ISSN 2047-3338

Identification of EEG Signal Towards the Motor Movement and its Imaginary Using Wavelet Transformation

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Abstract– **Technology using the brain signal, so-called electroencephalogram (EEG), either for controlling or for communication with certain devices is called as Brain Computer Interface (BCI). Through this research the brain signal of the Event–Related Synchronization /Desynchronization (ERS/ERD) as a kind of EEG signals for a motor movement was generated by movement and imagination to move the simulation of steering wheel of "turning right" and "turning left". ERS/ERD was obtained through a signal processing in the forms of centering, bandpass filter and signal correlation. The features obtained from the signal processing were subsequently correlated with the types of wavelet such as Daubechies8, Daubechies9, Daubechies10, Symlet6 and Symlet8. The correlation was carried out by involving 22 volunteers simultaneously and 2 volunteers separately. The result of this correlation shows that each volunteer has different scale of wavelet to yield a higher correlation values.**

Index Terms– **BCI, ERS/ERD, Centering, Wavelet Transform, Signal Correlation and Motor Movement**

I. INTRODUCTION

BIOELECTRIC in brain could be calculated using a set of instruments called electroencephalograph (EEG) in which the result of that calculation is needed for diagnosis of brain condition or patient mentality. The given anomaly on EEG in turn indicates a disorder to the brain of the patient.

In its development, the EEG signal, initially used to diagnose the brain, recently could also be applied for the needs of communication or control towards an external device. Technology using EEG to do controlling or communication using the external devices is known as BCI (Brain Computer Interface). The level of intensity and the pattern of electrical activity will be determined by a mental condition and external stimuli. At this point, the intensity of the brain wave on the surface of head skin could range from 0-200 microvolt with the frequency ranging from 0-50 Hz (Guyton and Hall, 1997).

ERS/ERD, an EEG signal emerging as a result of the given motor movement occurred in body, refers to one of the types of EEG signal used in the system of BCI. For this, an appropriate movement will increase or decrease the amplitude of signal in the range of specific frequency. This signal maximally will be measured in the area of motor cortex. Due to a given stimulus, motor behavior of someone could decrease or increase amplitude from ERS/ERD (Xu and Song, 2010). In order to obtain the signal of ERS/ERD, a signal processing comes to be essential due to the signal that will be hindered in the signal background, bioelectrical signal and other noise signals.

Several studies have been conducted on the processing and classification of EEG signals related to the motor movement. Xu and Song (2008) conducted a research on the EEG signal with an order of movement of the right and the left hand which was calculated at C3, CZ and C4 using the method of bipolar tapping. The signal of EEG was subsequently filtered using the bandpass filter of 0.5 - 30 Hz. The signal at the next stage was decomposed with a wavelet transformation, which here used Daubechies order 10 with 4 levels of decomposition. A statistical calculation was done towards the coefficients of wavelet that have been obtained including average, standard of deviation and average energy. Besides, the signal of EEG that has been filtered was processed by autoregressive (AR) of 6^{th} order using the Burg's method. The statistical calculation of the coefficient of wavelet and that of AR was used as an input from Linear Discriminant Analysis (LDA) later used for classification.

Mu et al. (2009) conducted a research of the signal of EEG with an order of the movement of the right and left hand measured from the electrodes at the points of C3, CZ and C4. Short Time Fourier Transform (STFT) was used to transform the signals located in the domain of time to be in the domain of time-frequency. It was initiated by filtering the signals ranging from 1 - 45 Hz. It was found then that during the movement of the left hand, the concentration of the energy was at the frequency of 10 - 15 Hz at the electrode position of C3. From the movement of the right hand, the energy concentration conversely was at the frequency of 10 – 15 Hz at the electrode position of C4. Fisher Distance method afterward was used for the process of classification.

Faradji et al (2010) in their research have calculated EEG from the position of C3, C4, P3, P4, O1 and O2 based on the international system of 10-20. This system based the measurement made of nasion inion on the left and right side of the head. This research involved four different orders:

calculating the multiplication, writing a letter to friend, spinning a three-dimension object and writing the order of numbers on a board. Data in a length of 2500 was divided into 45 segments, each of which was 256 in length where the overlap in the next segment was 206 data in length. EEG consisting of 6 channels was separately managed using a package of wavelet transformation – in this case Daubechies and Symlet. The base of wavelet obtained then was calculated using autoregressive (AR) purposively to get the coefficient of AR. Subsequently, the coefficient of AR from each segment for each channel was structured to be a vector that is a typicality of each channel. Here, the Burg's method was used and classification was done by using Quadratic Discrimant Analysis (QD).

Kumar and Ravi (2011) meanwhile conducted a research on the data of EEG, which was managed using the wavelet transformation in order to obtain certain feature of a brain signal. The wavelet transformation was used to do decomposition for obtaining the vector of decomposition which in turn was used to calculate the approximate coefficient, detail coefficient, horizontal coefficient and vertical coefficient. Those coefficients were the inputs to measure the energy and typicality of the EEG signal occurred due to the external stimulus.

In turn, the aim of this research is to find out the features of EEG signal for the motor movement and imagination of motor movement of "turn right" and "turn left". This signal features will be correlated to the transformation of the wavelets which in this case include continuous wavelet transformation (CWT) and mother wavelet that have a suitable form for the features. To obtain the feature, a process of signal processing including centering, bandpass filter and signal correlation was performed. The ranges of the bandpass filter used in this research are at 4-8 Hz, 4-13 Hz, 4-20 Hz, 8-13 Hz, 8-20 Hz and 13-20 Hz with a consideration that the range of the frequency covers that of signals of Tetha, Alpha and Beta Low from EEG in which ERS/ERD is probably present. A number of bandpass filters is used to accurately find out where ERS/ERD actually is. Centering is to exclude the background of the signals by excluding the average of the signals, thus, resulting in the signals with zero average. The correlation of the signal meanwhile is to determine the degrees of the signals correlating to each other.

The data is taken by positioning the electrodes to C3, C4, P3, and P4 (Central and Parietal) since these points are located in the area of motor cortex that is the area having a direct relevance with the motor order.

In Chapter II Fundamental will discuss several types of EEG signals used in BCI systems and the basic theory of wavelet transformation, Chapter III Research Methodology, Chapter IV Result of Research and Discussion, Chapter V Conclusion.

II. FUNDAMENTAL

This section is designed to discuss about the basic theories supporting this research.

A. Signal of EEG for BCI

BCI refers to a system taking and analyzing the signals from the nerves of the brain in the aim of creating communication between the brain and the computer. Simply, BCI is an interface between the brain signal and computer. A brain signal based interface requires an online detection from mental condition of a spontaneous activity.

Ochoa (2002) describes several waves of EEG related to the needs of BCI:

1. Wave of *Mu* and *Alpha*

   The wave of *Mu* refers to the spontaneous wave of EEG with a range of frequency between 8-12 Hz. It is related to the motor activity and maximally measured in the area of sensorimotor cortex.

2. ERS/ERD

   A proper motion will increase or decrease the amplitude of signal in the distance of specific frequency. This signal maximally will be measured in the area of motor cortex. The signal even appears when someone imagines a motion; for instance when someone does a movement under a preparation rather than as a signal of a movement.

3. Slow Cortical Potential

   A negative or positive large signal will shift in a signal of EEG for 300 ms to several minutes.

4. The Component of P3 from Evoked Potential

   A shift of positive signal in EEG occurs for 300 – 400 ms in approximately once a stimulus occurs. This signal maximally will be measured in the central parietal area. In P3, a practice is not required.

5. Short-Latency Visual Evoked Potentials

   In order to make this response appear, a response from a short visual stimulus is highly needed. This component maximally will be measured in the occipital area and there is no practice needed to make it appear.

6. Individual Neuron Recordings

   An electrode will be planted in someone who will accept the response from a local neuron or even stimulate the nerve tissue to grow in the planted electrode.

7. Steady-State Visual Evoked Potential (SSVER)

   A response towards a visual stimulus is modulated in certain frequency. SSVER is characterized through an increase of EEG activity caused by a stimulus of frequency. The visual stimulus is generated by the white fluorescent tube which is modulated at the range of 13-25 Hz or by using the flash of stroboscopic lamp.

It is found from those signals that there has been a significant relationship between what has been in someone mind and the characteristic of the recorded signals of EEG.

