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Event Related Potentials: Significant Lobe Areas and Wave Forms for Picture Visual Stimulus

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Abstract— Brain Computer Interfaces (BCIs) are direct interfaces for communication between the brain and computer. Even Related Potentials (ERPs) are a very important sub area of Brain Computer Interfaces which illustrate electrical potentials associated with auditory, sensory, motor or cognitive events. This is an emerging area that can be used to provide better solutions for disabled people, diagnose diseases, credibility assessments, virtual reality, robotic movements and so on. For this research, Electroencephalogram (EEG)-based Event Related Potentials on picture visual stimulus data set have been used for a single subject. Then pre-processing techniques were applied such as epoching, averaging, and artifact removing. Pre-processed signals were decomposed to obtain independent components using Independent Component Analysis (ICA) and noisy and artifactural components were removed. The processed dataset was used to identify most significant lobe areas, wave types and the influence of the P300 wave for picture visual stimulus by using EEGLAB. The result indicates that the most significant lobe areas responsible for picture visual stimulus are parietal lobe & occipital lobe. P5 is the best wave form to detect picture-based visual stimulus and P3 is mostly responded with Alpha frequency band and N4 is mostly responded with Beta frequency band.

Keywords— Removing Artifacts, Brain Computer interfaces, Heat maps, Wave Latency

I. INTRODUCTION

Event Related Potentials (ERPs) are very small electrical voltages generated in the brain in response to specific stimulus such as auditory, visual, thermo stimulus, etc. ERPs of human subjects can be categorized in to two groups as described by Sur & Sinha in [1]. Those are early waves and later waves. Early waves are peaking in first 100 ms after the stimulus. They are called sensory waves or exogenous ERPs and they largely depend on the physical parameters of the stimulus, which is caused to generate the particular voltage changes inside the human brain. On the other hand, later waves were generated while the subject evaluates the external stimulus. These waves are called as cognitive or endogenous ERPs as within this period the human brain does the information processing based on the given stimulus. These Event Related potentials used to capture raw Electroencephalogram (EEG) data which generated inside the brain for a particular stimulus and can use these data to

investigate, evaluate, or predict the humans cognitive processing as well as for the credibility detection, controlling long distance vehicles, virtual reality and many.

A. Brain Computer Interfaces

Brain computer Interface (BCI) is a relatively new technology which aims to build a direct interface between the human brain and the computer. There are many ERP based BCIs which can be applied for the different areas such as producing equipment for disabled people, credibility detection, virtual reality, disease diagnosis, robotic controlling and many more. Basically there are three types of BCIs: Invasive BCIs, Partially invasive BCIs and Non-invasive BCIs. Invasive BCIs place the electrodes directly into the brain and thus it provides the highest quality signals. Partially Invasive BCIs place the electrodes inside the skull but outside the brain and signal quality is weaker than the Invasive BCIs. The Non-invasive BCIs place the electrodes on the scalp. Thus it generates least signal clarity when comparing to the other two methods, but it is the safest method among all. Electroencephalogram (EEG) is one of the widely used non-invasive interfaces, due to portability, comfort of use and low cost setup.

B. EEG (Electroencephalogram)

Electroencephalogram is a non-invasive technology that can be used to capture the brain signals by placing electrodes on the scalp in a standard order. There are five major EEG brain waves based on their frequency ranges as described by Gonzalez in [2] and Suleiman & Fatehi in [3]. These different frequency band waves have the different characteristics and sometimes they have significant lobe area of the brain based on the stimulus. The wave types are Delta, Theta, Alpha, Beta, and Gamma waves. Frequency band of the Delta waves change between 0Hz-4Hz and it has a high voltage range between 70µV-100µV. Normally this rhythm can be found in indicative pathological states of neuronal difficulty (a coma situation). Frequency band of the Theta waves changes between 4Hz-8Hz and its voltage level is 50µV. These waves are related with emotional stress such as disappointment and frustration. Alpha waves frequency band varies between 8Hz-13Hz and it has low voltage range of 20µV-60µV considering the Delta and the Theta waves. These Alpha waves are generated in the relaxation state, and eye closing state as described by Polikar in [4] and it is mostly generated in the posterior region of the brain. Beta wave is in 14Hz-30Hz frequency range and it has a low voltage range of 10µV-15µV. It is normally generated in the frontal region of the brain that indicate alert, active or busy thinking states. Frequencies more than 30Hz were Gamma waves and normally those generate in the sensory cortex with very low voltages when brain is doing sensory processing or the memory matching tasks as stated by Polikar.

C. Architecture of the Brain

Mainly there are four lobes in the brain namely, Frontal lobe, Parietal lobe, Temporal lobe and Occipital lobe. The frontal lobe is located directly behind the forehead and it is involved in complex cognitive processes such as reasoning, judgment, movements, problem solving, planning and coordinating things. The Parietal lobe is capable of processing body information such as touch, muscle stretches etc. The Temporal lobe is associated with auditory processing and vision. It also involves in word semantics.

