



## GRAPHICAL USER INTERFACE CONTROLLED VIA BRAINWAVE SIGNALS FOR PARAPLEGIC REHABILITATION

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### ABSTRACT

This article presents a practical method for recorded raw brainwave signals in three different ways. The motivation for this experiment is to get the right and persistent raw brainwave signal for the future development of GUI controlled via brainwave signals. This step was very basic but very important step in that development. Motivation behind the work also include gaining the ability to examine the behavior of raw brainwave signals. To archive the objectives, the raw brainwave signals is recorded via two different platforms of GUI; MATLAB and NeuroSky Application. NeuroSky Mindwave Mobile device is used to capture the brain signals. The raw brain wave signals taken via MATLAB are found to be similar/ verified with other brainwave signals taken via others platform.

**Keywords:** functional electrical stimulation, spinal cord injury, rehabilitation.

### INTRODUCTION

Brain computer interface (BCI) allows direct communication between the brain and the Machine. BCI has a tremendous amount of applications in many different areas and very useful in the field of rehabilitation engineering, since it can be used for understanding the needs of the disabled person. BCI involves the use of a head-gear for extracting the brain waves called as Electroencephalography (EEG) (Ernst Niedermeyer *et al.* 2004). The brain is made up of billions of neurons. It exchanges information by discharging ions thereby conducting electrical impulses (Krishnakumar *et al.* 2013). Our knowledge about the brain and particularly the electrical signals has greatly increased in last century of neuroscience research emitted by neurons firing in the brain. The patterns and frequencies of these electrical signals can be measured by placing a sensor on the scalp. The MindSet contains NeuroSky ThinkGear™ technology in Figure-1 below. This device measures the analog electrical signals, commonly referred to as brainwaves. This device will process the brainwaves into digital signals to make the measurements available to games and other applications.



**Figure-1.** Example of NeuroSky mindwave mobile.

There are different types of activity in the brain as shown in Table-1 below which gives a general synopsis of some of the commonly recognized frequencies that tend to be generated by (NeuroSky inc, 2009):

**Table-1.** List of brain wave type and its frequency range.

Brainwave Type	Frequency Range	Mental states and conditions
Delta	0.1 Hz - 3Hz	Deep, dreamless sleep
Theta	4Hz - 7Hz	Creative recall, fantasy
Alpha	8Hz - 12Hz	Relaxed
Low Beta	12Hz - 15Hz	Formerly SMR
Mid Beta	16Hz - 20Hz	Thinking, aware of self
High Beta	21Hz - 30Hz	Alertness

The brain contains neurons and these neurons communicate with each other using electrical impulses. These impulses need to be captured and decoded to obtain what the user thinks at the given point in time. After the data is decoded, they need to be stored using a technique from which retrieval becomes simple. Electrical activity inside the brain can be detected with electrodes placed on the scalp or forehead. Small differences in voltage are measured between pairs of electrodes, and the resulting signal is amplified and drawn in the form of a wave. This drawing is called an electroencephalogram or EEG. The information about the brain-waves can be obtained using Electroencephalogram (R Sudirman and S C Seow, 2009) and raw brain impulses can be captured. This information contains a lot of unwanted data and thereby needs to be de-noised (R Sudirman *et al.* 2010) (V Gandhi *et al.* 2011) (A. Phinyomark, 2009). After this, the raw brainwave



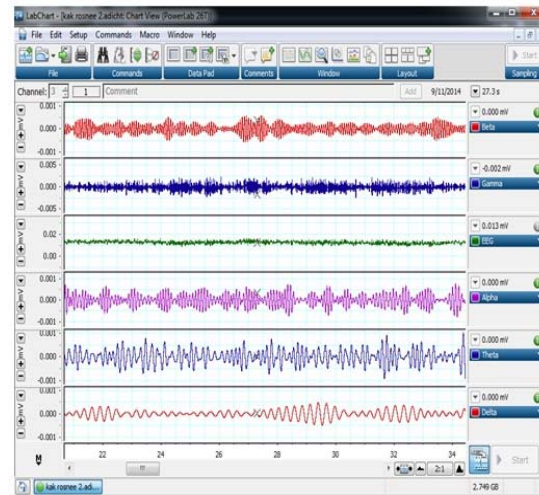
signals must be translated into a form that can be understood by humans (R Sudirman and S C Seow, 2009). This process can be done by using an Artificial Intelligent Technique, such as neural networks, fuzzy or by hybrid them (R Sudirman *et al.* 2010).