B. Wavelet Transformation

Continuous wavelet transformation (CWT) is developed as an alternative approach in solving the problems in STFT (Short-Time Fourier Transform). It is defined as a signal integral multiplied with the function of wavelet scale and shift ψ (scale, position, time):

$$C(scale, position) = \int_{-\infty}^{\infty} f(t)\Psi(scale, position, t)dt \quad (1)$$

$$CWT_x^{\psi}(\tau, s) = \Psi_x^{\psi}(\tau, s) = \frac{1}{\sqrt{|s|}}\int x(t)\psi^*\left(\frac{t-\tau}{s}\right)dt \quad (2)$$

In the equation of (1) and (2), τ refers to a shift, s is as a scale, and ψ (t) is as a transformation function or well known as mother wavelet. Meanwhile, the term of translation or shift is related to the location of window, which keeps on making a shift for the signal transformed. The result of CWT is a number of coefficients of wavelet C that is a function of scale and position. Multiplying each coefficient with wavelet with certain scale and shift will result in the element of wavelet from the original signal. There are many families from the bases of wavelet including Haar, Daubechies, Biortogonal, Coiflet, Symlets, Morlet, Mexican Hat and Meyer.

In this research the calculation was conducted towards 22 volunteers using the unipolar technique of "system 10-20" at C3, C4, P3 and P4.

III. RESEARCH METHODOLOGY

The data retrieval was conducted using Bio-signal calculation Instrument K&H Type KL-710.

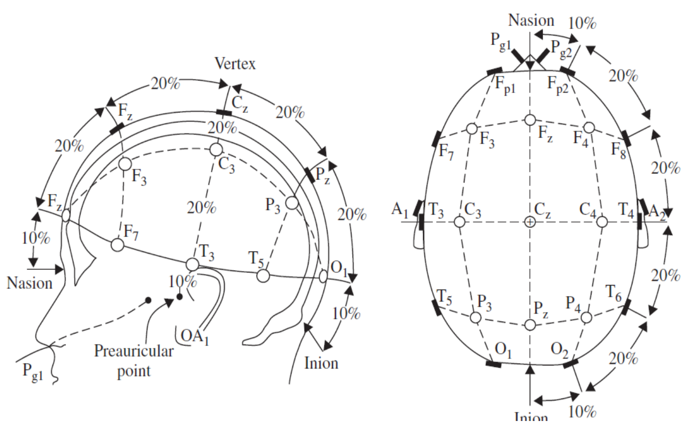

Fig. 1. Technique in installing electrode of EEG System 10-20 (Sanei, 2007)

Fig. 2. Bio-signal calculation Instrument K&H Type KL-710 (www.kandh.com.tw/products)

Fig. 3. The steering wheel and the turning sign

Fig. 4. The electrode points of EEG to volunteer

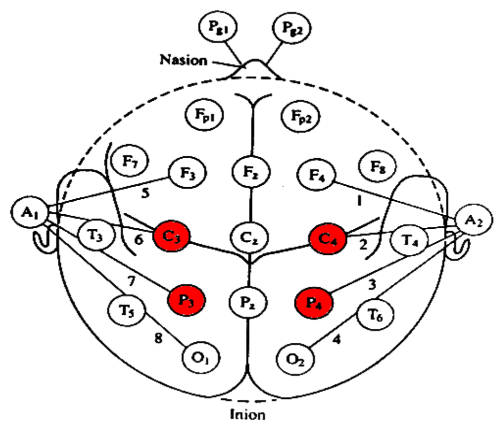

Fig. 5. The Scheme of the electrode points of EEG to the volunteer with the system of 10-20 (Gabriel, 1996)

The followings are the stages of data retrieval of EEG from the volunteer.

1. Electrode is installed at the points of C3, C4, P3 and P4 using the unipolar system with the right and the left ears as a point of reference.
2. The installation of EEG electrode is conducted by the nurse from the medical laboratory that is competent in installing the electrode and operating the EEG devices.
3. A steering wheel is positioned in front of the volunteer and adjusted based on the position of the hands to make

the volunteers comfortable. The screen of the monitor is functioned to emerge the stimulus that is in the form of directional sign of movement positioned at a distance in order to avoid the occurrence of the electrical potential of the brain emergence as a result of stimulus in the form of light.

4. When the calculation is started, the volunteer is required to focus on the direction of movement on the monitor screen. If on the screen, the directional sign appears as the turning right, the volunteer is required to turn the steering wheel to the right vice versa.
5. In each stage of the calculation from the stimulus of the directional sign, there are 5 times of turning right and 5 times for turning left, randomly emerged. The emerging period of on the monitor is within 3 seconds and the interval was for 3 seconds. The data retrieval is taken from each volunteer within 10 stages – 5 stages are by moving the steering wheel and other further five stages are without the steering wheel.
6. Based on the time obtained from the software, segmentation is subsequently conducted. It is aimed to make the process of characteristic extraction come to be easier and more focused merely on the signal of ERS/ERD occurred at 200-400 ms after stimulus. The segmentation is conducted by picking out the data 1 second before reaching 2 seconds after the stimulus of the directional sign of turning right and turning left are given. Thus, the segmented data of 25 data of turning right and turning left from each of volunteer will be obtained.
7. The signals of EEG from the calculation are categorized based on the direction of the movement of ”turning right” and ”turning left” and the position of electrodes of C3, C4, P3 and P4 and the motor movement by moving the steer wheel and motor movement without moving the steer wheel.
8. The calculation was conducted to 22 volunteers who are under fit condition and not suffering from muscle paralysis.

Fig. 6. The Condition of Volunteer in data retrieval

The block diagram of this research is as follows:

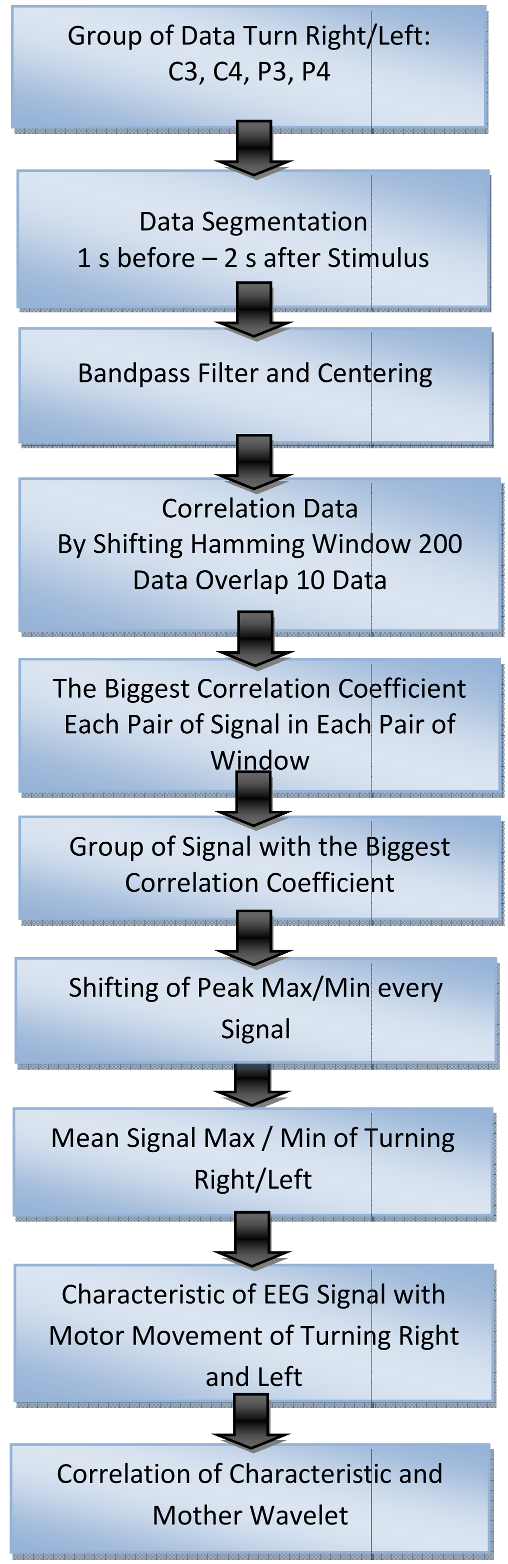

Fig. 7. Block Diagram of Research

In this research, the segmentation will be done to the data of EEG from the result of the calculation from the electrodes of C3, C4, P3 and P4 both from the motor movement of “turning right” and “turning left” and from the motor movement by moving the steer wheel or that of without moving the steer wheel. The segmentation will be by picking out the data 1 second before reaching 2 seconds after the emergence of the stimulus on the screen of the monitor. The process of segmentation was aimed to make the signal from the motor movement to be the only one managed. Some ranges of bandpass filter are used to find out the characteristics of EEG signal that is capable of differentiating between the signal of EEG of turning right and that of the turning left. The ranges of the bandpass filter used include 4-8 Hz, 4-13 Hz, 4-20 Hz, 8-13 Hz, 8-20 Hz and 13-20 Hz. Centering at this point is functioned to omit the background signals.

