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**Submission date:** 11-Jul-2018 11:28AM (UTC+0700)

**Submission ID:** 981759129

**File name:** jurnal\_hindarto\_std\_inggris\_iop.docx (131.49K)

**Word count:** 2516

**Character count:** 13562

# The Value Of The Standard Deviation Of Wavelet Subband Coefficients As Feature Extraction For Electro Encephalo Graph (EEG) Signal

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**Abstract.** In principle, this study describes the classification of EEG signals using Backpropagation Neural Network as a classification and Discrete Wavelet Transformation for feature extraction by taking the standard deviation value on each Wavelet subband. The purpose of this research was to identify the EEG signals used in the movement of the cursor. BCI competition 2003 data sets Ia as the data for this research. This data contains the data classes 0 (for the movement of the cursor to the top) and class 1 (for the movement of the cursor to the bottom). EEG signals are classified in two stages. In the first stage, the value of the standard deviation on each discrete wavelet subband used to extract the features of EEG signal data. This feature as inputs on Back propagation Neural Network. On the second stage of the process into two classes (class 0 and class 1) EEG signal data file, there are 260 training data file 293 of EEG and signal data file signals EEG testing, so that the whole be 553 file data signals EEG. The results obtained for the EEG signal classification was 78.7% of the data signal is tested.

Key words : EEG, BCI, Discrete Wavelet, Standard Deviation, BackPropagation

## 1. Introduction

Our brain is composed of billions of brain cells called neurons. Any neurons communicate with each other (in a relationship) and emits electric waves. Electrical waves emitted by neurons in the brain, this is called "brain waves" or brainwave. So called brain waves are "electric current" issued by the brain. When the brain is no longer removing the brain waves, then we know that the brain is dead. Brain waves can be measured with an equipment Electroencephalograph (EEG). Note that the frequency of brain waves generated by the neurons vary between 0-30 Hz and are classified into waves of delta, theta, alpha and beta. Each wave have different characteristics and indicate the mental condition of a person [1].

To connect between the brain and the object to be controlled by the brain uses a tool called Brain Computer Interface (BCI) system which acquires and analyzes nerve signals with the goal of creating a direct communication channel between brain (EEG signal) and a computer. BCI is also a communication system that does not require muscle activity [2].

Research by taking the test data from the data set from BCI Competition 2003-Data Sets Ia, namely data signals EEG to move the cursor up and down the driven by the human mind. Research by using

the average of the SPC and gamma bandpower, results from a process of classification of 88.7% [3]. Research by taking a slow cortical potential (SCPs) and wavelet package transform as the extraction of features that produce a classification of 91.47 [4]. The feature extraction process by taking the values of the RMS, spectral centroid, bandwidth, zero crossing rate, spectral roll-off frequency, band energy ratio and delta spectrum magnitude with Bayesian classification process, resulting in a classification of 90.44 [5].

## 2. Materials And Methods

### 2.1. Materials

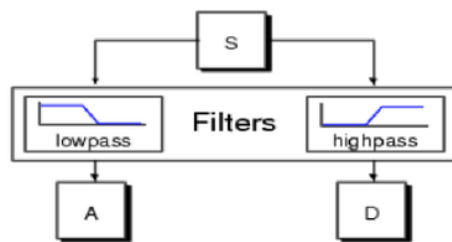
EEG signal DataSet drawn from the BCI competition 2003 data came from Dr. Birbaumer and his team at the University of Tübingen, Germany (Blankertz 2004) [13]. Six-channel EEG was recorded from a healthy subject and the sampling rate of 256 Hz and the length of the recording for 3.5 seconds. The results of any experiment each channel of 896 samples. Subjects were asked to imagine moving your cursor up or down on the computer screen while his recorded SCP. The subject receive visual feedback of the SCPs (feedback phase). The DataSet is divided into training (268 experiment) and trial (293 experiments), in accordance with the task force BCI 2003 Ia.

