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Monitoring Human's Emotion through Fast Fourier Transform Method form Brainwave Features

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***Abstract*—Emotions are intrinsic to the way humans are interacting with each other. A human being can understand the emotions of another human being to a certain extent and behave in the best manner to improve the communication in a certain situation however a machine cannot. This paper aims to make an analysis of human emotion from brainwave. Certainly, this paper deals with the detection of emotions using EEG signals and based on the emotion detected. In this project an Electroencephalogram (EEG) headset will be used to record the brain signals of an individual by analyzing his/her brain state and to detect his/her emotions using FFT algorithms. Using EEG-based emotion recognition, the computer can observe the users emotional state. As a result, this will help to improve users knowing his mental state accurately. This kind of emotion analysis system will have widespread potential applications in future environments.**

Keywords—emotion detecting, fast fourier transform, electroencephalogram (EEG)

I. INTRODUCTION

The human brain is the most complex and main organ. This is because the brain is an organ that functions as a center of control of activity in the human body. The brain works using an electrical system, which produces small electrical signals in a regular pattern and channeled through the cells of cells called neurons. Each neuron communicates with each other by emitting electric waves. Electric waves released by neurons in the brain are what are called brain waves [1].

Humans have the natural ability to use all their senses in receiving messages in a conscious state. Through these senses, humans can feel emotional states when they get a stimulus [2]. Recognizing human emotions directly can be assessed from several criteria, such as facial expressions, sounds, or body movements. Other criteria for identifying human emotions can also be based on data recorded on human brain activity, better known as Electroencephalography [3].

EEG is a tool used to view electrical activity in the human brain. In this study, we will use Neurosky Mindwave Mobile which is equipped with a sensor on the forehead and noise filter in the form of an ear clip mounted on the left ear to observe and record brain waves [4]. The type of the EEG output is in the way of electrical signals in the brain in the form of a graph with brain wave voltage on the time or frequency that can be seen using a computer [5]. Brain wave graphs on EEG vary depending on the condition of the human brain at the time of recording. It can be influenced by the presence of internal stimuli when experiencing an emotion (happy, sad, angry, surprised and thinking) [6].

In this study, the spectrum analysis method based on Fast Fourier Transform (FFT) used in characterizing EEG output brain waves to analyze the existence of brain wave differences between emotions and standard in a person [7].

Agus Siswoyo's research, Zainal Arief and Indra Adji Sulistijono entitled "Classification of Brain Signals Using Fuzzy Logic Methods with NeuroSky Mindset" conducted a study of the classification of brain signals where Fuzzy logic is used to process input attention signals to obtain signal duty cycle values PWM to regulate the flame LED as a type of classification of brain signals [8].

II. RESEARCH METHOD

A. Neurosky Myndwave

Mindwave measures the voltage between sensors placed on the forehead and sensors that clamp the left ear (ear clip) as ground. More precisely, the position on the forehead is Fp1, as determined by the International System 10-20 (Jasper, 1958). Besides, this tool already has Noise Cancellation Technologies that can eliminate noise frequencies from other sources such as muscle movements and electrical devices. The filter removes electrical interference that varies from 50 Hz to 60 Hz depending on geographical location [9].

B. Stimulus

Before starting the experiment, preparation time is needed to place the Neurosky Mindwave and adjust the position of the subject to be comfortable during activities, the processing time is unpredictable because it depends on how long the subject takes to complete a stimulus. The stimulus that will be given to the subject is listening to songs, watching videos or reading books. The stimulus serves to find out whether the subject of emotion is when he is given a song, video or book [10].

C. Fast Fourier Transform

The Fast Fourier Transform method requires around 10,000 mathematical algorithm operations for data with 1000 observations, 100 times faster than the previous method. The discovery of Fast Fourier Transform and the development of personal computers, the Fast Fourier Transform technique in the data analysis process became popular and is one of the standard methods in data analysis. One form of transformation commonly used to convert signals from the time domain to the frequency domain is the Fourier transform [11].