Correlation towards 25 data from each volunteer with and without the movement of the steering wheel is separately categorized. The first data is correlated to the second data until the 25th data. Windowing in the form of Hamming window with 200 data is done to each signal from 25 data with an overlap of 10 data for each shift of the window. Hamming window is used to decrease the function of sinc on each signal in window. The followings are the formulas from the Hamming window:

$$w_n = 0.54 - 0.46 \cos \frac{2\pi n}{N-1} \qquad (3)$$

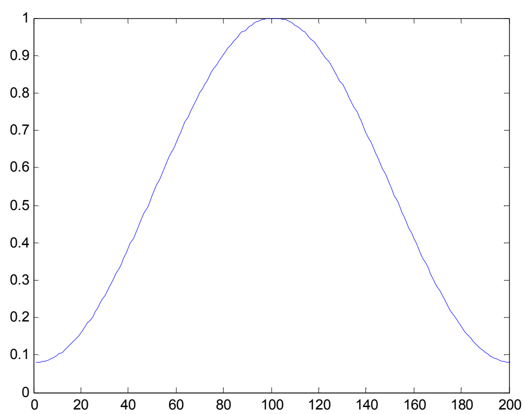

Fig. 8. Hamming window

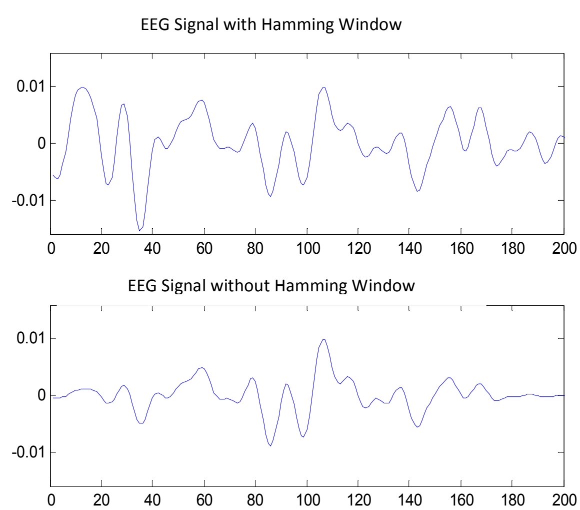

Fig. 9. Signal of EEG with and without hamming window

The first Window from the first data is correlated to the first window to the last window from the second data. Subsequently, the second window from the first data is correlated to the first window up to the last window from the second data ke-2 continuously until the last window of the first data is correlated to the first window to the last one from the second data. Each pair of each window shift will result in one coefficient of correlation. The signal from the pair of windows with the highest coefficient of correlation will be obtained from the first and the second data. This phase was done by the first data to the second data 2: 25, the second data to the third data: 25, the third data to the fourth data: 25 and continuously until the 24th data to the 25th data. By doing so, a group pf data containing several signals that are correlated each other will be obtained.

The coefficient of correlation is obtained by finding out the ratio of the eigenvalue, which is a comparison from the value of the first and the second eigen from the matrix of covariant of signal in the window pair. The largest ratio of eigenvalue indicates that the signal has a larger correlation value.

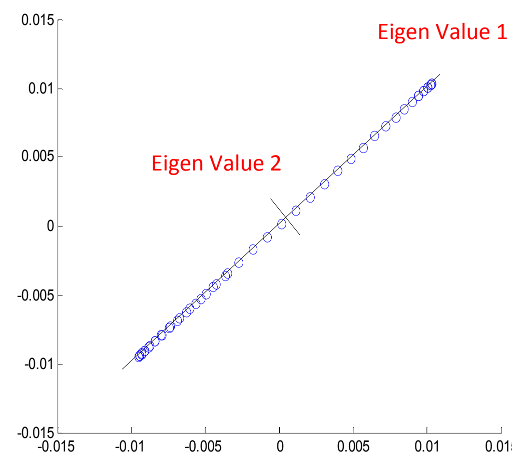

Fig. 10. Comparison of Eigen Value

Potential of the brain as a result of a mechanical movement is characterized by the increase or decrease of amplitude of signal significantly (Kooi, 2010). For this, the point of the maximum and minimum peak for the group of signals correlated each other will be found out which subsequently is to be shifted and united into one point. The group of the signals with the points of maximum and minimum peak that have been combined will be averaged in order to obtain one averaged signal with a maximum peak and one averaged signal with the point of minimum peak from 22 volunteers. Those averaged signals will be used as a characteristic of motor movement of turning right and turning left.

IV. RESULT OF RESEARCH AND DISCUSSION

In this research, one averaged signal with a point of maximum peak was obtained and one averaged signal with the point of minimum peak for the turning right and that of with the maximum peak and another with the point of minimum peak for the turning left from 22 volunteers for each point of electrode C3, C4, P3 and P4 in each bandpass filters; namely 4 – 8 Hz, 4 – 13 Hz, 4 – 20 Hz, 8 – 13 Hz, 8 – 20 Hz and 13 – 20 Hz

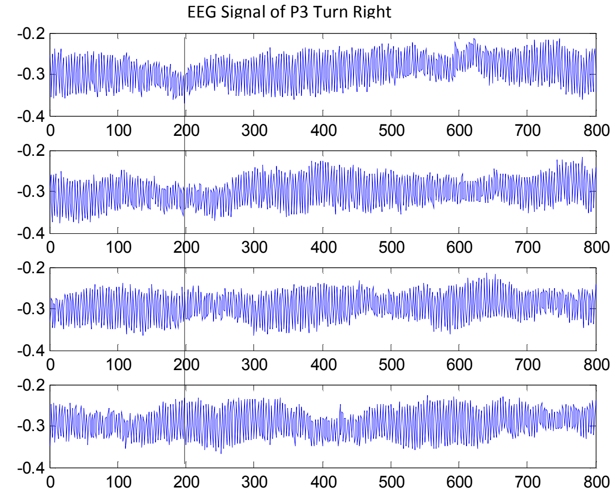

Fig. 11. Signal of EEG before being filtered (Line = the stimulus point)

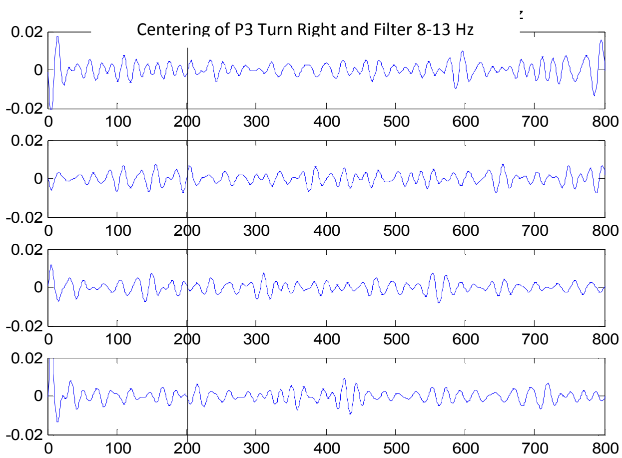

Fig. 12. Signal EEG filter 8-13 Hz (Line = the stimulus point)

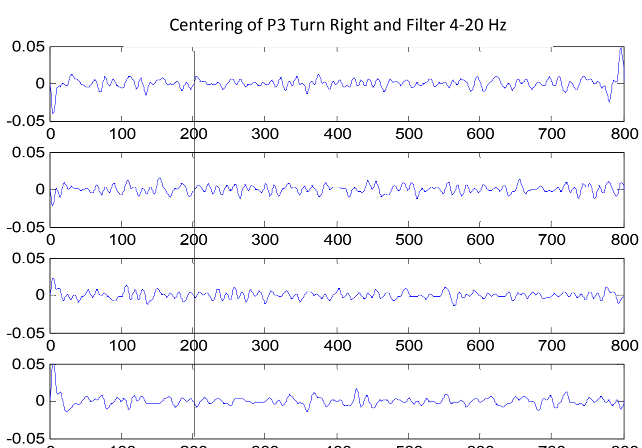

Fig. 13. Signal EEG filter 4-20 Hz (Line = stimulus point)