### 2.2. Wavelet Transform

Transformation is the process of representing a signal into another domain / region. The purpose of the transformation is to further highlight the nature or characteristics of the signal. The wavelet definition is the set of functions in the vector space  $L^2\mathbb{R}$  having the properties of (i) limited energy, (ii) is a band-pass function in the frequency domain, (iii) is the result of translation and dilation of a single function [6][7].

### 2.3 Discrete Wavelet Transform

On the case of Wavelet Transformation Discrete scale and position values are based on the two power numbers (scale and  $10^{\log}$  position). Time-scale representation is obtained by digital screening. The signal is passed on the high pass filter to analyze high frequencies and pass on the low pass filter to analyze low frequencies. The screening result is an approximation coefficient (low frequency component and high scale) and detail coefficient (high frequency component and low scale).



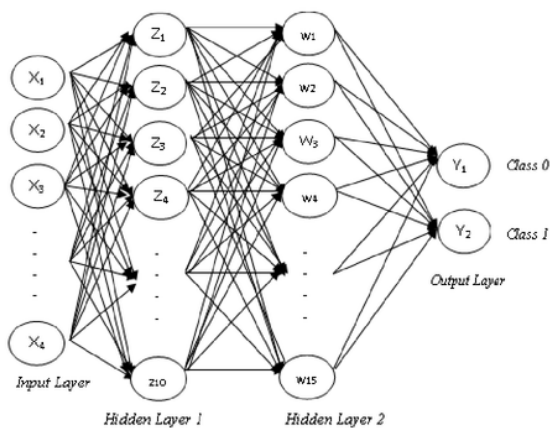
**Figure 1.** Ground level filtering on DWT

Figure 1 is the process of obtaining approximation coefficients and details which are also called decomposition. Decomposition process can be repeated (multiple level decomposition) [8][9]. In the signal analysis using DWT the selection of the number of decomposition levels is very important. The dominant frequency component of the signal is selected to determine the number of decomposition

levels. The decomposition rate is chosen so that portions <sup>5</sup> of the signal are correlated well with the frequency required for signal classification to be maintained in the wavelet coefficients. The number of levels is chosen to be 5, because the EEG signal does not have a useful frequency component over 30 Hz. Thus the signal is decomposed into details D1 - D5 and one final approach. Estimates and detailed records of this reconstructed <sup>12</sup> from Daubechies wavelet filter 4 (DB4) [10][11]. The wavelet coefficients are extracted provides a compact representation that shows the distribution of the signal energy of EEG in time and frequency. To further reduce the dimensions of the extracted feature vector extraction of ECG signal characteristics, obtained by means of the signals to thermally 5 levels using the discrete wavelet transform. Wavelet function used is the db4. Illustration of the decomposition of EEG signals 5 levels with frequency cuplik 256 Hz like Figure 3. Each EEG signal is decomposed through 5 levels so that the retrieved signal details (D1, D2, D3, D4, danD5) and signal approximation (A5). In this study, the value of the standard deviation of the respective coefficients from D3, D4, and D5 A5 is used as a hallmark of EEG signals.

## 2.4 Backpropagation Neural Network

Neural network (ANN) is defined as a computer system based on biological neural modeling (neuron) through the approaches of biological computational properties. The ANN can be imagined as a network with simple intermediate processing elements. Processing elements interact through variable connections, called weights, and when properly adjusted can produce desirable properties. The basic idea of ANN is the concept of learning. Network learning to generalize the characteristics of the behavior of objects. When viewed from a human point of view, it is the same as how humans learn something. Humans recognize objects by arranging the brain to classify or generalize the object [12]. There are two main learning parameters in the reasoning behind that is the learning rate  $\alpha$  and momentum  $\mu$ . Learning Rate used to set fast, slow learning. The momentum is used to avoid the striking weight changes due to different data with others. Part of the Neural Network BackPropagation, is where architecture can be seen in Figure 2. To research the number of 4 input neurons, with two hidden layers, and the two classes as output



