Extraction of ElectroEncephaloGraph (EEG) Signal Using the Subband Coefficient of Wavelet Transform on Cursor Moves

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Abstract. This research explains the application of ElectroEncephaloGraph (EEG) signal waves used to move the up cursor and down cursor. In each sub band of the waveform, Electro Encephalo Graph (EEG) will produce the average and standard deviation to be used as a feature of the EEG. Artificial Neural Network Backpropagation as the basis for determining whether the cursor moves up or the cursor moves down. The data used in this study is EEG data derived from BCI Competition 2003 (BCI Competition 2003). Decision-making is done in two stages. In the first stage, the mean and standard deviation values on each wavelet subband as a feature extraction of EEG data. This feature is an input to the Backpropagation Neural Network. In the second stage of the process of inserting into two classes (class 0 and class 1) EEG data files, there are 260 EEG and 293 file training data files from EEG file test data files, totaling to 553 EEG data files. The results obtained for the classification of EEG results were 79.2%.

Keywords: EEG, Mean, Device Standart, Wavelet, BackPropagation

1. Introduction

To move a cursor on the computer screen, usually someone needs a keyboard or mouse to run it. This is not possible with someone who does not have a hand or someone who cannot move his hand. Initially it may be just wishful thinking but the creative and revolutionary ideas of researchers both from home and abroad to be able to move the cursor without using the hands.

The human brain without opening the skull when recorded can generate a weak electrical current, the recording format is named brain Electroencephalography (EEG). This has been announced by a psychiatrist named Germany Hans Berger there year 1929. So to connect between the brain and the object that will be controlled by the thought digunkannya tool called Brain Computer Interface (BCI). BCI is a system that acquires and analyzes neural signals with the aim of creating a direct communication channel between the brain (EEG signal) and computer. BCI is also a communication system that does not require muscle activity [1]. The BCI system allows subjects to send commands to electronic equipment simply by using brain activity [2]. The BCI system can also be used to play simple games on mobile devices [3].

Brain Computer Interface (BCI) is a communication system that translates the direct action of the user's brain activity into EEG signals and control commands. BCI can be used for spelling, browsing the Internet, controlling robot devices, or performing other tasks with just thoughts [2-4]. Existing BCI is often used to present information in the signal to assess the state of the subject's brain with different EEG signal categories.

Accurate features and identification methods that are user-specific and specific application requirements may be a problem for EEG-based communication to be efficient. Appropriate input design, feature extraction, and matching classifier. Different attributes of EEG signals have been used as inputs for BCI, such as your rhythms (8-12 Hz) and beta rhythms (18-25 Hz), event-related potentials, such as, for example, established P300-evoked response, or slow cortical potential (SCP) [2-4].

The EEG signals in a person, generally composed of wave components distinguished by their frequency region, ie alpha waves (8 - 13 Hz), often appear in the conscious state, closed eyes and relaxed conditions; beta waves (14 - 30 Hz), often appear when a person is in a state of thinking; teta waves (4 - 7 Hz), commonly occurring in someone who is light sleep, drowsiness or emotional stress; delta waves (0.5 - 3 Hz), often present in someone who is in a deep sleep state. Therefore, the representation of EEG signals into many frequency domains is done in research relating to the analysis of EEG signals.

Representations in the frequency domain include for the identification of waves on EEG signals using Fourier Transform and Neural Network methods to distinguish normal people and those of epilepsy [5]. Other research by taking data from BCI Competition 2003 among others the research used two channel (channel 4 and channel 6),four features by combining slow cortical potentials (SCPs) and wavelet packet transform and Neural Networks for the classification process. The result of the classification process is 91.47% [6].

EEG feature extraction based on wavelet packet decomposition for brain computer interface. This study also uses BCI 2003 data competition using six channels (channel 1, channel 2, channel 3, channel 4, channel 5 and channel 6) and takes 17 (seventeen) features with neural network as a classification process. The result of the classification process is 90.80% [7]. In this study, EEG signal processing to perform to move the cursor up or down on the computer screen while his recorded using SCP method of Wavelet transform. To detect the movement of the cursor this research method using Neural Network by taking a set of statistical features of Wavelet subband Transform is used as input.

2. Materials and Methods

2.1. Material

The EEG signal dataset taken from the BCI 2003 competition data comes from Dr. Birbaumer and his team at the University of Tuebingen, Germany (Blankertz 2004) [13]. Six EEG channels were recorded from a healthy subject and the sampling rate of 256 Hz and a 3.5 second recording time. The result of each experiment of each channel is 896 samples. Subjects were asked to imagine moving the cursor up or down on the computer screen when the SCP was recorded. Subjects receive visual feedback from SCPs (feedback phases). The dataset is divided into training (268 experiments) and trials (293 experiments), according to the BCI 2003 description [8].