Correlation is a term commonly used to describe whether or not there is a relationship with something else. In simple terms, that is precisely what understanding correlation means. Correlation analysis is a method or method to determine whether or not there is a linear relationship between variables. If there is a relationship, the changes that occur in one of the variables X will result in a difference in the other variable (Y). The term is said to be a causal term, and the term is a

characteristic of correlation analysis — the Fast Fourier Transform algorithm equation in equation 1.

$$f_j = \sum_{k=0}^{N-1} w_N^{kj} f_k \quad (1)$$

Suppose that N can be divided into two so that the equation below divided into two parts, namely for even k and odd k. Then given a new variable with equation 2:

$$M = \frac{N}{2} \quad (2)$$

So that equation 3 is obtained:

$$f_j = \sum^{M-1} w_N^{2kj} f_{2k} + \sum^{M-1} w_N^{(2k+1)j} f_{2k+1}$$

Where N is the amount of data, then equation 4 is what is known as FFT:

$$M = \frac{N}{2} M = \frac{N}{2}; w_N = e^{\frac{-2\pi i}{N}}; w_M = e^{\frac{-2\pi i}{M}}; k, j = 0, 1, \ldots, N-1. \quad (4)$$

The above equation is used to find cos correlation and signal sin on Fast Fourier Transform. A correlation that occurs between two variables is not always in the form of an addition to the value of variable Y if the variable X increases, a correlation like this is called a positive correlation. Sometimes it is found that there is a relationship where if one of the variable values increases the other variable decreases, a relationship like this is called a negative correlation. Not only positive and negative correlations, but also sometimes found cases where the relationship between variables is fragile, and even no correlation founded.

D. Research Tools and Materials

The main tools and materials used, and their functions can be seen in Table 1.

TABLE I. RESEARCH TOOLS AND MATERIALS

Tools and Materials	Explanation
Laptop	To design and simulate the
	MATLAB program using the
	FFT method.
EEG NeuroSky	For brain wave recording
Mindwave	
Bluetooth Adapter	As a device to connect
	Neurosky Mindwave with a
	Laptop
Stimulus	As a means to determine the
	emotional state of individuals
	who are the subject of
	research
MyndPlayerPro	Used to get the brain wave
	parameters of each subject
MATLAB	Used for brain wave feature
	extraction using the FFT
	method.

E. Block Diagram

The design of the system for monitoring one's emotions with the FFT algorithm was initially carried out in the stages of research design and conceptual research framework used for brain wave classification using Neurosky Mindwave to analyze emotional patterns using Fast Fourier Transform. In this research, it will produce a script on MATLAB Software that can analyze features. From the results of the subject recording data when conducting a new test can extract the feature using the Fast Fourier Transform method, which then after obtaining the dining feature, data classification will be formed.

To simplify the process of making the script, this time, the research needs to make systematic steps. The existence of levels in this study is expected to guide in formulating research problems. The design flow can be seen in Figures 1 and 2.

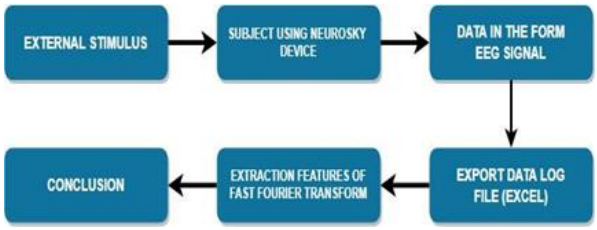

Fig. 1. System Design Block Diagram

The subject will be given a stimulus in the form of music, video and books with Neurosky placed in the head of the sub-field so that the EEG signal is obtained. Then pre-processing is done on the newly acquired EEG signal. The pre-processing stage aims to display the average signal from the original signal and erase the baseline or baseline in the EEG signal to get the signal output. The results of the EEG signal pre-processing were then analyzed using Fast Fourier Transform to obtain a noise-free EEG signal to extract all essential frequency components from EEG signals such as alpha, beta, gamma, delta, and theta. Separation of the frequency of the wave part of the EEG signal for grouping the features of a subject's brain waves that will carry out tests based on certain level signals. Fast Fourier Transform is used for gathering and detecting brain waves where these brain waves provide different features. The results of the selection of prominent EEG signals from brain wave signals in identifying features result in the identification of data classification.

Fig. 2. Hardware Design Block Diagram

The block diagram above, it can be seen that Bluetooth adapters function as communication protocols between laptops with Neurosky Mindwave. The data sent is in the form of brain wave record values measured using Neurosky Mindwave and will be posted periodically according to how long the recording process is.

F. Algorithm

The design of software in this study has the aim of making hardware work on software that is created and can be read by computers. Figure 3 is a software design flow diagram.