1) *Generic Model of Event Related Potentials:* Basically there are four steps in ERP based experiments. They are: Signal Acquisition, Signal Pre-Processing, Feature Extraction and Classification. Only the first two steps were used in this research as the aim was to identify waves, lobe areas and the influence of P300 for picture-based visual stimulus. For this research, an existing dataset based on visual stimulus for one subject was used. An EEG can use 10-20 international system of electrode placement as shown in Fig. 1 for capturing the EEG signals as described by Nunez & Manual [5].

There are three sub steps in signal pre-processing such as Epoching, Artifact removing and Averaging. Epochs are the segments which are based on the stimulus. Averaging means calculating the mean value for all epochs based on the stimulus in order to filter out only the important information.

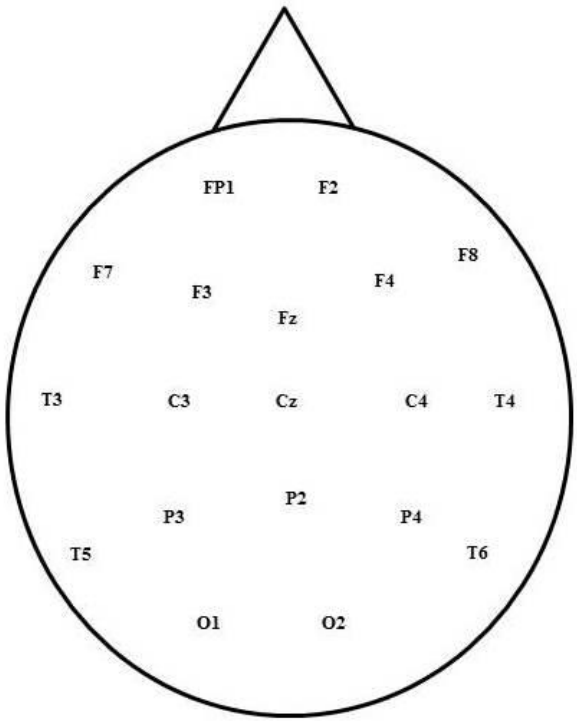

Fig. 1 10-20 international standard System of Electrode Placement

2) Artifacts

Artifacts are the unwanted or unnecessary data which are mixed with original event based EEG data. There are two groups of artifacts as described by Luck [6]. Those are Physiological artifacts and Extra physiological artifacts. Physiological artifacts were generated from the human body such as eye movements, eye blinks, muscle movements etc. Extra physiological artifacts were generated from outside of the human body such as from Air Conditioners, Power line noises, equipment cause noises etc. Artifacts were identified by considering the frequencies, residual variance, peaks as described by Mozaffar & Petr [7] and mostly those are removed by using filters such as Finite Impulse Response (FIR), Infinite Impulse Response (IIR), Band Pass filters and Fast Fourier Transform (FFT), Independent Component Analysis (ICA).

A. Objectives

In this research, picture-based visual stimulus were used to investigate the following three aspects.

- The significance of the P300 wave
- Most influential lobe of the brain
- Most influential wave types

P300 wave is a most important wave for the cognitive based event related potentials according to Hoffman et al. [8]. Identifying above mentioned areas will be help to suggest some solutions for the people who are suffering from visual weaknesses.

II. METHODOLOGY

The dataset for this research was downloaded online from Delorme, et al. [9] and processed using EEGLab, a MATLAB toolbox distributed under the free GNU GPL license for processing data from electroencephalography (EEG), magnetoencephalography (MEG), and other electrophysiological signals.

A. Filtering

Filtering the continuous data minimizes the introduction of filtering artifacts at epoch boundaries. The continuous EEG data set was filtered using FIR (Finite Impulse Response) filter. First lower edge was filtered using 1Hz frequency and then higher edge was filterer using 50 Hz frequency. After these two steps frequency range between 1Hz-50Hz signals are filtered and hence more than 50Hz line noises were removed from the data.

B. Epoching and Running ICA

The filtered data set was segmented into epochs and Independent Component Analysis (ICA) was applied in order to decompose independent components. ICA decomposed multivariate signals in to its statistically independent components. The assumptions described in [7] were considered when applying the ICA to epoch data set. Considering the properties of the independent components, artifactural components were removed by visual inspection.

Correct components can be identified among the artifacts by considering following information. Correct Components mostly have dipole-like scalp maps, peaks at the typical frequencies are recently arises and regular EPR image plots. Finally scalp maps were generated in order to identify the most significant lobe area, wave types and the influence of p300 wave.