2.2. Discrete Wavelet Transformation

In pattern recognition, feature extraction is one specific form to reduce dimensions. Representation of the features needed to transform the input data that is too large to be processed and allegedly very many redundant input data, but does not contain the needed information. Extraction Feature is a way to transform the input data to the feature set. Extraction feature must be selected appropriately and carefully so that the data that diekstrasi can be used as expected. Ekatrasi features are used to extract the relevant information from the input data correspond to the desired task and can reduce the representation, not the input data with full size. Extraction of feature against signal and the results that have been achieved by using the wavelet transform can be found in the following Study [9-10].

The frequency domain of the EEG signal provides useful information rather than time domain representation. The wavelet transform provides a multi-resolution description of the nonstationary signals. EEG is a non-stationary signal then wavelet is suitable for EEG signal [11]. At high frequencies will represent a good time resolution and for low frequencies will also represent better frequency

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resolution. the multi-scale feature of Wavelet allows the decomposition of a signal into a number of scales, each scale representing a particular roughness of the signal under study. The multi-axis decomposition procedure of the x [n] signal is schematically shown in Figure1.

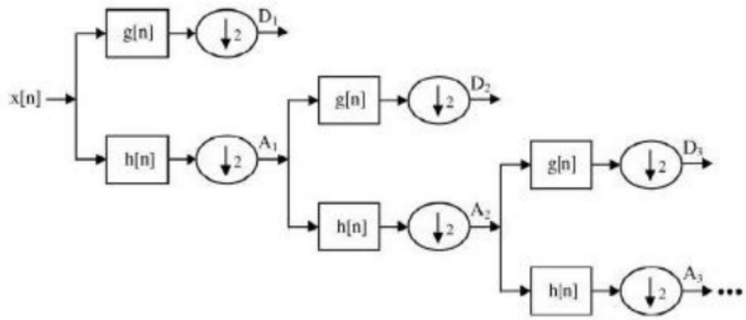

Figure 1. Sub band Decomposition of discrete wavelet transform

Changes in the EEG signal is detected using daubechies wavelet sequence 2 daubechies wavelet, because the order of 2 to feature interiors more appropriate. EEG signal is decomposed into details of D5 to be used in this research.

A wavelet coefficient in the extraction of compact representations that show the distribution of signal energy of EEG in time and frequency bands shown with a good representation on wavelet coefficients that have been in the extraction. Therefore, the feature vectors are represented can be obtained from EEG signal detail that calculated and estimated coefficients of wavelet of EEG signals. Retrieving the value of the statistics of wavelet coefficients can be used to reduce the dimensions of the vector features. The following statistics feature is used to represent the time frequency distribution of EEG signals, i.e. the value of the average and standard deviation of wavelet coefficient on each sub band

2.3 Backpropagation Neural Network

Backpropagation Neural Network training algorithm is social interactions which have many layers. Backpropagation Neural Network using the error output to change the values of the weights does it weigh-in the direction of retrograde (backward). To get this error, the propagation of phase forward (forward propagation) should be done in advance. The terms of the activation function in the Backpropagation Neural Network is a continuous, terdifferensial easily, and is a function that does not go down.

The activation function which can meet the third condition is logsig, tansig, and purelin. The method of recognition is the process of initializing the data to be further processed by Backpropagation Neural Network. The data to be identified are presented in the form of a vector. Each target has data presented also in the form of a vector. Target or output reference is a character map that shows the location of the input vector. While the method of training is the process of storing data and recognize the exercise of knowledge or information obtained into the weighting-weighting. There are 3 phases in the Backpropagation Neural Network training, i.e., phase forward (feed forward), a phase of retreat (back propagation), and a modified phase weighting. In phase feed forward, advanced input pattern is calculated starting from the input layer to output layer. In the phase of back propagation, each output unit receives the target pattern is related to the input pattern to calculated the value of the error.

The error will dipropagasikan withdraw. While the phase weighting modification aimed at lowering the error that occurred. The third phase is repeated continuously until a termination condition is met [12]. At the end of the 80-90s of the 20th century introduced the rule of generalization-delta algorithm, as highlighted by other [13]. Generally, backpropagation algorithms of functions as follows. On the output layer, vector output compared with the desired output. The error is calculated from the rule of the delta and redistributed back through the network to adjust the weights in the interest of minimizing the

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difference between the output and the desired output is NN. Such a network can be learned by using the activation function is differentiable functions.