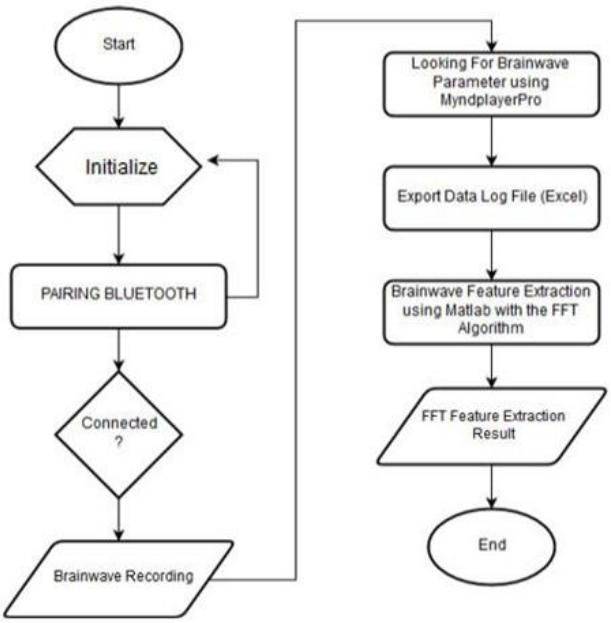

Fig. 3. Flow Chart

G. System Testing

In this study, the subject will be given a stimulus in the form of listening to music, viewing a video or reading a book with Neurosky placed in the head so that an EEG signal is obtained. Then pre-processing is done on the newly acquired EEG signal. The pre-processing stage aims to display the average signal from the original signal and erase the baseline or baseline in the EEG signal to get the signal output. The results of the EEG signal pre-processing were then analyzed using Fast Fourier Transform to obtain a noise-free EEG signal to extract all essential frequency components. From EEG signals such as alpha, beta, gamma, delta, and theta. Separation of the frequency of the wave part of the EEG signal for grouping the features of a subject's brain waves that will carry out tests based on certain level signals.

Fast Fourier Transform is used for gathering and detecting brain waves where these brain waves provide different features. The results of the selection of prominent EEG signals from brain wave signals in identifying features result in the identification of data classification.

Fig. 4. Illustration of System Testing

III. RESULTS AND DISCUSSION

The test results will be divided into several stages. The first stage is testing brain wave conversion from RAW data into a Fast Fourier Transform (FFT) spectrum. Second is testing for brain wave analysis when under normal circumstances and in certain emotions using FFT. Then the last is a table that contains the output of attention (focus, emotion, and attention) and meditation (meditation, relaxation) from the results of brain wave recording.

A. Converting RAW data into FFT

The process of converting RAW data into FFT is done using the Matlab software where the data input is RAW data output from Neurosky. For the results that have been running in the form of Neurosky amplitude waves and FFT frequency waves. The results obtained from running the program will be shown in Figures 5 (a) and 5 (b) below.

(a)
(b)

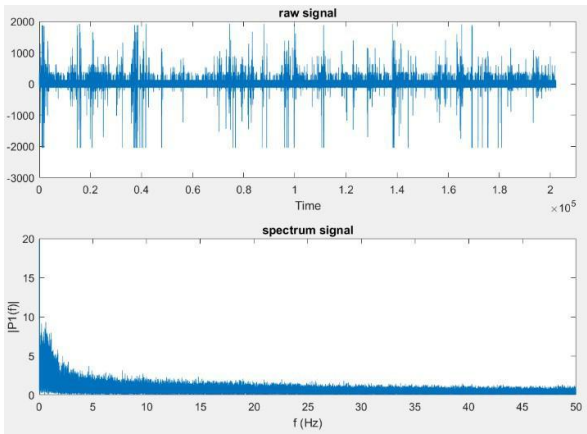

Fig. 5. The results of running the program conversion from the raw signal (a) to the FFT spectrum (b).

From the picture above shows the difference between Neurosky data in the form of RAW data or raw data from the subject and the Fast Fourier Transform signal spectrum from a subject data. The result of running the program is that there are two forms of signals, namely Neurosky wave signals in the form of a neurosky amplitude and wave in the form of frequency, wherein figure 5 (a) raw signal is raw data obtained from Neurosky waves that are tested on subjects that are

thinking complicated things and can see a high amplitude from 0 to 2 × 105. In Figure 5 (b) is a Neurosky wave frequency signal spectrum that is tested on subjects in a state of thinking about complicated things. There are frequencies of 0 to 50 Hz which have different amounts at each frequency. The results of the signal spectrum will be different for each stimulus given to the subject.

B. *FFT Spectrum Analysis of Individual Regular Brainwaves and Emotions*

FFT spectrum analysis process is carried out between regular and specific emotional waves. The picture below explains the results of running programs for subjects with the FFT method in figure 6.1 and 6.2.

