Evoked Potential Analysis for Brain Computer Interface

Nishant [1], Debolina Dey [2]

1 Assistant Professor, Department of Electrical & Electronics Engineering, Arni University, Kathgarh-176401.
2 Assistant Professor, Department of Electrical Engineering, MEFGI, Rajkot-360003.

Abstract

This article describes an approach to measure and analyse the Electroencephalogram (EEG) data to develop a brain computer interface (BCI). When an external stimulus is applied to the sensory area of the brain, It responds by producing an electrical potential known as Evoked Potential. The investigation of the serial information processing of human brain is very important for designing the brain computer interface. Since EEG signals have good temporal resolutions and can be recorded non- invasively using surface electrodes on the scalp, EEG has been used as a basic tool of the brain computer interface. In this study, EEG signal has been measured while the person is subjected to different audio, visual and mental stimulus. As a result of the frequency analysis of the different signals it is observed that there is a change in output voltage in a particular cortical region which is task related.

INDEX TERMS: Brain Computer Interface (BCI), Electroencephalogram (EEG), Evoked Potential.

1. INTRODUCTION

Brain Computer Interface also known as a direct neural interface or a Brain computer interface is a way of direct communication between brain and an external device. BCIs are often directed at assisting, augmenting or repairing human cognitive or sensory-motor functions. In the area of Biomedical Technology and Computer Science that emphasizes the proactive, seamless roles of interfaces and systems, the brain computer interface is an important field which is at top priority of studying. A brain computer interface is a system which is directly or in-directly connected to the brain, which allows users to communicate with the external environment without using any muscular movement. Brain computer interface are based on imaging methods for the brain as EEG or functional magnetic resonance imaging (fMRI). Electric brain activity is measured directly or indirectly and interpreted using computer program.

Research into BCI has mainly involved recording of the EEG waves using surface electrodes. Much BCI research has involved the development of powerful signal processing techniques to enable accurate control of systems using BCI. In most of the cases the subjects are trained using live training methods by subjecting the subjects to several audio, visual and mental stimulus. Electroencephalography is the most studied potential non-invasive interface, mainly due to its fine temporal resolution, ease of use, portability and low set-up cost. But as well as the technology's to noise, another substantial barrier to using EEG as a brain computer interface is the extensive training required before users can work the technology. The primary advantages of EEG for implementation of BCI is that, it provides continuous instantaneous data and there is no exposure to radiation. Moreover EEG can be recorded non-invasively which requires no cuts or surgery.

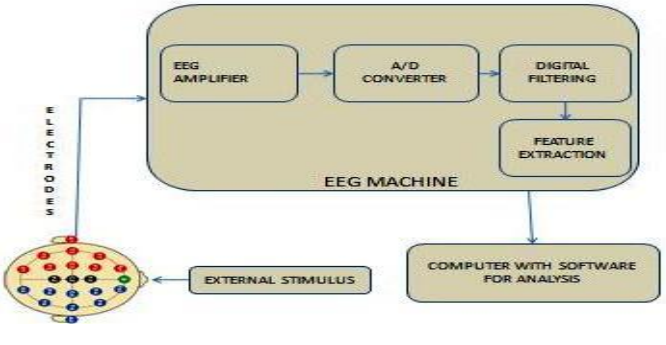

Fig 1: BCI Concept.

2. METHODS

2.1. Participants

The subjects were 12 healthy, right handed, aged between 20 to 28 years and out of which 50% are males and 50% are female subjects and have vision normal or corrected to normal visions. All the subjects had shaved their heads to acquire better EEG signal from skull with the help of surface electrodes.

2.2. Stimulus

As per the requirement of the experiment, subjects are subjected to different types of audio, visual and mental stimulus. The audio stimulus are consisted of different type of sounds which are of different frequencies and different pitch, for example, sounds like high frequency beep sound, crying sound of a woman, high pitched sound and some soothing music are also used. Video stimulus includes visual effects like quick images, puzzles and different color of lights of the visible light spectrum is used, since lights of different wavelengths have impact in the different. Mental task involves remembering earlier occurred event.