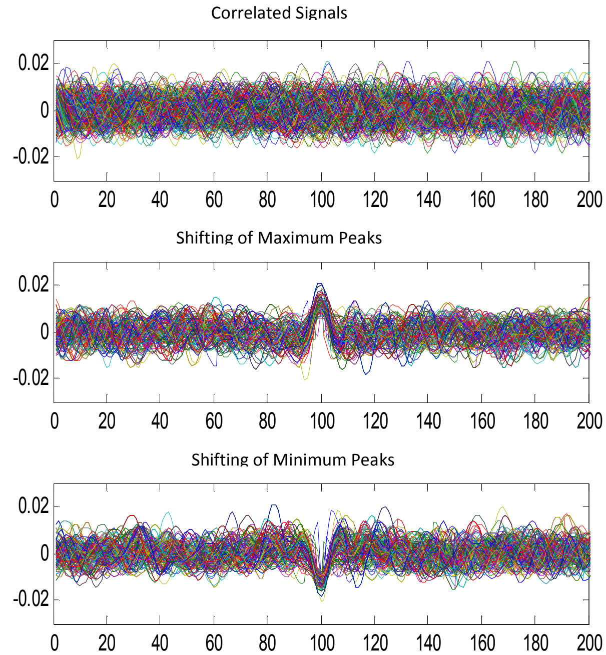

Fig. 14. The Signals correlated to the shift of the maximum and minimum peak

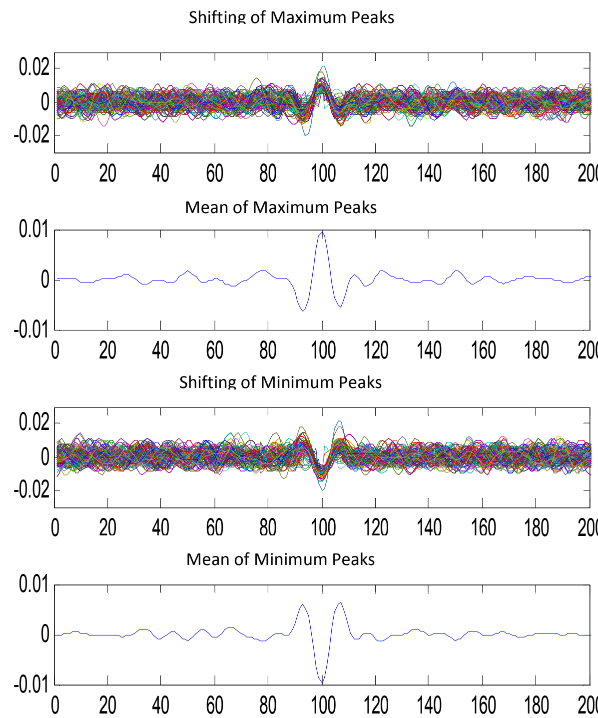

Fig. 15. The signal average of the maximum and minimum peak

The coefficients of the lowest correlation from a pair of EEG signal for turning right and left from each electrode and each average of bandpass filter indicate the most significant difference among the pairs of signal characteristics of the signals of turning right and turning left. The following table show the coefficient of correlation of each pair of signal of turning right and turning left for each electrode and the average of bandpass filter for the motor movement with and without moving the steering wheel.

Table 1: The Coefficient of signal characteristic correlation by moving the steering wheel

		FILTER					
		4 - 8 Hz	4 - 13 Hz	4 - 20 Hz	8 - 13 Hz	8 - 20 Hz	13 - 20 Hz
C3	PEAK MAX	3480	640	593	1775	851	1106
	PEAK MIN	2804	557	540	996	769	752
C4	PEAK MAX	788	616	372	1306	777	1064
	PEAK MIN	967	554	551	1673	965	1241
P3	PEAK MAX	1264	595	371	1884	610	1119
	PEAK MIN	1673	426	385	1931	908	1367
P4	PEAK MAX	1381	406	371	864	676	883
	PEAK MIN	761	337	243	941	652	1197

Table 2: Coefficient of correlation of signal characteristics without moving the steering wheel

		FILTER					
		4 - 8 Hz	4 - 13 Hz	4 - 20 Hz	8 - 13 Hz	8 - 20 Hz	13 - 20 Hz
C3	PEAK MAX	560	407	524	630	508	527
	PEAK MIN	770	540	357	824	383	803
C4	PEAK MAX	8949	4756	2982	4155	4050	2174
	PEAK MIN	8858	4424	3190	6080	5360	2723
P3	PEAK MAX	10475	8623	3024	6278	4743	6107
	PEAK MIN	17507	7514	2326	15982	3854	7512
P4	PEAK MAX	12955	5357	3249	10134	3762	3864
	PEAK MIN	7468	6426	3524	6533	4466	4887

It can been seen from Table 1 and Table 2 that the pair of signal characteristics with the lowest correlation coefficient by moving the steer wheel is at the electrode of P4 filter 4–20Hz at the point of minimum points. On the other hand, the characteristic of the signal without moving the steer wheel is at the electrodes C3 filter of 4 –20 Hz at the point of minimum peak. Thus, the characteristics of those signal used as a reference in making wavelet of turning right and turning left are taken from the signals. From Table 1 and Table 2 it can be seen that the group of the signal characteristics in the range of frequency 4–20 Hz has a lower correlation coefficient compared to other frequencies.

Once the characteristics of the signal of EEG with the motor movement of turning right and turning left have been obtained, the characteristics will be correlated to mother

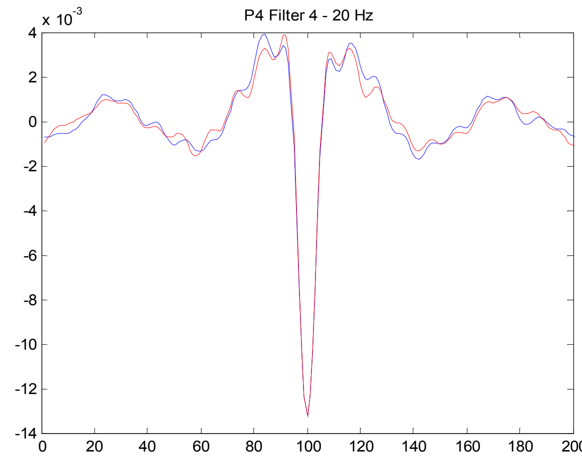

Fig. 16. The pairs of characteristics of P4 filter 4-20 Hz with movement of the steer wheel for the shift of the minimum peak (right=blue, and left = red. Left = red)

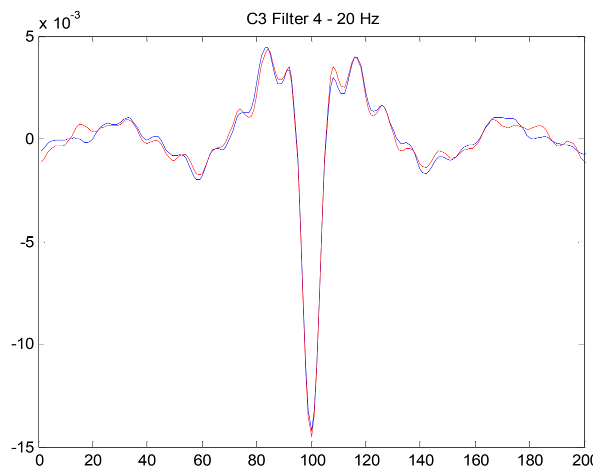

Fig. 17. The characteristic of pairs of C3 filter 4-20 Hz without any movement of shifts for the shift of the minimum peak of the points. (right = blue, left = red)

wavelet. Mother wavelet is chosen for having an equal form to the features of the EEG signal. In this research Daubechies8, Daubechies9, Daubechies10, Symlet6 and Symlet8 will be chosen to be correlated using the characteristics of the EEG signal.

