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A Classification of EEG Signals of Eye-Open and Eye-Closed Using Neural Network

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Abstract- EEG (electroencephalography) is a famous modality to study the appearance of electrical activity over the scalp. This paper includes an experiment which gives 90% accuracy of recorded signals. In this experiment, classification is done in the open eye or closed eye. These signals are decomposed by using DWT into the sub-band frequencies. Then features are extracted from these frequencies. By these features, the classification will carry out by using the ANN classifier. Classification accuracy is a useful content that gives the reliability to perform the imagined movements.

Keywords- EEG, DWT, NN

I. INTRODUCTION

The brain is a very complex human body organ. Every thought process is done in the brain. By the thought process, signals of the brain are provided to the other organs of the body to control their movements. These signals are measurable by the advanced devices. It can be used in the medical or crime departments to know the exact psychological, physiological and spiritual thought condition of the human.

This paper concept is useful for disabled peoples, who are not able to do their daily activities by their own hands. By the open eye and closed eye signals, they can hold or release object by using a robotic arm.

This paper gives the open eye and closed eye signals classification accuracy 90% to do this needful use for the disabled peoples.

I. I EEG SIGNAL

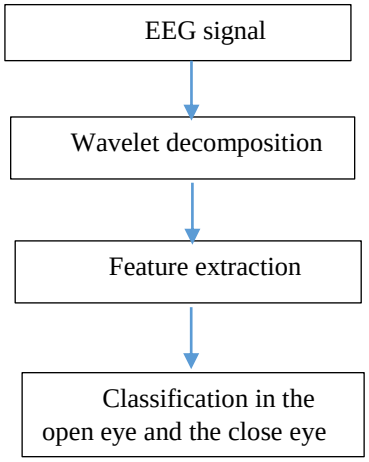
The brain is a very complicated organ of the human body which coordinates the functions of (muscles & nerves) and cognitive behavior. The signals of a brain can study with these modalities such as CT (Computed Tomography), PET (Positron Emission Tomography), MRI (Mag. Resonance Imaging) like these EEG is an important and popular method based on the frequency of a signal [1].

EEG signal has applications in neuroscience, cognitive science, psychological physiological research. The electrical currents in the brain were firstly proposed in 1875 by English Physician Richard Caton. Later in 1924, a German neurologist Hans Berger studied the brains electrical activity by using radio equipment [2]. The human brain consists of the cerebral cortex includes100 Billion of cells or neurons. Those neurons are responsible for the transmission of information signals in the form of current or called an electrical activity that can be measurable over the scalp [2] [3]. In the open eye state, the information of the outer environment is captured by the eye. That captured information has interpretation according to the brain called “visual perception”.

The muscles of the eye and alert system of the brain are activated during this process. But in the closed state, this whole process is stopped. So if there is no any information got captured by the eye, there is no visual perception [3].In this, both processes different electrical activities will detect. This paper gives the accuracy and reliability of EEG signals. There are two datasets EO & EC will be processed by using DWT and ANN.

II. METHODOLOGY

EEG signals are analyzed and classified by the following steps;



A) Fig.1 Signal Processing.

II. I ACQUISITION OF EEG SIGNAL

Eye open (EO) and Eye closed (EC) two data sets are available online by the Department of Epileptology University of Bonn [2]. For this, the internationally famous system used to record these EEG signals over the scalp called 10-20 system. This system contains 21 electrodes, amplifiers, Filter. The electrical current measured over scalp ranges from 0.5 to 100 HZ. Healthy persons were taken to record the open Eye and closed Eye data. Each data had 30 Epochs that recorded using a 128 channel amplifier in the duration of 23.6 seconds. Sampled at 173.61 HZ and filtered using a band pass filter range between 0.53 HZ to 40 HZ. 10-20 system means every electrode placed at one another 10% or 20% of a distance of front-back-right-left of the skull. This arrangement decided by the International Federal of societies for EEG and the clinical Neurophysiology [1] [2] [3].

II.II DISCRETE WAVELET TRANSFORM

The signals can be stationary or non- stationary by nature (stationary means the signal statics do not vary with time & non-stationary means whose signal statics varies with time). To transform the signal from the time domain to the frequency domain, A Fourier transform can be used. F.T can be applicable for stationary signals but for the non-stationary signal, there is a drawback of the signal varying with time. This problem can be solved by using a wavelet transform. W.T is a windowing technique of short and long regions.

F.T transforms a signal into the sinusoidal wave where W.T conveys a signal as a shifted & scaled set of functions into one function called as mother wavelet.

$f(t)=\sum_k 2^{j/2}.aj(k)\varphi(2^j\ t-k)+\sum_k\sum_j 2^{\frac{j}{2}}.dj(k)\ \Psi(2^j\ t-l)$...i

Where φ (t) - scaling function

ω (t) - mother wavelet

By this function will get

$a_j(k)=\int_{-\infty}^{\infty} f(t).\varphi(2^j\ t-k)\ dt$ ii

$d_j(k)=\int_{-\infty}^{\infty} f(t).\Psi(2^j\ t-k)\ dt$ iii

The above two-equation gives the approximation coefficient and detail coefficient. There are various wavelets to analyze the signals at different scale like Daubechies wavelet, Haar wavelet, Shannon wavelet, Mexican Hat wavelet [4]. After using these wavelets we get different resulting data. In this paper, the db4 wavelet used because it cancels self-similarity properties of signals and it is used in the biomedical area [6].