2.3. Recording

While the subjects are subjected to different stimulus, at the same time they are seated to undergo real time EEG. The EEG machine we used to record brain waves is Neurospy, which is manufactured by Nasan Medical Electronics and a compatible software is installed in computer to store and analyse recorded data. EEG can be recorded using different types of electrodes system. One such electrode system is the internationally accepted 10-20 electrode system. This system is based on the relationship between the location of an electrode and the underlying area of cerebral cortex. The "10" and "20" refer to the fact that the actual distances between adjacent electrodes are either 10% or 20% of the total front–back or right–left distance of the skull. Each site has a letter to identify the lobe and a number to identify the hemisphere location. Electrodes are connected to the skull with the help of a conductive paste. This paste increases the conductivity of surface electrodes. Different type of audio, visual and mental stimulus are given to all the subjects one by one and recorded EEG wave forms are saved in Neurospy software and are analysed using frequency maps and amplitude maps.

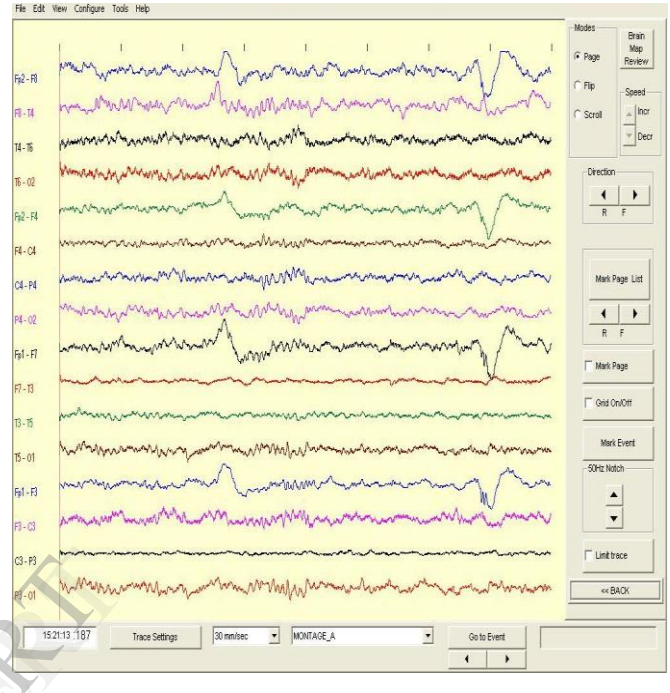

Fig 2: Recorded EEG Waves

2.4. Data Analysis

Before the offline data analysis artifacts rejection was performed to discard epochs in which effects due to Line Frequency, Electrode movement, Electrode pop, Sweating, eye blinking, body movements, muscle activity. A Fast Fourier transform (FFT) analysis and electric potential map analysis were performed in order to maximize the topographic specificity of electrical sources for each electrode. Two specific programs were used for the FFT analysis of the EEG waveforms. Beta waves has a frequency of 13-35Hz, alpha waves has a frequency of 8-13 Hz and theta waves has a frequency of 4-8 Hz. EEG was measured and filtered using a band pass filter of 4-35Hz. EEG waves are analysed by studying the change in power at different cortical areas of human brain.