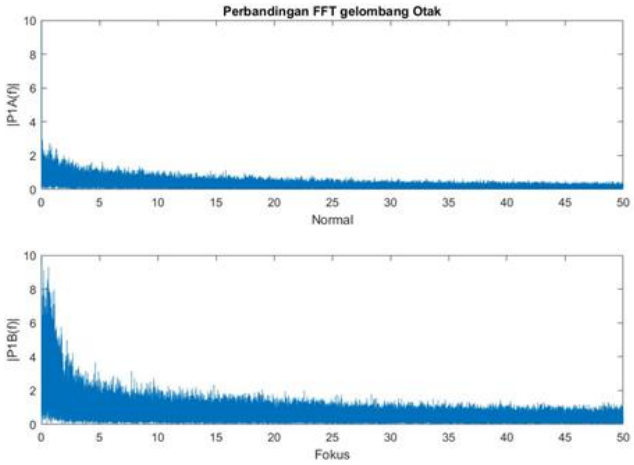

Fig. 6. FFT results when normal and focused (thinking)

It can be seen that the first subject brain wave has a difference where at regular times it has the highest amplitude of 3 at a frequency of 0 - 50Hz, while at a time of shock has the highest amplitude of 9 at a frequency of 0 - 50Hz.

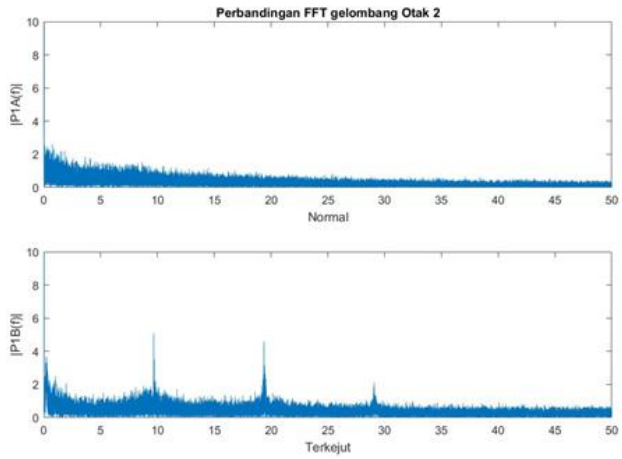

Fig 6.2. FFT results when normal and shocked

It can be seen that the second subject's brain waves have differences were at regular times they have the highest amplitude of 2.5 at a frequency of 0 - 50Hz, while at a time of shock have the highest amplitude of 5.5 at a frequency of 10Hz.

From the results of the comparison of two subjects when the state of focus and surprise, can be seen the results of the FFT spectrum between the two there are differences where at the time of focus state has a higher amplitude value than when the state of shock. But in a state of shock, there are several amplitude surges in the frequency range 0-5Hz, 9-10Hz, 19-20Hz and 29-30Hz.

C. *Result of the Comparison Between each Emotions*

The highest amount of data is collected from each frequency to compare the values obtained from each emotion.

TABLE II. THE HIGHEST NUMBER OF FREQUENCIES FROM 0 - 4 HZ WITH A RANGE OF 0.25 HZ

Number of Frequency	Normal	Sad	Focus
0	0.994657	7.24039	9.132084
1	1.37297	8.690236	9.305327
2	1.130835	5.606634	7.961354
3	1.148225	5.627591	5.079505
4	1.252391	3.079352	5.772849
5	1.229974	3.980656	4.964825
6	1.176037	2.310313	3.505903
7	1.136177	3.825499	4.23123
8	0.934976	2.522899	3.422293
9	0.980023	2.519064	2.954882
10	0.985	2.40315	3.148272
11	0.923255	3.102467	2.641035

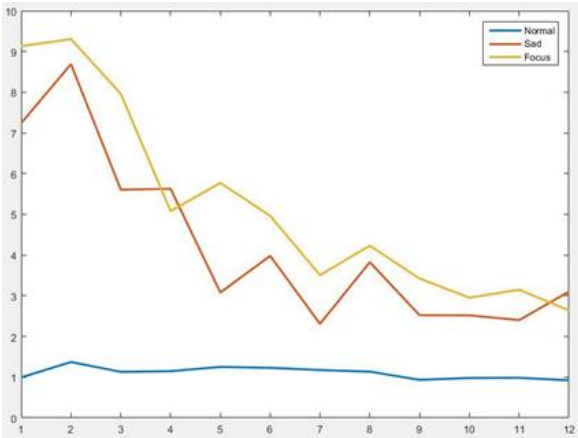

Fig. 7. FFT results when normal and shocked

IV. CONCLUSION

Based on the results that have been done, the results of the conclusion that each subject has its brain wave pattern based on the stimulus given so that the subject is in a particular emotional state. While it can be seen the shape and value of the brain wave frequency spectrum using Fast Fourier Transform from each recorded brain wave, but still needed to take more brain wave record data and expand its scope as reviewed in terms of age, gender, and others others so that the results of the shape or value of the FFT spectrum can be more accurate and detailed.

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