This raw information is then stored in such a way that, information can be retrieved efficiently (Luis Tari, 2012) (Weifeng Su *et al.* 2012). EEG-based interfaces are being used for a wide range of applications. Researchers are creating brain interfaces to aid disabled users who are unable to use typical computer interfaces (Junker, 2001). While the clinical psychologists use this benefit of BCI to treat some conditions, including attention hyperactivity disorder (ADHD), epilepsy, and alcoholism (Budzynski, 2003). Artists and musicians have also been experimenting with this BCI technique to create unusual art, music and performances (Rosenboom *et al.* 1990).



**Figure-2.** Example of BCI in music.

Often, the term EEG is also used as an abbreviation for electroencephalography, which is the entire process of recording brain activity. In this paper, the term EEG is used to describe the entire process (Amy Palke, 2004). To implement the EEG brain computer interfaces, the digital computer technology is now commonly used. Current methods often sample, digitize, and filter waves into their component frequencies. To divide the signals into different frequency bands and to form a spectrum also, the digital signal processing techniques can be used too (Miranda, 2003). Figure-3 show the raw brain wave signals and its component after filtered.



**Figure-3.** A raw EEG sample and its filtered component frequencies.

### Graphical user interface (GUI)

MATLAB is viewed by many users not only as a high-performance language for technical computing but also as a convenient environment for building graphical user interfaces.

A graphical user interface (GUI) is a pictorial interface to a program. Data visualization and GUI design in MATLAB are based on the Handle Graphics System in which the objects organized in a Graphics Object Hierarchy can be manipulated by various high and low-level commands (Sergey Simakov, 2005). A good GUI can make programs easier to use by providing them with a consistent appearance and with intuitive controls like pushbuttons, list boxes, sliders, menus, and so forth. The GUI should behave in an understandable and predictable manner so that a user knows what to expect when he or she performs an action. For example, when a mouse click occurs on a pushbutton, the GUI should show the action described on the label of the button. The basic elements of the MATLAB GUIs are very important. Does not to know a complete description of components or GUI features still acceptable, but it does provide the basics required to create functional GUIs for your programs (Ahmed Al Ameri and Refaat Yousef Al Ashi, 2004).

In this paper, the main target is to get the right and persistent raw brainwave signal for the future development of GUI controlled via brainwave signals. This GUI controlled BCI can give benefit to the disorders patient such as Attention Deficit/Hyperactivity Disorder and thus may aid in their rehabilitation (Beom-Soo Shim, 2007).

### METHODOLOGY

List of equipment for this experiment:

- i. NeuroSky brainwave set
- ii. MATLAB
- iii. Bluetooth set

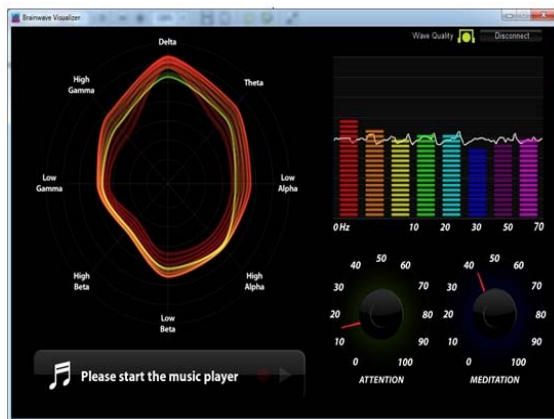


### Experimental paradigm

Raw brainwave signals are recorded using two different platform GUI from a voluntary male subject. The subject was seated in a comfortable chair in front of a computer monitor. The room used for the experiment does not have any special acoustic control. During the recording, the subject was instructed to keep himself relaxed. For the beginning of the experiment, the subject has asked to close the eyes and start focusing on moving his knee joint slowly up and down. The subjects repeats the same task twice due to they have two different GUIs. Each experiment takes about 30 seconds, and all data is recorded. All the signal that appear on the monitor are the raw signals from the brain. The protocols for the tasks are detailed below:

#### Task 1 – GUI one

The subjects are asked to move his leg up and down. The brainwave signals were recorded by using NeuroSky GUI template for this first condition as shown in Figure 4a.