III. RESULTS

Data statistics of channel one before and after artifact removing is shown below in Fig. 2 & Fig. 3. EEG signal is not a Gaussian distribution because of its complexity. But it is close to the Gaussian distribution since it was cleaned from artifacts.

Based on Fig. 4, Fig. 5 & Fig. 6, following results were observed. Most significant lobe areas for picture based visual stimulus are the Parietal lobe and the Occipital lobe. Most influential waves for picture based visual stimulus are P500 in all bands and specially P200, P300 and P400 in alpha band and N400 in beta band. P300 influences only at the alpha band.

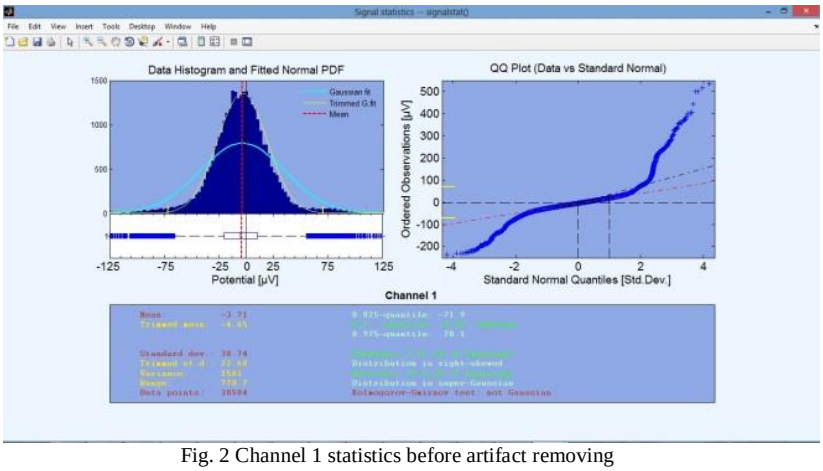

Fig. 2 Channel 1 statistics before artifact removing

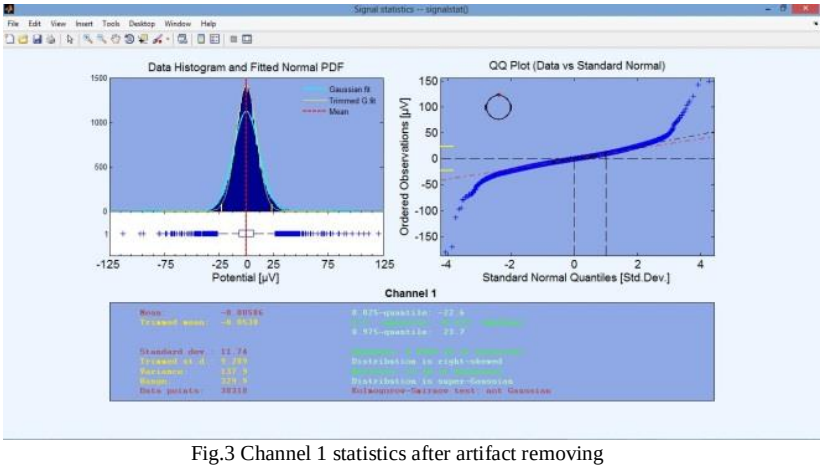

Fig.3 Channel 1 statistics after artifact removing

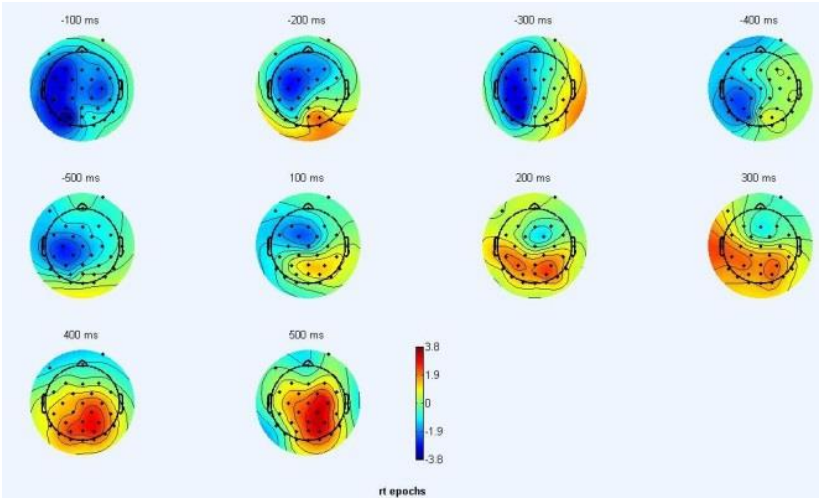

Fig.4 Channel 1 statistics after artifact removing ERP scalp map from -500ms to 500ms