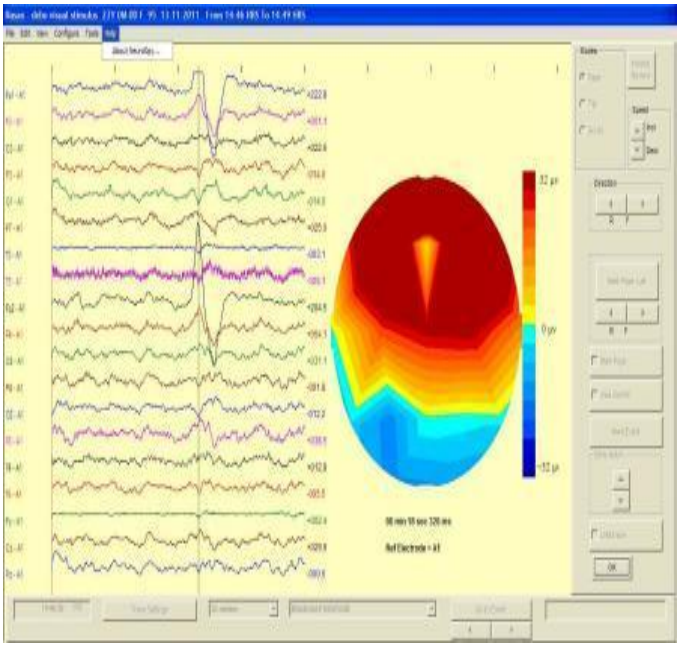

Fig 3: Single amplitude Brain map

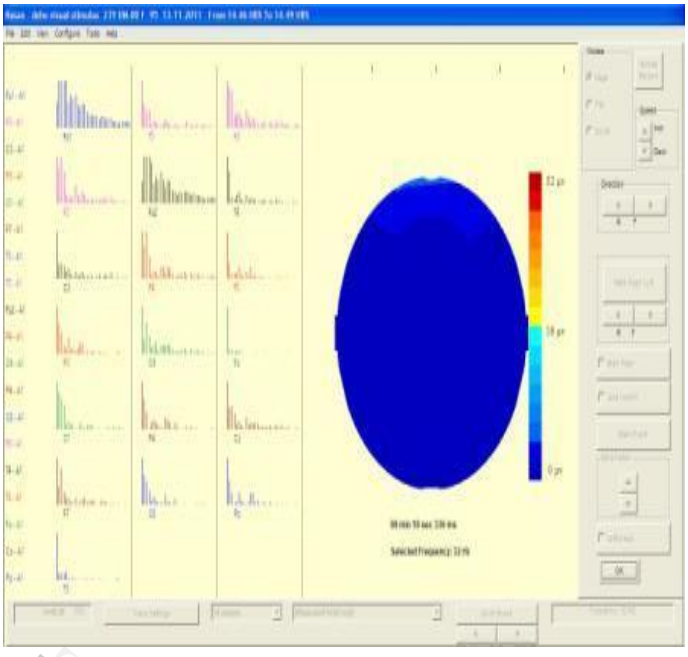

Fig 5: Single frequency Brain map

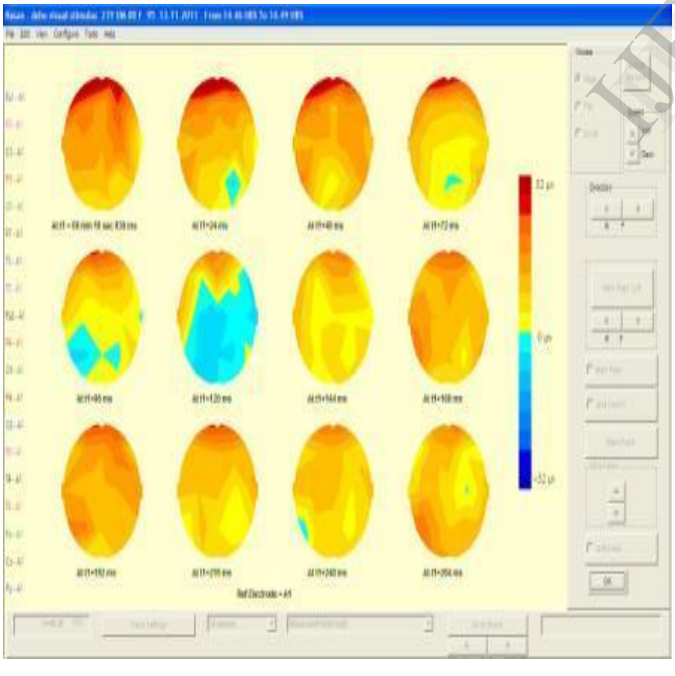

Fig 4: Progressive Amplitude Brain map

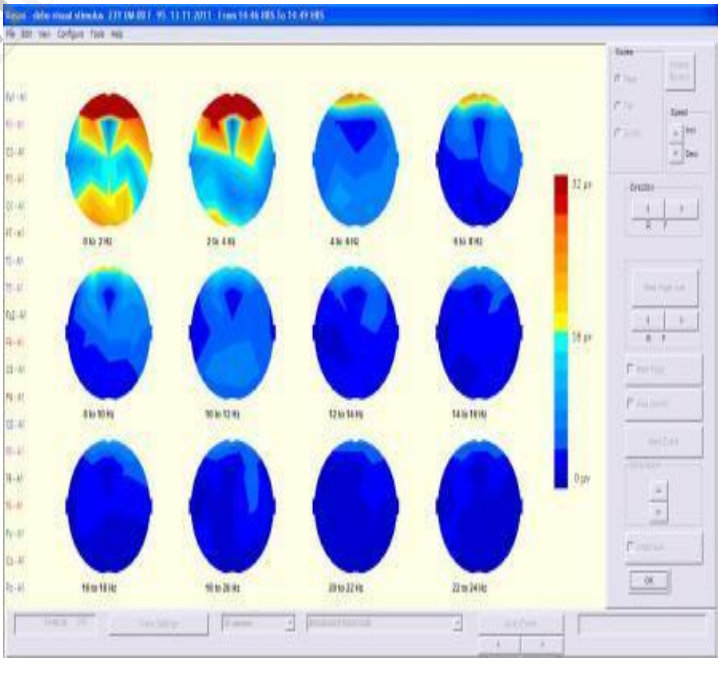

Fig 6: Progressive frequency Brain map

3. RESULT

The spectral power percent for each EEG component in each task is shown in the above diagram and each EEG function component is task co-relation. The above figures shows the average cortical potential map of all subjects at different tasks. The origin of the theta waves showed that theta occurs at the frontal lobes, similarly the origin of alpha waves is the post central lobe and that of the beta wave is the temporal lobe.

4. DISCUSSIONS

This result showed that the power spectrum of EEG components which were recorded at the different situations. It is seen that theta waves were released with high level task and has the most value in present time. Even theta waves have a relation with the visual stimulus and remembrance activity of the brain. Similarly with audio task beta and alpha waves are associated.

5. CONCLUSION

Results of the study indicates that the brain waves for each task and each level of mental activity are different and the conclusion can be drawn from the fact that each task generate a separate value of voltages and with the voltages generated from the brain waves one can operate some brain controlled equipments such as lights, operating a mouse.

REFERENCES.

[1] Benjamin Blankertz, Florian Losch, Gudio Dornhege, Gabriel Curio and Klaus Robert Muller. The Berlin Brain-Computer Interface:"Accurate performance from first session in BCI-Naïve Subjects".IEEE Transaction On Biomedical Engineering, 2008.

[2] Quentine Noirhomme, Richard I.Kitney and Benoit Macq. "Single Trail EEG Source Reconstruction for Brain Computer Interface".IEEE Transaction on Biomedical engineering, 2008.

[3] S.G. Mason and G.E. Birch. "A General Framework for Describing Brain-Computer Interface Design and Evaluation", revised and resubmitted to IEEE Trans. Rehab. Engineering,2003.