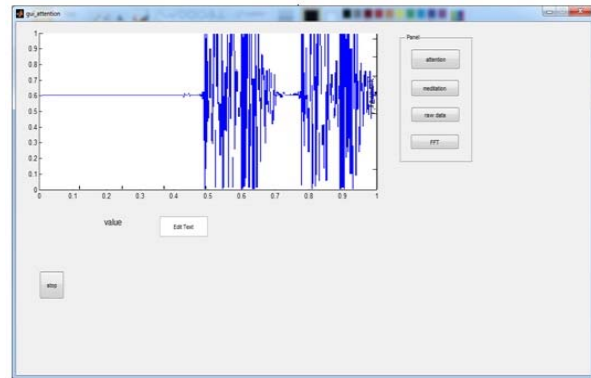


**Figure-4(a).** Brainwave signals was recorded by using NeuroSky.

The data presented in that NeuroSky GUI template were quite detail but only for monitoring purposes. For the purpose of storing and analyzing the data, this template was not suitable as it cannot do the task even when the data that showed on the template were detailed. Also, this template cannot be reprogrammed to make it suitable for current usage. Therefore, this template are not suggested in this research due to the limitation in its functionality.

#### Task 2 – GUI two

As the last task, the subject continues to move his leg up and down. Now the brainwave signals are recorded by using MATLAB GUI for this condition as shown in Figure-4(b).



**Figure-4(b).** Brainwave signals was recorded by using MATLAB.

Compared to the NeuroSky GUI template, this MATLAB GUI were more interesting and had many functionalities. This GUI also can do the storing and analyzing data process that are recorded from the subject's brain. Although, the process to make this MATLAB GUI template are difficult and complicated. It is very reasonable and worth it for the purpose of research and much more for the research that has a lot of storage and data analysis process.

### EEG recording

Raw brainwave signals are recorded using NeuroSky Mindwave Mobile as shown in the Figures below. This NeuroSky device reacts to the mind attention (alpha and beta wave) via wireless communication system (Bluetooth). The experiment consists of twenty trials per task. Each trial lasts for 30 seconds. The subjects take breaks for 15 minutes between trials. All trials for a single subject are conducted on the same day. One healthy subject aged 28 participated in the experiment, at the time of data recording the subjects are free from illness or medication. In this experiment, two signal types have been the highlight: alpha and beta and two different GUI platform has been tested. Figure-5 shows the position of electrodes during the experiment.



**Figure-5.** The position of NeuroSky on the subject during the experiment. (a) Back view, (b) Side view.





## RESULT AND DISCUSSION

The final step in this experiment is to make the comparison between all two raw brain wave signals and analyzed them. This process is done via MATLAB and Microsoft Excel software as shown in Figure-6(a) and Figure-6(b) below:

1	Alpha	Alpha	Alpha	Alpha	Beta	Beta	Beta	Beta
2	Mean	Std Dev	Maximum	Minimum	Mean	Std Dev	Maximum	Minimum
3	mV	mV	mV	mV	mV	mV	mV	mV
4	0.000306	0.000357	0.001142	-0.00047	-0.00016	0.000262	0.000465	-0.00091
5	2.98E-06	0.000265	0.00054	-0.00054	3.08E-06	0.000289	0.000576	-0.00056
6	-3.66E-06	0.000352	0.000801	-0.00079	5.95E-07	0.000271	0.000678	-0.00068
7	-2.34E-07	0.00021	0.000553	-0.00055	2.18E-06	0.00024	0.000547	-0.00053
8	3.79E-08	0.00022	0.000516	-0.00051	-1.35E-06	0.000183	0.000467	-0.00054
9	3.30E-06	0.00025	0.000717	-0.0007	-2.07E-06	0.000211	0.000489	-0.00051
10	-1.47E-06	0.000324	0.000825	-0.00082	-1.82E-06	0.000255	0.000452	-0.00049
11	6.88E-07	0.000304	0.000689	-0.00069	1.76E-06	0.000239	0.0005	-0.0005
12	-6.29E-07	0.000201	0.000499	-0.0005	-1.15E-06	0.000249	0.000639	-0.00065
13	-2.80E-07	0.000318	0.000806	-0.00077	1.63E-07	0.000211	0.000483	-0.00049
14	-3.98E-06	0.000293	0.000705	-0.00068	2.44E-06	0.000214	0.000447	-0.00047
15	6.17E-06	0.000238	0.00065	-0.00062	-2.75E-07	0.000182	0.000391	-0.00037
16	-3.76E-06	0.00028	0.000565	-0.00056	-8.35E-07	0.000195	0.000514	-0.00049
17	4.16E-06	0.000275	0.000587	-0.0006	-1.47E-06	0.000249	0.000575	-0.00058
18	-3.53E-06	0.000292	0.000708	-0.00075	1.03E-06	0.000178	0.000428	-0.00044
19	4.64E-06	0.00023	0.000526	-0.00052	1.16E-06	0.000149	0.000287	-0.00029
20	-8.01E-06	0.000268	0.000682	-0.00067	-1.85E-06	0.000212	0.000508	-0.00051
21	2.73E-06	0.000243	0.000766	-0.00076	1.23E-06	0.000259	0.000769	-0.00074
22	4.02E-07	0.000275	0.00069	-0.00074	9.83E-07	0.000294	0.000676	-0.00068
23	-1.45E-06	0.000364	0.000847	-0.00082	-1.38E-07	0.000194	0.000538	-0.00054
24	-1.76E-06	0.00027	0.000642	-0.00064	-1.41E-06	0.000191	0.000446	-0.00044
25	-6.80E-07	0.000237	0.000551	-0.00055	2.17E-07	0.000198	0.000429	-0.00043
26	6.99E-06	0.000244	0.000583	-0.00057	1.43E-06	0.000163	0.000416	-0.00041
27	-4.59E-07	0.000308	0.000861	-0.00089	-7.50E-07	0.000279	0.000651	-0.00061

Figure-6(a). Sample raw data recorded in excel via MATLAB.



Figure-6(b). Sample raw data presented in NeuroSky GUI.

The signal is taken or recorded using NeuroSky device while the subject carries out the activity, as discussed previously. From MATLAB GUI, this raw signal can be stored in Excel as an example and can be analyzed directly using MATLAB software itself by online (real-time). Also, data that has been stored in Excel can be retrieved and analyzed by offline. Compared to other method, the signal or data from the brain only be presented on the GUI and cannot be saved or analyzed.

After the raw brainwave signals have been analyzed, it can be summarized that the raw signal taken via MATLAB GUI and Neurosky device can be used in this experiment. This because even the point of the sensor in Neurosky was very limited, but some signal still can be captured. The importance here is how to manipulated the signal captured; attention and meditation signals in this

research. Also from the experiment show that the signal captured by MATLAB GUI was same with signals capture via other software (show in Figure. 6b). So this proves that MATLAB can be used to analyze the brainwave signal in this research.

Also, this MATLAB GUI template is suitable for this research because of reasons that already discussed before; it can do a storing and analyzing data process. More importantly it also can be upgraded or reprogrammed it back to be adjusted to the current situation and also to future needs. The GUI template is very important because it will act as a medium between brainwave and device that want to be controlled or more accurately very important for a BCI system. To get a better and the right raw brainwave signal is very important and can benefit many areas of research, especially the rehabilitation engineering.

## CONCLUSIONS

The main goal of this experiment is to get the right and persists raw brainwave signal for the future development of GUI controlled via brainwave signals. So after performing some experiments, it can be concluded that the raw brainwave signals that were recorded with MATLAB GUI is persistent and valid signals. In this case, human thinking activity (attention), the alpha and beta type signal has produced highest feedback. An individual can control his electroencephalogram (EEG) through imaginary motor tasks, it also enables him to control devices through an EEG and BCI. So, as for future work, there should be a lot of other brainwave signal and GUI experiments because many benefits can be produced from this area.

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