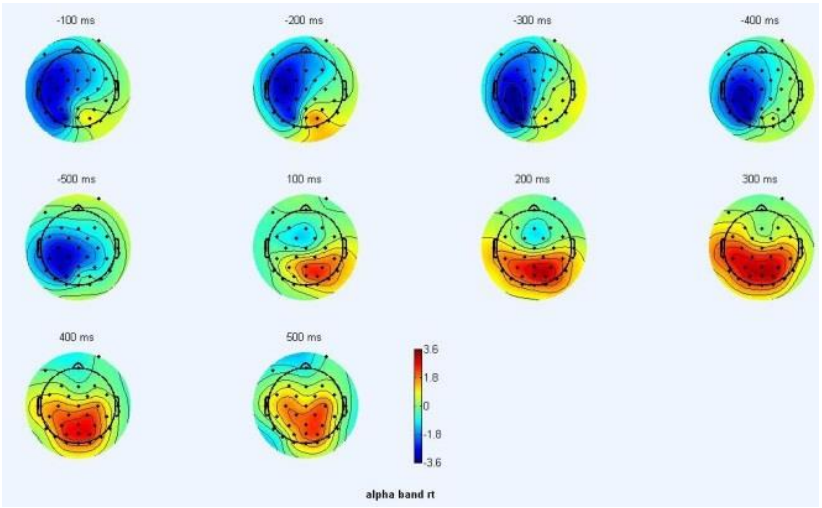

Fig.5 ERP scalp map for alpha band from -500ms to 500ms

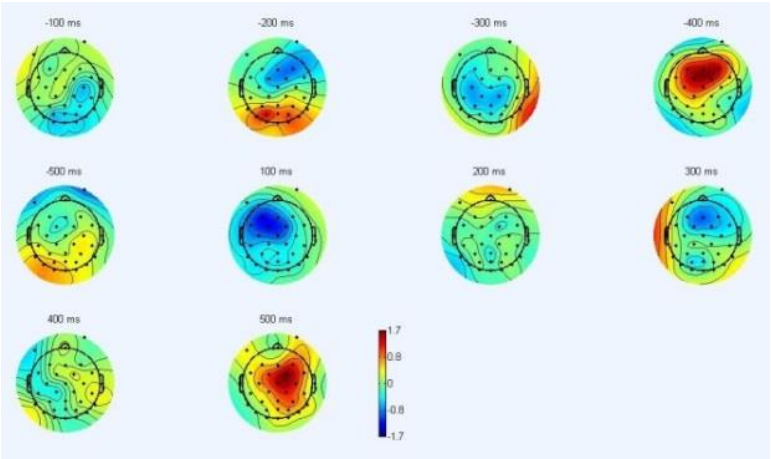

Fig.6 ERP scalp map for beta band from -500ms to 500ms

IV. CONCLUSION AND FUTURE WORKS

Significant lobe areas and wave forms for picture-based visual stimulus were investigated within this research. The results provide avenues for researchers, scientists, students etc. to continue further studies related to this field of study. Further, these findings will be useful in designing equipment for visually impaired people. In future, we are planning to extract the best features for picture-based visual stimulus and continue experiments for more than one subject in order to increase the accuracy. The research can be further extended with more than one subjects to improve the accuracy of the results.

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REFERENCES

[1] Shravani Sur and VK Sinha. Event-related potential: An overview. Industrial psychiatry journal, 18(1):70, 2009
[2] Avid Roman Gonzalez. Eeg signal processing for bci applications. In Human–Computer Systems Interaction: Backgrounds and Applications 2, pages 571–591. Springer, 2012.
[3] Abdul Bary Raouf Suleiman and Toka Abdul-Hameed Fatehi. Features extraction techniqes of eeg signal for bci applications. Faculty of Computer and Information Engineering Department College of Electronics Engineering, University of Mosul, Iraq, 2007.
[4] Robi Polikar. Machine learning for bci, 2012.
[5] Benito Nunez and Ivan Manuel. EEG artifact detection. PhD thesis, Czech Technical University in Prague, 2011.
[6] Steven J Luck. An introduction to the event-related potential technique. MIT press, 2014.
[7] Shadab Mozaffar and D Petr. Artifact extraction from eeg data using independent component analysis. Information Telecommunication and Technology Center, University of Kansas, Lawrence, KS, Tech. Rep. ITTC-FY2003-TR-03050-02, 2002.
[8] Ulrich Hoffmann, Jean-Marc Vesin, Touradj Ebrahimi, and Karin Diserens. An efficient p300-based brain–computer interface for disabled subjects. Journal of Neuroscience methods, 167(1):115–125, 2008.
[9] Delorme, A., Rousselet, G., Mace, M., Fabre-Thorpe M. Interaction of Bottom-up and Top-down processing in the fast visual analysis of natural scenes. Cognitive Brain Research, 103-113