In decomposition, the EEG signal is passed through the half band pass filter and low pass filter. It gives an approximation coefficient for high pass filter and a detail coefficient for low pass filter. The signal is divided by the half at every step this is by the Nyquist theorem. It reduces the time resolution by half and doubles the frequency. The signal is decomposed up to the 5

levels and we get 5 sub-band frequencies at different levels. These sub-band frequencies ranges are delta (below 3.5 HZ), Theta (4-7 HZ), Alpha (8-13 HZ), Beta (13-30 HZ). Above 40 HZ it considered as noise and neglected [1] [2] [3] [6].

B) Decomposition Levels

DECOMPOSTION LEVEL	SUB BAND FREQUENCIES	TYPE OF WAVE
LEVEL 0 *X(k)*	80 MHZ	SIGNAL
LEVEL 1 *D1(k)*	40-80 MHZ	BETA-GAMMA
LEVEL 2 *D2(k)*	20-40 MHZ	NOISE
LEVEL 3 *D3(k)*	10-20 MHZ	ALPHA-BETA
LEVEL 4 *D4(k)*	5-10 MHZ	THETA-ALPHA
LEVEL 5 *D5(k)*	2.5-5 MHZ	DELTA-THETA
LEVEL 5 *A5(k)*	2.5 MHZ	DELTA

II.III FEATURE EXTRACTION

Feature extraction of the distorted signal is carried out next. The energies of these sub-band frequencies are extracted. It gives relevant information about the signal to perform the needed task. Feature extraction distinguishes signals between open eye and closed eye [8].The energies are obtained by the Parseval's Theorem,

$$\mathrm{EDi} = \sum_{j=1}^{N} |Dij|^2$$

$i = 1 \ldots l$ iv

$$\mathrm{EAi} = \sum_{j=1}^{N} |Aij|^2$$

$i = 1 \ldots l$ …v

EDi is an energy of the detail coefficient and *EAi* is the energy of the approximation coefficient. Two sets of eye open and eye closed are classified by this distributed energy at the different resolution levels [8].

II.IVCLASSIFICATION

ANN's are used for complex pattern recognition and classification. This is a non- linear, adaptive, supervised learning system that solved the problems on input/output data at the training phase. After this, the system deployed in the testing phase .ANN is used by supervised learning rule in which the system compares the current output to the desired output for this feedback is applied and it will adjust the weights as per desired weights. For this, levenberg-Marquardt backpropagation algorithm is used. ANN consist of the input node, one or more hidden layer and output node. The features of signals are fed to the input node and passed through the hidden layers with their associated weights.

The output will get at hidden layer,

$$Vk = \sum_{i=1}^{n} w_{ki} x_{ki} \quad \ldots\ldots vi$$

Where, Xk .inputs

WK weights of unit k

$$Yk = \sum_{i=1}^{n} \emptyset(v_k + v_{ko}) \quad \ldots . vii$$

Where Vk is net input, YK is output, Φ- is sigmoid- activation function of the neuron. Expressed

fx= $1/1+e^{-x}$

5×60 inputs are fed to the 10 hidden layers with sigmoid activation function for neuron [8].

III. RESULTS AND DISCUSSIONS

For the decomposition of wavelets db4 wavelet used with 5 levels. By decomposing the wavelet we get the A5 approximation coefficient and the detail coefficient D2, D3, D4, D5. Shown in the fig.

Original signal

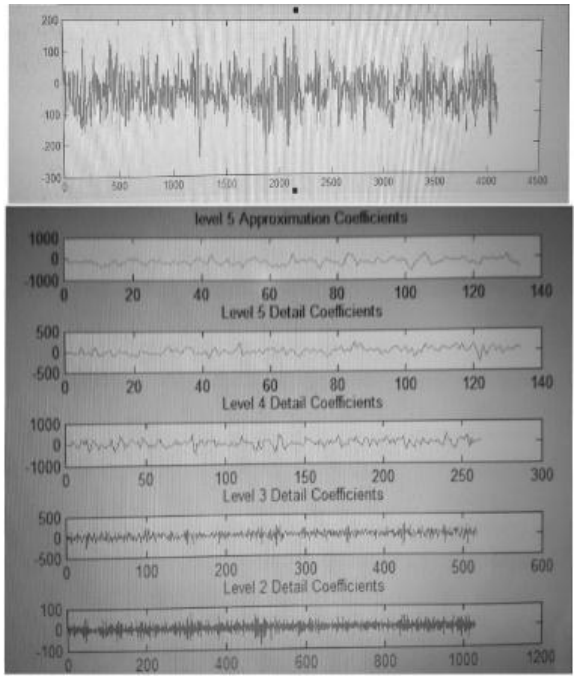


Fig. approximation and detail coefficients.

After this energy of the signals are calculated for feature extraction shown in Eq.iv & v.

In the classification table, 30 samples of two data sets are used to classify in open eye and closed eye. It gives accuracy 90% shown in fig c to perform the desired task by disabled people using robotic arm with more effectively [8].

Class	Eye close	Eye open	Accuracy
Eye close	25	1	96.2%
Eye open	5	29	85.3%
		Overall success rate	90%

Fig. C) confusion table of classification results.

IV. CONCLUSION

This paper gives an automatic method for the classification of signals using the ANN classifier and DWT. Feature extraction of the signal is an important step to classify the signals with accuracy 90%. This gives computational speed to perform one desired task.

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