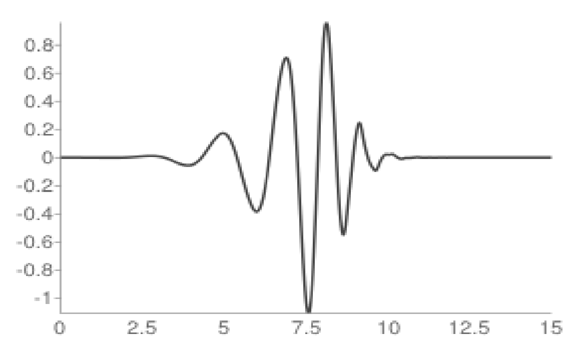

Fig. 18. Daubechies8

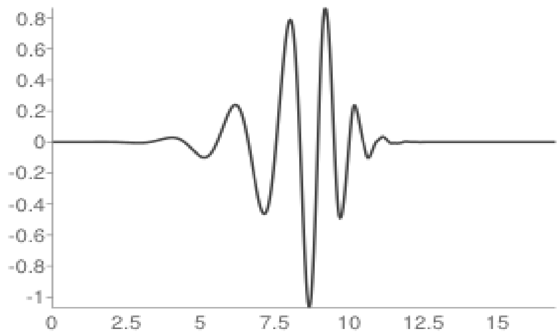

Fig. 19. Daubechies9

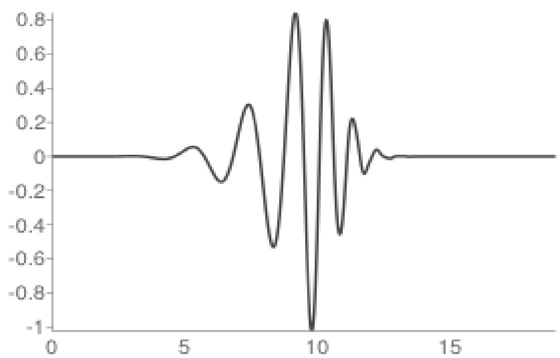

Fig. 20. Daubechies10

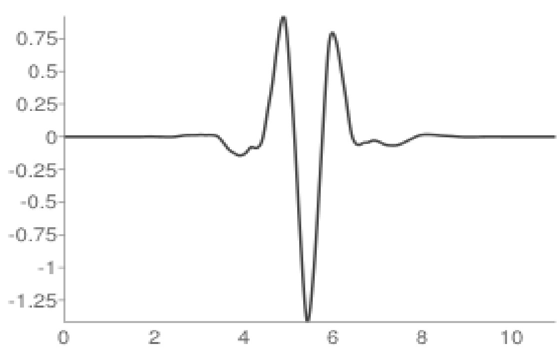

Fig. 21. Symlet6

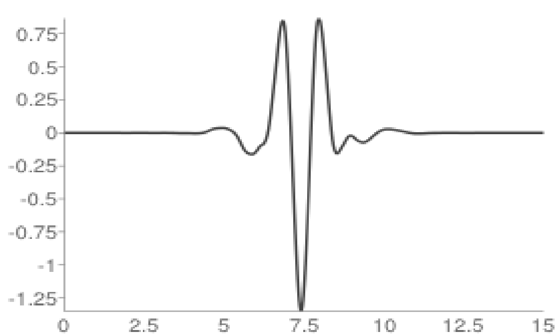

Figure 22. Symlet8

The wavelet testing was conducted towards a group of testing data that have been prepared. The testing data also include the data used in the process of data processing but with different length of data segmentation. If in the processing phase, segmentation data is done in 1 second before reaching 2 second after the stimulus is given, the directional sign will be emerged. The segmentation in the testing data is done in 3 seconds before reaching 3 seconds after the stimulus is given. Through the sampling rate of 200 data per second, if the data in the processing phase results in 600 point in data length, it can result in the data of 1200 points in the testing phase.

The testing was conducted by correlating Daubechies8, Daubechies9, Daubechies10, Symlet6 and Symlet8 with the testing data; namely group of testing data of turning right and turning left for the movement with and without steer wheel in each position of electrode C3, C4, P3 and P4. Accuracy in this testing is determined by calculating the number of signal with the highest coefficient of correlation that is the point of the maximum peak in the range of data of 1 second until 2 seconds after the stimulus is given.

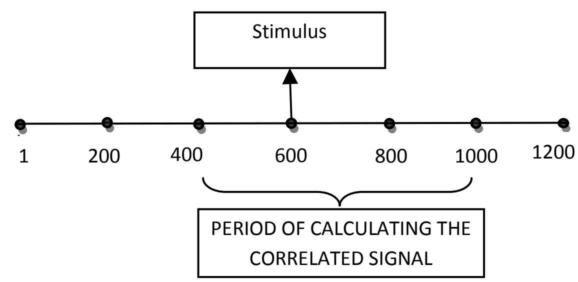

Fig. 23. Structure of the testing data

The followings tables present the results of correlation of EEG data of turning right and turning left with the mother wavelets of Daubechies8, Daubechies9, Daubechies10, Symlet6 and Symlet8 with 1:200 in scale. The numbers shown in the tables are the maximum and minimum values from the result of correlation from scale 1 to scale 200 for each type of wavelet.

The numbers shown in the following tables cover the “Max Peak”, a correlation with the highest signal peak in the period of calculation from the testing data towards the type of short type of the wave. “Min Peak” refers to a correlation with the lowest peak of the signal. Meanwhile, “Max-Min Peak refers to the correlation with the highest and the lowest peak; one of which was merely to be chosen.

Table 3: Correlation of 22 Volunteers at the Maximum Values (%) for the Movement with Steering Wheel

		STEERING WHEEL								
		PEAK MAX			PEAK MIN			PEAK MAX + MIN		
		RIGHT	LEFT	DIFF	RIGHT	LEFT	DIFF	RIGHT	LEFT	DIFF
C3	SYMLET6	56.2	56.9	2.9	57.1	56.9	5.8	69.8	70.5	4.4
	SYMLET8	56.7	57.1	2.5	57.3	57.1	7.1	68.7	69.5	4.0
	DAUBECHIES8	57.6	56.4	6.9	56.5	56.0	5.8	69.3	71.8	4.7
	DAUBECHIES9	57.3	56.9	4.2	58.5	57.5	5.1	71.6	73.6	5.1
	DAUBECHIES10	58.0	58.2	4.4	59.5	56.2	5.6	71.5	72.7	4.4
C4	SYMLET6	54.7	53.6	4.4	55.5	56.2	3.1	69.6	68.5	3.3
	SYMLET8	54.4	54.4	2.7	54.7	55.6	3.8	66.5	66.9	2.5
	DAUBECHIES8	54.4	55.3	4.9	54.9	56.5	3.1	69.8	69.1	4.2
	DAUBECHIES9	54.4	55.5	4.2	55.6	56.0	3.3	70.0	70.5	5.1
	DAUBECHIES10	55.5	56.4	4.4	55.1	56.2	4.7	70.5	70.0	4.4
P3	SYMLET6	57.6	57.8	4.2	56.4	57.1	6.2	71.5	69.5	6.9
	SYMLET8	57.8	57.8	3.8	58.0	56.7	7.1	71.1	69.3	5.6
	DAUBECHIES8	56.7	56.2	6.7	56.4	57.8	4.7	69.3	70.9	6.7
	DAUBECHIES9	58.4	56.7	7.1	55.1	58.4	4.4	70.7	70.9	6.7
	DAUBECHIES10	57.3	56.7	5.3	56.4	58.4	4.7	69.8	70.9	5.3
P4	SYMLET6	58.7	58.5	6.4	56.4	57.6	5.3	70.9	70.2	7.1
	SYMLET8	58.4	59.5	4.5	56.0	58.2	5.5	69.6	69.6	5.5
	DAUBECHIES8	57.3	57.3	6.7	56.9	57.1	5.3	69.6	70.9	6.0
	DAUBECHIES9	58.4	58.5	7.1	56.2	57.3	6.2	71.3	71.3	8.0
	DAUBECHIES10	57.1	56.7	6.2	57.5	57.1	6.9	70.5	71.5	6.2
MAX		**58.7**	**59.5**	**7.1**	**59.5**	**58.4**	**7.1**	**71.6**	**73.6**	**8.0**

Table 4: Correlation of 22 Volunteers at the Maximum Values (%) for the Movement without Steering Wheel