**Figure 2.** Architecture Backpropagation Neural Network with two hidden layers

In this study, the process of data classification is done by separating EEG signals into two parts, the data in the training process of 268 the data vector and the data to process the test data used amounted to 293 the data. This network has 4 inputs ( $x_1, x_2, x_3, x_4$ ) come from the feature DWT, 10 nodes in the hidden layer 1 ( $z_1, z_2, \dots, z_{10}$ ), 15 nodes in the hidden layer 2 ( $w_1, w_2, \dots, w_{15}$ ), and outputs the binary type to identify conditions ( $y_1, y_2$ ). Research on network architecture can be seen in Figure 2. The output pattern with 2 outputs in the form of binary target. The type of the pattern can be seen in table 1.

**Table 1.** The Output Vector Patterns

No	Classification Of Data	The Output Pattern
1.	Cursor moves up	0
2.	Cursor moves Down	1

1

### 3. Results And Discussion

This study describes the cursor movement detection of EEG signals obtained from BCI dataset Competition 2003. The EEG data is processed using a DWT as a feature extraction of EEG signals. On the process of EEG signal feature value DWT is taken from the value of the standard deviation on the frequency sub bands DWT.

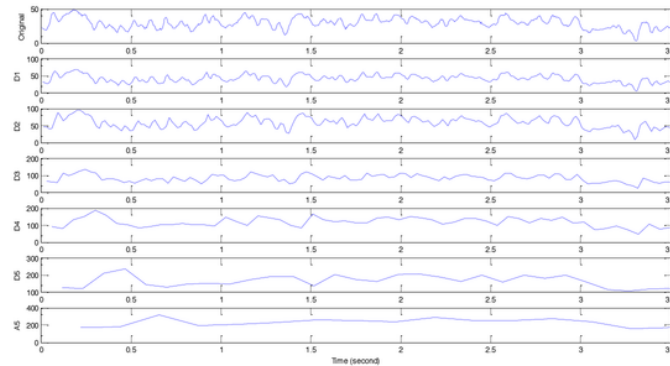


Figure. 3. Approximate and detailed coefficients of EEG signal taken from a healthy subject

EEG recording is divided into frequency bands such as sub-coefficient wavelet A5, D5, D3, and D4 uses the DWT is seen in Figure 3. Then a set of features extracted from the frequency sub-band wavelet (0-4 Hz), (4-8 Hz), (8-16 Hz) and (16-32 Hz). After normalization, EEG signals are decomposed using DWT and features extracted from the sub band. The following features are used to represent the frequency distribution of time signals are examined, namely the value of the standard deviation of each sub band coefficients of Wavelet.

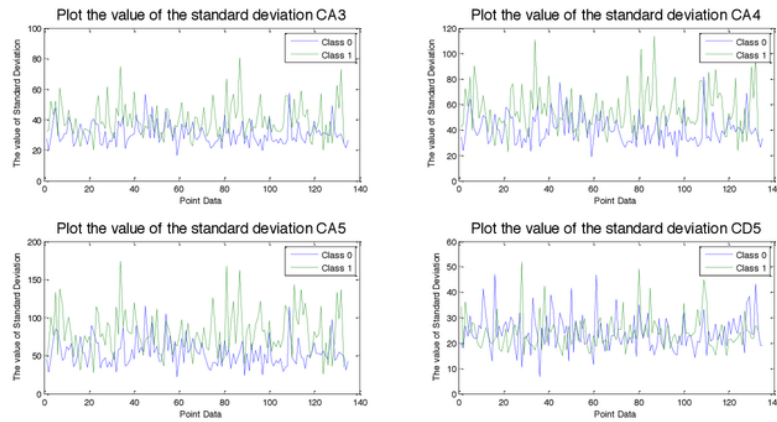


Figure 4. The value of the Standard Deviation of a class 0 and class 1 of each sub band