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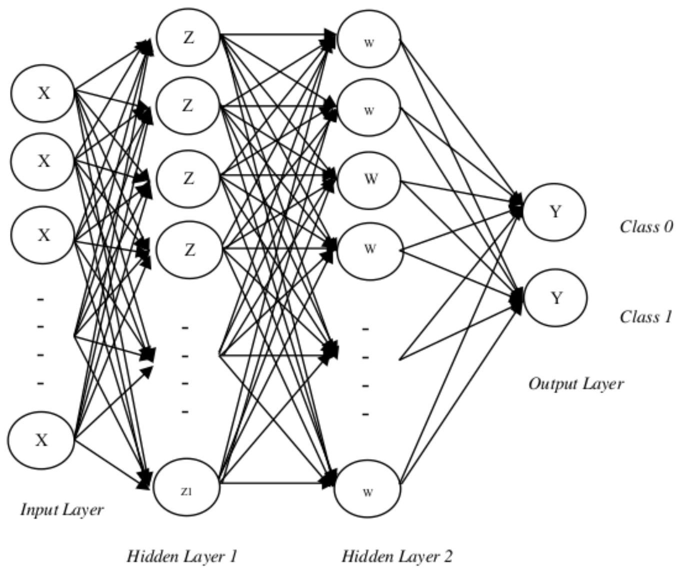

Figure 2. Backpropagation Neural Network Architecture with 2 hidden layers

In this study, the data classification process is done by separating the EEG signals into two parts, ie data for the training process as much as 268 vector data and data for the data testing process used as many as 293 data. This network has an input of 8 nodes (x 1, x2, ..., x8) derived from DWT fiture, 15 nodes for hidden layer 1 (z1, z2, ... z15), 30 nodes for hidden layer 2 (w1, w2, ... w30), and Binary type output for condition identification (y1, y2). Network architecture in research can be seen in Figure 2. Output pattern with 2 target output in binary form. These types of patterns can be seen in Table 1.

Table 1. Output Vector Patterns

No	Data Classification	Output Patterns
1.	Up Cursor Movement	0
2.	Down Cursor Movement	1

3. Results and Discussion

The data used is using data from BCI comptetion 2003 Data set Ia. This data set consists of 6 channels (electrode mounted on the scalp of 6 pieces of electrode sensor, resulting in 6 pieces of signal EEG channel). Data set It consists of Trainning data and Testing data.

A large amount of data, will cause the old computing process caused by a lot of data is processed, so that the presence of features that result in a little quick computing process. In this study, an EEG signal is only taken by the mean and standard deviation of each subband of the DWT process to be a feature extraction for the identification process.

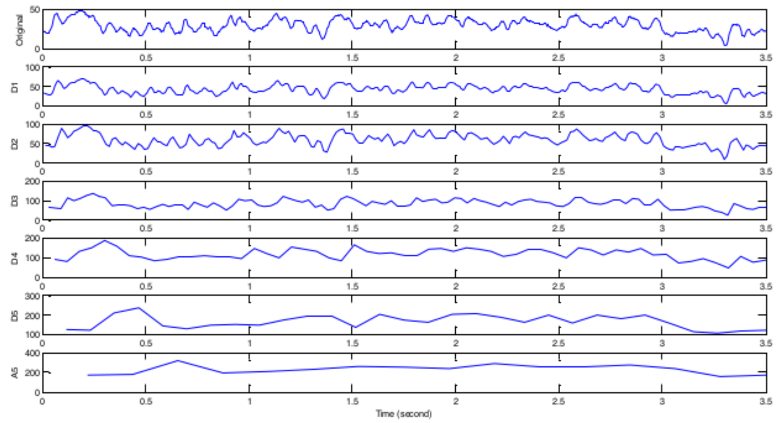

Figure 3. Approximate and detailed coefficients of EEG signal taken from a healthy subject

The EEG record is divided into sub-band frequencies such as the wavelet coefficients A5, D5, D4, and D3 using DWT shown in Figure 3. Then a feature set is extracted from the wavelet sub-band frequency (0-4 Hz), (4-8 Hz), (8-16 Hz) and (16-32 Hz). After normalization, the EEG signal is decomposed using DWT and features extracted from the sub-band.

Figure 4. Mean and standard deviation of the wavelet coefficients

Figure 4 shows that for mean and standard deviation on each subband for class 0 and class 1 has a difference value. Different scores indicate that the classification rate by taking the mean and standard deviation is quite good.