		NON STEERING WHEEL								
		PEAK MAX			PEAK MIN			PEAK MAX + MIN		
		RIGHT	LEFT	DIFF	RIGHT	LEFT	DIFF	RIGHT	LEFT	DIFF
C3	SYMLET6	55.1	59.1	2.0	54.7	56.0	4.4	68.2	70.0	4.2
	SYMLET8	54.5	59.1	3.1	55.8	55.5	2.2	66.9	68.9	3.6
	DAUBECHIES8	55.1	55.8	3.1	54.7	56.0	2.7	70.9	67.3	3.6
	DAUBECHIES9	56.4	55.6	6.0	54.7	56.0	3.5	70.9	68.2	2.7
	DAUBECHIES10	54.7	55.8	2.9	54.7	56.0	4.7	70.7	69.1	3.1
C4	SYMLET6	57.1	56.4	4.5	54.4	57.5	4.9	68.0	67.6	4.9
	SYMLET8	56.5	56.7	4.0	54.0	58.5	4.9	67.8	66.5	5.5
	DAUBECHIES8	56.5	55.3	5.6	57.1	55.6	5.8	67.8	67.6	7.3
	DAUBECHIES9	56.2	56.7	4.2	56.5	56.2	2.9	67.5	67.1	5.8
	DAUBECHIES10	56.2	56.4	3.6	57.1	55.5	6.4	70.0	68.2	4.7
P3	SYMLET6	55.8	59.5	3.5	56.0	58.9	3.5	66.2	72.2	2.2
	SYMLET8	55.6	60.4	2.0	56.2	58.5	2.9	66.5	71.8	2.4
	DAUBECHIES8	55.6	60.7	3.8	55.3	59.6	2.2	68.9	71.8	2.9
	DAUBECHIES9	56.2	60.7	6.5	55.6	60.0	2.2	68.9	72.4	5.3
	DAUBECHIES10	55.5	60.7	3.8	55.3	61.1	7.6	70.4	72.5	4.4
P4	SYMLET6	57.8	57.5	2.5	54.9	58.5	5.6	69.1	69.5	6.4
	SYMLET8	57.3	57.3	3.5	55.5	58.9	3.8	68.5	69.5	4.4
	DAUBECHIES8	57.1	58.4	6.5	55.8	57.1	3.3	69.5	69.8	5.6
	DAUBECHIES9	56.2	56.7	6.4	56.0	57.6	2.9	70.2	70.7	7.8
	DAUBECHIES10	56.7	56.7	6.4	56.0	57.3	3.8	69.8	70.5	7.1
MAX		**57.8**	**60.7**	**6.5**	**57.1**	**61.1**	**7.6**	**70.9**	**72.5**	**7.8**

Table 5. Correlation of 22 Volunteers at the Maximum Values (%) for the Movement with Steering Wheel

		STEERING WHEEL								
		PEAK MAX			PEAK MIN			PEAK MAX + MIN		
		RIGHT	LEFT	DIFF	RIGHT	LEFT	DIFF	RIGHT	LEFT	DIFF
C3	SYMLET6	0.18	0.73	-3.82	0.55	0.91	-5.64	0.73	1.64	-4.00
	SYMLET8	0.18	0	-4.36	0.36	0.36	-5.27	0.55	0.73	-3.27
	DAUBECHIES8	0	0.18	-3.82	0	0	-3.64	0.18	0.18	-4.36
	DAUBECHIES9	0	0	-2.55	0	0	-4.18	0.18	0.18	-2.00
	DAUBECHIES10	0	0	-4.36	0	0	-3.64	0.18	0.18	-2.91
C4	SYMLET6	0.73	0.18	-5.45	0.55	0.91	-4.36	1.27	1.27	-5.27
	SYMLET8	0.18	0.18	-4.91	0.91	0.91	-4.18	1.45	1.45	-4.91
	DAUBECHIES8	0	0.18	-5.46	0	0.18	-3.45	0.18	0.36	-4.18
	DAUBECHIES9	0	0	-6.91	0	0	-6.54	0.18	0.18	-4.00
	DAUBECHIES10	0	0	-5.09	0	0	-4.36	0.18	0.18	-3.64
P3	SYMLET6	0.18	0.91	-7.82	0.55	0	-3.64	0.73	1.27	-3.27
	SYMLET8	0.18	0.18	-5.27	0	0.18	-3.45	0.36	0.55	-4.18
	DAUBECHIES8	0	0	-3.64	0	0	-5.27	0.18	0.18	-4.00
	DAUBECHIES9	0	0	-7.82	0	0	-3.82	0.18	0.18	-4.36
	DAUBECHIES10	0	0	-6.55	0	0	-6.91	0.18	0.18	-6.00
P4	SYMLET6	0.73	0.36	-5.27	0.73	0.36	-5.46	1.27	0.91	-6.18
	SYMLET8	0.55	0	-5.27	0.36	0.18	-4.73	1.27	0.18	-5.45
	DAUBECHIES8	0	0	-4.55	0.18	0	-4.91	0.18	0.18	-3.45
	DAUBECHIES9	0	0	-3.46	0	0	-5.64	0.18	0.18	-5.09
	DAUBECHIES10	0	0	-5.27	0	0	-4.91	0.18	0.18	-4.18
MIN		**0**	**0**	**-7.82**	**0**	**0**	**-6.91**	**0.18**	**0.18**	**-6.18**

Table 6: Correlation of 22 Volunteers at the Minimum Value (%) for the Movement without Steering Wheel

		NON STEERING WHEEL								
		PEAK MAX			PEAK MIN			PEAK MAX + MIN		
		RIGHT	LEFT	DIFF	RIGHT	LEFT	DIFF	RIGHT	LEFT	DIFF
C3	SYMLET6	0.55	0.91	-8.00	0.73	0.36	-7.09	1.45	1.27	-7.27
	SYMLET8	0.18	0.18	-6.73	0.55	0.55	-6.36	0.73	0.73	-5.82
	DAUBECHIES8	0	0	-10.55	0.18	0	-8.91	0.18	0.18	-7.82
	DAUBECHIES9	0	0	-10.55	0	0	-9.27	0.18	0.18	-10.73
	DAUBECHIES10	0	0	-10.18	0	0	-9.27	0.18	0.18	-8.91
C4	SYMLET6	0.73	0.55	-4.18	0.18	0.55	-7.27	0.91	1.27	-4.18
	SYMLET8	0.55	0.73	-3.82	0.36	0.55	-7.82	1.09	1.09	-4.00
	DAUBECHIES8	0	0	-7.27	0	0	-5.64	0.18	0.18	-6.18
	DAUBECHIES9	0	0	-6.91	0	0	-6.91	0.18	0.18	-5.45
	DAUBECHIES10	0	0	-6.73	0	0	-6.73	0.18	0.18	-6.18
P3	SYMLET6	0.18	0	-8.73	0	0.91	-9.46	0.18	0.91	-9.45
	SYMLET8	0.18	0.18	-10.00	0	0.91	-9.09	0.36	1.27	-9.64
	DAUBECHIES8	0	0	-10.91	0	0	-9.27	0.18	0.18	-7.64
	DAUBECHIES9	0	0	-11.09	0	0	-9.82	0.18	0.18	-8.55
	DAUBECHIES10	0	0	-10.73	0	0	-10.00	0.18	0.18	-10.55
P4	SYMLET6	0.73	0.18	-5.27	0.18	0.36	-7.82	0.91	0.55	-6.55
	SYMLET8	0.36	0.55	-5.46	0.36	0.55	-7.09	0.91	1.45	-5.64
	DAUBECHIES8	0	0	-6.73	0	0	-6.00	0.18	0.18	-5.27
	DAUBECHIES9	0	0	-6.54	0	0	-5.82	0.18	0.18	-6.55
	DAUBECHIES10	0	0	-5.82	0	0	-5.82	0.18	0.18	-6.36
MIN		**0**	**0**	**-11.09**	**0**	**0**	**-10.00**	**0.18**	**0.18**	**-10.73**

The numbers in Table 3 to Table 6 show the number of the data of EEG correlated to the values of the maximum and minimum peak in percentage (%) from 22 volunteers both for the motor movement (with steer wheel) and for imaginary of motor movement (without steer wheel) of turning right and turning left. In those tables DIFF refers to a difference from the number of the signal correlated from the equal type of wavelet to the group of the testing data of turning right and turning left. The highest values for DIFF with the positive values (+) show that the type of wavelet is suitable for the data of turning right; while the highest value for DIFF with the negative value (-) show that the type of the wavelet is suitable for the data of turning left.