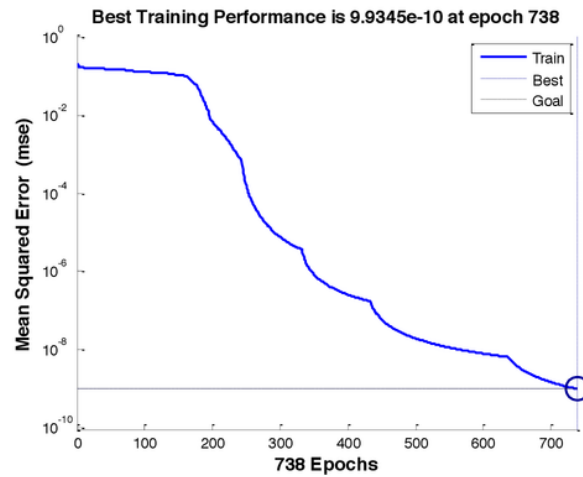
In Figure 4 shows that in the value of the standard deviation in each sub band for class 0 and class 1 has the value difference. The difference in value is not the same show that level of classification by taking the value of the standard deviation is quite good.

Classification using a Backpropagation Neural Network implemented using the standard deviation value of feature process DWT as input. In this study, a set of training amounted to 260 data samples and test data 293 sample data. 260 sample data (from normal subjects) for channel 1 is used for training and 293 sample data (from normal subjects) for each channel used for testing. The distribution of the sample classes in the training data collection and validation are summarized in table 2. To improve the ability of backpropagation, training and test sets formed by data obtained from different subjects. The training data set is used to train a backpropagation, whereas the test data used to verify the accuracy and effectiveness of Backpropagation who has been trained to detect the movement of the cursor moves up and down.

**Table 2.** The distribution of classes from the data for training and testing

Class	Training sets	Test sets
Up Cursor (class 0)	130 x 6 Channel	293 x 6 channels
Down Cursor (class 1)	130 x 6 Channel	(mix)





**Figure 5.** A training neural network of Performance using 2 hidden layers

260 data training from channel 1 in 738 the training period and the size of the steps for adaptation parameter has a value of  $9.93 \cdot 10^{-10}$ . Performance Backpropagation using 2 hidden layers capable to perform the training process with minimal error limits, so 100% had the accuracy of the training process.

**Table 3.** Backpropagation accuracy results with 2 hidden layers for all channels

	Channel 1	Channel 2	Channel 3	Channel 4	Channel 5	Channel 6
Accuracy	71,0 %	71,6 %	77,4 %	78,7 %	73,4 %	70,2 %

From table 3 to see that channel 4 who occupy a good degree of accuracy compared to channel the other with an accuracy of 78.7%.

**Table 4.** Neural network performance against the number of Hidden Layer of different

	MSE (One Hidden Layer)	MSE (Two Hidden Layer)	MSE (Three Hidden Layer)
Time	21 s	35 s	31 s
Iteration	1000	738	557
MSE	$6,38 \cdot 10^{-2}$	$9,93 \cdot 10^{-10}$	$9,79 \cdot 10^{-10}$
Accuracy	67,2 %	78,7 %	73,4 %

From table 4 visible that by using 2 hidden layers on backpropagation can already achieve the accuracy value of 78.7% of the test process.

#### 4. Conclusion

In this paper the researchers introduced the Discrete Wavelet to extract features with standard deviation values take on each sub band. The process of classification of EEG signals is divided into two classes, namely class 0 and class 1. This research, using EEG signals 553 file data for training and testing. The accuracy of the classification of Backpropagation reached 78.7% of the test data. The work of researchers who will come, will examine the appropriate search techniques for the extraction of features and classification of EEG signals, so the level of accuracy to command moves the cursor would be better. The results obtained are compared with the methods already examined.

### Acknowledgement

The authors are grateful to the Chairman of Muhammadiyah University of Sidoarjo who gave time for the research that the researcher and the Directorate of Research and Community Service, Directorate General of Research, Research and Development of the Ministry of Research, Technology and Higher Education of the Republic of Indonesia supported the fund for this research.

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