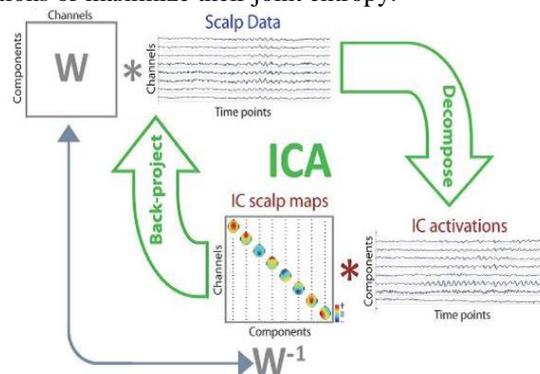


Figure1.1(Flowchart for ICA data decomposition and back projection)

In figure1.1(Flowchart for ICA data decomposition and back projection) ICA applied to a matrix of EEG scalp data finds an \hat{W} unmixing matrix of weights (W) that, when multiplied by the (channels by time points) Scalp data matrix, gives a matrix of independent component (IC) activities or activations (lower right). This is the process of ICA decomposition of the data into maximally temporally independent processes, each with its distinct time series and scalp map. The process of back projection recaptures the original scalp data by multiplying the IC activations matrix (lower right) by the matrix of independent component (IC) scalp maps (lowercenter) whose columns give the relative projection weights from each component to each scalp channel[8]. EEG activity at different electrodes is highly correlated and thus contains redundant information. Several artifacts might be represented at the same set of electrodes and ICA is used to isolate and measure these artifacts.

V. EXPERIMENTAL PARADIGM

In this paper, we use the 2a data set from the BCI competition IV(2008)[9]. The data set consists of EEG data recorded from 9 subjects. For a given subject two sessions were recorded on two different days. Each session consisted of 6 runs and each run consisted of 48 trials (12 trials for each motor imagery class). In each trial a cue was shown on the screen instructing the subject to perform one of the following motor imagery tasks: left hand, right hand, both feet, or tongue motor imagery.[10]

Thus a single session during the experiment consisted of 288 trials, 72 trials for each motor imagery task. Each trial started with a short sound (warning tone). At the same time a fixation cross was shown on the computer screen. After 2 seconds, in the place of the fixation cross, a cue was shown (in a form of a small arrow) telling the subject to start the corresponding motor imagery task. After another 1:25 seconds the arrow changed back to the fixation cross. The motor imagery task should have been continued until the sixth second of the trial when the fixation cross disappeared. After that there was a short break (1:5 seconds). The data was recorded using 22 EEG and 3 Electrooculogram(EOG, a technique for measuring the eye movements) channels. The signal was recorded at 250 Hz sampling frequency and was 0:1â€“ 100 Hz band-pass filtered and 50 Hz notch filtered. The EEG electrode placement during this experiment was a bit different than the 10-20 system . It consisted of the Fz, C3, Cz, C4 and Pz electrodes and additional 17 electrodes positioned at 10%% distances away from the mentioned five electrodes .

VI. RESULTS AND DISCUSSIONS

In this paper, we have preformed data visualisation and pre-processing,using functions of EEGLAB.

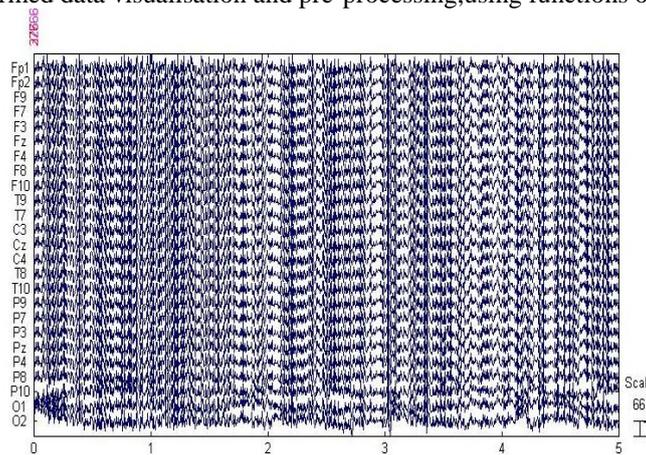


Figure 1.2(Data Scrolling)

Data Visualisation- In figure 1.2(Data Scrolling) the EEGLAB scrolling data review function allows the user to review and reject data by visual inspection. Data epochs are plotted at 25 electrode sites(channel names on the left). Other channels in the dataset can be accessed using the vertical slider on the left. The arrow buttons (lower left) scroll horizontally through the data.we can mark (or unmark) data epochs for rejection by clicking on them. Pressing â€“Update Marksâ€™ saves the accumulated rejection markings.

Pre-processing- For artifact removal, ICA method is used to remove artifact related component. In Figure 1.3(Independent Component Properties)the use of infomax ICA applied to the EEG epochs of the dataset 1. EEGLAB contains an automated version , runica() of the infomax ICA algorithm with several enhancements both as a Matlab function and as a stand alone binary C program that allows faster and less memory intensive computation.The Component Properties display for IC3 verifies that it accounts for eye artifacts since its activity spectrum is smoothly decreasing .We can eye movement components from the data without removing other activity of interest. The noise in the EEG signal can be eliminated by pre-processing and thus improving the performance of EEG analysis.

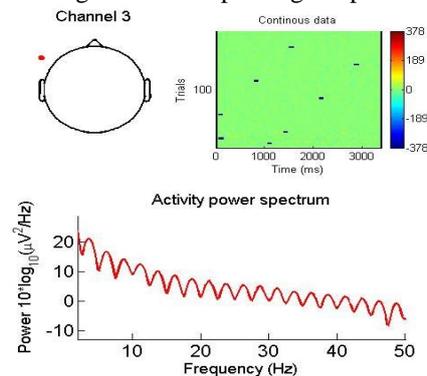


Figure 1.3(Independent Component Properties)

VII. CONCLUSION

From the above study of papers and analysis of facts we conclude that ECG signal analysis have diversified advantages, applications and future possibilities of research. The EEGLAB software is used for pre-processing of EEG signals.The use of ICA method for artifacts removing from EEG signals is very useful. The important information can be obtained considering only the relevant signals, obtained after applying the independent components analysis. It is evident that EEG signals analysis, real time signal processing and generation of EEG signal opens a diversified scope of research for biomedical signal processing and disease diagnosis.

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