Table 3 to Table 6 shows that the value of DIFF for the correlation of Daubechies8, Daubechies9, Daubechies10, Symlet6 and Symlet8 towards the testing data of turning right and turning left from 22 volunteers simultaneously with the equal scale will result in the lower value of the presentation. Afterwards, correlation for the type of wavelet Daubechies8, Daubechies9, Daubechies10, Symlet6 and Symlet8 will be done to each volunteer that in this research was for 2 volunteers.

Table 7: Correlation of the Volunteer 1 at the Maximum Value (%) for the Movement without Steering Wheel

		STEERING WHEEL								
		PEAK MAX			PEAK MIN			PEAK MAX + MIN		
		RIGHT	LEFT	DIFF	RIGHT	LEFT	DIFF	RIGHT	LEFT	DIFF
C3	SYMLET6	80	68	20	80	64	28	92	76	16
	SYMLET8	84	72	32	72	68	24	92	80	28
	DAUBECHIES8	68	72	24	76	68	28	84	80	24
	DAUBECHIES9	72	68	32	72	68	28	84	80	28
	DAUBECHIES10	76	68	24	68	72	24	80	84	24
C4	SYMLET6	76	64	36	68	72	36	80	80	32
	SYMLET8	76	60	40	68	76	36	84	80	36
	DAUBECHIES8	68	64	36	68	64	32	84	76	36
	DAUBECHIES9	68	64	40	72	68	32	80	76	28
	DAUBECHIES10	72	72	40	72	72	36	84	80	36
P3	SYMLET6	68	72	24	76	64	20	84	84	28
	SYMLET8	72	76	20	76	68	24	84	84	20
	DAUBECHIES8	80	72	32	76	72	16	92	84	28
	DAUBECHIES9	80	72	24	68	72	20	84	80	20
	DAUBECHIES10	84	68	28	72	72	28	88	84	28
P4	SYMLET6	72	72	20	72	68	24	88	76	16
	SYMLET8	76	68	16	68	68	28	88	76	24
	DAUBECHIES8	80	72	28	84	80	28	92	80	28
	DAUBECHIES9	72	72	24	84	76	28	92	80	28
	DAUBECHIES10	72	72	20	84	68	36	92	76	28
MAX		**84**	**76**	**40**	**84**	**80**	**36**	**92**	**84**	**36**

Table 8: Correlation of Volunteer 1 at the Maximum Values (%) for the Movement without Steering Wheel

		NON STEERING WHEEL								
		PEAK MAX			PEAK MIN			PEAK MAX + MIN		
		RIGHT	LEFT	DIFF	RIGHT	LEFT	DIFF	RIGHT	LEFT	DIFF
C3	SYMLET6	60	72	12	60	72	16	76	84	16
	SYMLET8	60	68	8	56	68	12	68	80	16
	DAUBECHIES8	64	64	12	56	68	12	72	84	12
	DAUBECHIES9	60	68	12	56	68	8	76	80	12
	DAUBECHIES10	60	72	16	60	72	12	76	84	16
C4	SYMLET6	68	68	28	68	72	24	76	80	24
	SYMLET8	68	68	28	68	72	20	76	80	20
	DAUBECHIES8	68	76	28	68	76	24	80	88	36
	DAUBECHIES9	72	76	24	76	80	20	80	84	28
	DAUBECHIES10	64	72	24	68	84	24	84	84	24
P3	SYMLET6	64	72	16	68	72	16	72	84	24
	SYMLET8	64	80	16	68	80	16	72	88	16
	DAUBECHIES8	68	68	24	68	72	12	72	88	28
	DAUBECHIES9	68	72	20	64	68	16	72	84	16
	DAUBECHIES10	64	76	12	64	68	24	72	84	16
P4	SYMLET6	80	68	20	84	76	32	84	88	24
	SYMLET8	80	72	16	80	72	36	84	84	24
	DAUBECHIES8	76	76	28	84	68	28	84	80	32
	DAUBECHIES9	76	72	24	80	68	32	84	84	28
	DAUBECHIES10	76	76	28	80	72	32	84	84	32
MAX		**80**	**80**	**28**	**84**	**84**	**36**	**84**	**88**	**36**

Table 9: Correlation of Volunteer 1 at the Minimum Value (in %) for the Movement with the Steering Wheel

		STEERING WHEEL								
		PEAK MAX			PEAK MIN			PEAK MAX + MIN		
		RIGHT	LEFT	DIFF	RIGHT	LEFT	DIFF	RIGHT	LEFT	DIFF
C3	SYMLET6	0	0	-24	0	0	-32	4	4	-28
	SYMLET8	0	0	-28	0	0	-28	4	4	-28
	DAUBECHIES8	0	0	-40	0	0	-28	4	4	-36
	DAUBECHIES9	0	0	-32	0	0	-28	4	4	-32
	DAUBECHIES10	0	0	-20	0	0	-32	4	4	-32
C4	SYMLET6	0	0	-12	0	0	-28	4	4	-16
	SYMLET8	0	0	-12	0	0	-28	4	4	-16
	DAUBECHIES8	0	0	-16	0	0	-16	4	4	-20
	DAUBECHIES9	0	0	-20	0	0	-16	4	4	-28
	DAUBECHIES10	0	0	-24	0	0	-24	4	4	-28
P3	SYMLET6	0	0	-28	0	0	-28	4	4	-24
	SYMLET8	0	0	-28	0	0	-28	4	4	-32
	DAUBECHIES8	0	0	-32	0	0	-32	4	4	-28
	DAUBECHIES9	0	0	-28	0	0	-24	4	4	-28
	DAUBECHIES10	0	0	-32	0	0	-32	4	4	-28
P4	SYMLET6	0	0	-20	0	0	-16	4	4	-16
	SYMLET8	76	68	16	68	68	28	88	76	24
	DAUBECHIES8	0	0	-20	0	0	-28	4	4	-24
	DAUBECHIES9	0	0	-20	0	0	-16	4	4	-12
	DAUBECHIES10	0	0	-20	0	0	-12	4	4	-20
MIN		**0**	**0**	**-40**	**0**	**0**	**-32**	**4**	**4**	**-36**

Table 10: Correlation of Volunteer 1 at the Minimum Value (%) for the Movement without Steering Wheel

		NON STEERING WHEEL								
		PEAK MAX			PEAK MIN			PEAK MAX + MIN		
		RIGHT	LEFT	DIFF	RIGHT	LEFT	DIFF	RIGHT	LEFT	DIFF
C3	SYMLET6	0	0	-28	0	0	-28	4	4	-28
	SYMLET8	0	0	-20	0	0	-28	4	4	-24
	DAUBECHIES8	0	0	-24	0	0	-32	4	4	-24
	DAUBECHIES9	0	0	-32	0	0	-36	4	4	-24
	DAUBECHIES10	0	0	-32	0	0	-32	4	4	-32
C4	SYMLET6	0	0	-28	0	0	-32	4	4	-32
	SYMLET8	0	0	-32	0	0	-32	4	4	-36
	DAUBECHIES8	0	0	-36	0	0	-36	4	4	-32
	DAUBECHIES9	0	0	-36	0	0	-40	4	4	-32
	DAUBECHIES10	0	0	-36	0	0	-40	4	4	-36
P3	SYMLET6	0	0	-24	0	0	-28	4	4	-24
	SYMLET8	0	0	-20	0	0	-24	4	4	-24
	DAUBECHIES8	0	0	-28	0	0	-28	4	4	-32
	DAUBECHIES9	0	0	-36	0	0	-40	4	4	-32
	DAUBECHIES10	0	0	-28	0	0	-36	4	4	-28
P4	SYMLET6	0	0	-20	0	0	-24	4	4	-24
	SYMLET8	80	72	16	80	72	36	84	84	24
	DAUBECHIES8	0	0	-24	0	0	-20	4	4	-28
	DAUBECHIES9	0	0	-20	0	0	-28	4	4	-20
	DAUBECHIES10	0	0	-20	0	0	-36	4	4	-28
MIN		**0**	**0**	**-36**	**0**	**0**	**-40**	**4**	**4**	**-36**

Table 11: Correlation of the Volunteer 2 at the Maximum Value (%) for the Movement with Steering Wheel