[4] Chin-Teng Lin, Yu-Chieh Chen, Tien-Ting Chiu, Li-Wei Ko, Sheng-Fu Liang, Hung-Yi Hsieh, Shang-Hwa Hsu."Devolpment of wireless Brain Computer Interface with embedded multitask scheduling and its applications on real time Driver's Drowsiness Detection and warning".IEEE Transaction on Biomedical Engineering, 2008.

[5] Ming Cheng, Xiaorong GAO, Shangkai GAO and Dingfeng Xu. "Design and Implementation of a Brain-Computer Interface with High Transfer Rates". IEEE Transaction on Biomedical Engineering, vol. 49, no. 10, Oct 2002.

[6] Johnny Chung Lee, Desney S.Tan, "Using a Low-Cost Electroencephalograph for Task Classification in HCI Research", Carnegie Mellon University, Microsoft Research.

[7] Torsten Felzer, "On the Possibility of Developing a Brain-Computer Interface (BCI)" Technical University of Darmstadt, Department of Computer Science, 2001.

[8] Niedermeyer, Ernst; da Silva, Fernando Lopes, "Electroencephalography: Basic Principles, clinical applications and related fields", 5th Ed 2005.

[9] Paul L.Nunez, Ramesh Srinivasan, "Electric Fields of the Brain: The Neurophysics of EEG", 2nd Ed 2006.

[10] Jessica D. Bayliss,"A Flexible Brain-Computer Interface", University of Rochester, New York, 2001.

[11] Jorge Baztarrica Ochoa, "EEG Classification for Brain Computer Interface Applications", 2002.

[12] Benjamin Blankertz, Guido Dornhege, Matthias Krauledat, Klaus-Robert Müller, Volker Kunzmann, Florian Losch, and Gabriel Curio, "The Berlin Brain-Computer Interface : EEG-based communication without subject training". IEEE Trans. Neural System Rehabilation Engineering, 14(2):147-152, 2006.

[13] Klaus-Robert Müller and Benjamin Blankertz, "Towards noninvasive Brain Computer Interfaces". IEEE Signal Processing Magazine, 23(5):125-128, September 2006.

[14] C.W. Andersen, E.A. Stoltz and S. Shamsunder. "Multivariate autoregressive models for classification of spontaneous electroencephalographics signals during mental tasks". IEEE Transactions on Biomedical Engineering, 45:277–286, 1998.