Classification using Artificial Neural Network Backpropagation is implemented using the mean value feature and standard deviation of the DWT process as input. In this study, 260 data samples (from normal subjects) for channel 1 were used for training and 293 samples of data (from normal subjects) for each channel were used for testing. The distribution of sample classes in the training and validation datasheets is summarized in Table 2. To improve the capability of backpropagation, the training and test

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are shaped by data obtained from different subjects. The training data sets are used to train the backpropagatioan, while the test data set is used to verify the accuracy and effectiveness of trained Backpropagation to detect the up cursor and down cursor.

Tabel 2. Class distribution of the samples in the training and test data sets

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

The result of feature extraction is used for input for neural network, this research uses backpropagation method (8-15-30-2) which is 8 inputs derived from characteristic of EEG signal and 2 hidden layer that is 15 units at hidden layer 1 and 30 units at hidden layer 2 as well as 2 targets (upward cursor movement for class 0 and downward curot movement for class 1). In addition to using the 8-15-30-2 network architecture, for this experimental study also uses additional and reductions for hidden layer.

In the process of identification with the neural network process first done is a training process that is searching the best weight value with the acquisition of the smallest error value of the desired output target. In the process of mapping is done identification of EEG signal from movement of up cursor and downward cursor movement based on weight value which have been got in training process.

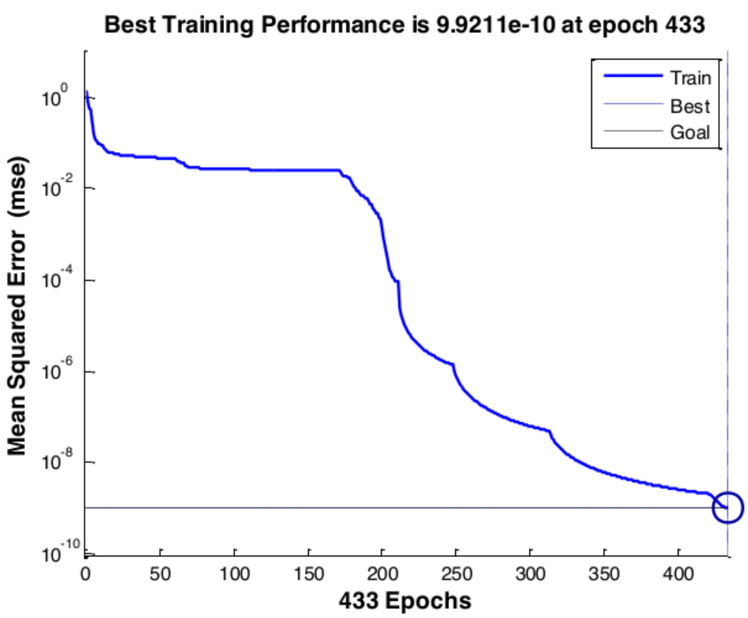

Figure 5. Training Performance of artificial neural networks using 2 hidden layers

260 training data from channel 1 in 433 training period and step size for adaptation parameter has initial value of 9,92.10-10. Performence Backpropagation using 2 hidden layers is able to perform the training process by passing the minimum error limit, so that 100% has the accuracy of the training process.

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

	Channel 1	Channel 2	Channel 3	Channel 4	Channel 5	Channel 6
Accuracy	61,0 %	64,2 %	79,2 %	72,2 %	77,2 %	74,0 %

Table 3 shows that channel 3 occupies a good level of accuracy compared to other channels with an accuracy of 79.2%.

Table 4. Neural network performance against Hidden Layer numbers different

	MSE (1 Hidden Layer)	**MSE (2 Hidden Layer)**	**MSE (3 Hidden Layer)**
Time	35 second	59 second	152 second
Iteration	1000	433	831
MSE	$2{,}22.10^{-2}$	$9{,}92.10^{-10}$	$9{,}25.10^{-8}$
accuracy	73,0 %	79,2 %	75,4 %

From table 4 it can be seen that by using 2 hidden layers in backpropagation it can achieve the accuracy value of 79.2% of the testing process

4. Conclusions

In this paper, researchers introduced the Discrete Wavelet to extract the feature by taking the mean and standard deviation values on each subband. The process of classifying EEG signals is divided into two classes: class 0 and class 1. This study uses 553 EEG signal data files for training and testing. Backpropagation classification accuracy reached 79.2% for test data. Future research work, will examine the search techniques suitable for feature extraction and EEG signal classification, so the accuracy level for the command move the cursor would be better. The results obtained will be compared with the methods already studied.

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