		STEERING WHEEL								
		PEAK MAX			PEAK MIN			PEAK MAX + MIN		
		RIGHT	LEFT	DIFF	RIGHT	LEFT	DIFF	RIGHT	LEFT	DIFF
C3	SYMLET6	60	60	24	64	64	20	72	72	24
	SYMLET8	60	60	20	60	64	20	72	72	20
	DAUBECHIES8	60	60	20	60	64	16	72	76	16
	DAUBECHIES9	68	64	24	64	68	16	72	76	20
	DAUBECHIES10	64	64	20	68	72	20	76	80	24
C4	SYMLET6	68	68	16	60	60	20	76	76	20
	SYMLET8	68	68	28	64	60	20	72	76	24
	DAUBECHIES8	68	60	20	68	64	24	76	68	20
	DAUBECHIES9	68	64	24	64	68	20	80	76	20
	DAUBECHIES10	68	60	16	64	68	20	80	76	20
P3	SYMLET6	80	72	16	68	64	36	88	84	16
	SYMLET8	80	72	16	64	64	24	84	84	20
	DAUBECHIES8	72	64	36	72	68	24	84	84	28
	DAUBECHIES9	72	72	32	68	60	24	92	88	28
	DAUBECHIES10	76	72	36	68	64	28	88	84	28
P4	SYMLET6	76	68	36	64	56	20	84	76	28
	SYMLET8	76	68	36	64	60	24	80	76	32
	DAUBECHIES8	76	60	32	64	56	32	80	76	36
	DAUBECHIES9	72	64	36	64	56	28	84	72	36
	DAUBECHIES10	72	60	32	68	68	28	84	76	36
MAX		**80**	**72**	**36**	**72**	**72**	**36**	**92**	**88**	**36**

Table 12: Correlation of Volunteer 2 at the Maximum Value (%) for the Movement without Steering Wheel

		NON STEERING WHEEL								
		PEAK MAX			PEAK MIN			PEAK MAX + MIN		
		RIGHT	LEFT	DIFF	RIGHT	LEFT	DIFF	RIGHT	LEFT	DIFF
C3	SYMLET6	64	72	12	60	72	12	76	76	20
	SYMLET8	60	72	8	60	72	16	72	80	12
	DAUBECHIES8	60	76	4	60	72	8	76	88	8
	DAUBECHIES9	60	72	12	60	76	8	72	84	8
	DAUBECHIES10	64	76	8	56	80	12	76	88	12
C4	SYMLET6	68	72	24	68	84	24	80	84	28
	SYMLET8	68	72	20	68	80	24	80	84	24
	DAUBECHIES8	68	76	20	68	72	24	76	84	24
	DAUBECHIES9	72	76	28	68	76	24	80	80	20
	DAUBECHIES10	68	76	20	80	84	32	92	84	32
P3	SYMLET6	72	76	32	64	76	24	80	88	32
	SYMLET8	72	72	28	64	88	24	80	88	28
	DAUBECHIES8	68	76	20	64	64	24	76	84	24
	DAUBECHIES9	60	68	20	64	64	28	76	80	36
	DAUBECHIES10	60	60	20	68	72	20	80	80	20
P4	SYMLET6	72	72	20	64	72	12	76	80	12
	SYMLET8	68	76	16	64	72	12	76	80	12
	DAUBECHIES8	72	76	20	76	72	16	80	80	20
	DAUBECHIES9	72	68	20	76	76	16	80	80	20
	DAUBECHIES10	76	72	24	76	72	16	80	88	20
MAX		**76**	**76**	**32**	**80**	**88**	**32**	**92**	**88**	**36**

Table 13: Correlation of Volunteer 2 at Minimum Value (in %) for the Movement with Steering Wheel

		STEERING WHEEL								
		PEAK MAX			PEAK MIN			PEAK MAX + MIN		
		RIGHT	LEFT	DIFF	RIGHT	LEFT	DIFF	RIGHT	LEFT	DIFF
C3	SYMLET6	0	0	-24	0	0	-36	4	4	-28
	SYMLET8	0	0	-28	0	0	-40	4	4	-36
	DAUBECHIES8	0	0	-28	0	0	-32	4	4	-28
	DAUBECHIES9	0	0	-20	0	0	-28	4	4	-24
	DAUBECHIES10	0	0	-20	0	0	-32	4	4	-28
C4	SYMLET6	0	0	-12	0	0	-24	4	4	-20
	SYMLET8	0	0	-16	0	0	-20	4	4	-20
	DAUBECHIES8	0	0	-20	0	0	-24	4	4	-20
	DAUBECHIES9	0	0	-20	0	0	-36	4	4	-24
	DAUBECHIES10	0	0	-20	0	0	-24	4	4	-28
P3	SYMLET6	0	0	-28	0	0	-20	4	4	-24
	SYMLET8	0	0	-24	0	0	-20	4	4	-20
	DAUBECHIES8	0	0	-28	0	0	-24	4	4	-28
	DAUBECHIES9	0	0	-32	0	0	-28	4	4	-40
	DAUBECHIES10	0	0	-32	0	0	-24	4	4	-36
P4	SYMLET6	0	0	-16	0	0	-20	4	4	-12
	SYMLET8	0	0	-20	0	0	-16	4	4	-24
	DAUBECHIES8	0	0	-24	0	0	-20	4	4	-28
	DAUBECHIES9	0	0	-20	0	0	-24	4	4	-28
	DAUBECHIES10	0	0	-20	0	0	-20	4	4	-20
MIN		**0**	**0**	**-32**	**0**	**0**	**-40**	**4**	**4**	**-40**

Table 14: Correlation of Volunteer 2 at Minimum Value (%) for the Movement without Steering Wheel

		NON STEER WHEEL								
		PEAK MAX			PEAK MIN			PEAK MAX + MIN		
		RIGHT	LEFT	DIFF	RIGHT	LEFT	DIFF	RIGHT	LEFT	DIFF
C3	SYMLET6	0	0	-28	0	0	-36	4	4	-28
	SYMLET8	0	0	-24	0	0	-32	4	4	-24
	DAUBECHIES8	0	0	-36	0	0	-36	4	4	-24
	DAUBECHIES9	0	0	-32	0	0	-36	4	4	-24
	DAUBECHIES10	0	0	-40	0	0	-44	4	4	-32
C4	SYMLET6	0	0	-16	0	0	-44	4	4	-20
	SYMLET8	0	0	-20	0	0	-36	4	4	-12
	DAUBECHIES8	0	0	-24	0	0	-40	4	4	-24
	DAUBECHIES9	0	0	-20	0	0	-44	4	4	-16
	DAUBECHIES10	0	0	-28	0	0	-44	4	4	-24
P3	SYMLET6	0	0	-28	0	0	-36	4	4	-28
	SYMLET8	0	0	-24	0	0	-44	4	4	-24
	DAUBECHIES8	0	0	-40	0	0	-20	4	4	-28
	DAUBECHIES9	0	0	-28	0	0	-24	4	4	-24
	DAUBECHIES10	0	0	-24	0	0	-36	4	4	-32
P4	SYMLET6	0	0	-32	0	0	-32	4	4	-28
	SYMLET8	0	0	-28	0	0	-32	4	4	-24
	DAUBECHIES8	0	0	-28	0	0	-24	4	4	-28
	DAUBECHIES9	0	0	-24	0	0	-28	4	4	-28
	DAUBECHIES10	0	0	-24	0	0	-24	4	4	-28
MIN		**0**	**0**	**-40**	**0**	**0**	**-44**	**4**	**4**	**-32**

In Table 7 to Table 14, it is found that if Daubechies8, Daubechies9, Daubechies10, Symlet6 and Symlet8 are correlated to the testing data of turning right and turning left will obtain the higher value of DIFF. This then shows that each volunteer has correlation with the various scales.

V. CONCLUSION

Some conclusions are taken from the research as follows.

1. In order to obtain the features of the EEG signal for the motor movement of ERD/ERS, a signal processing can be used including centering, bandpass filter and correlation of signal with a consideration that ERD/ERS is hidden in other background signal and bioelectrical signal
2. ERD/ERS is as a result of the motor movement occurred in the area of motor cortex of brain.
3. Bandpass filters that give a significant difference between the signals of motor movement of turning right and turning left are from 4 to 20 Hz.
4. The pair of signal features for the motor movement of turning right and turning left has the lowest value of the correlation coefficient in the characteristic of signal that is by moving the steering wheel at the electrode of P4 filter 4 – 20 Hz of the shift of the point of minimum peak.
5. Each volunteer has a different scale of wavelet transformation in order to obtain a high correlation both for the motor movement and for the imaginary of motor movement.

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