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Eeg Signal Classification and Speech Synthesizer for Disables

KEYWORDS: Electroencephalography (EEG), Brain computer interface (BCI), neural network, Stroke, & Spinal cord.

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ABSTRACT *Several patients are no longer able to communicate effectively with the outside world. For instance, patients affected with stroke, spinal cord injury or a brain stem stroke where people require alternate method of communication and control. Their brains may offer them a way out. The EEG based brain computer interface (BCI) is the technique used to measure brain activity. The goal of the current work is the development of an electroencephalogram (EEG) based BCI system. The overview of this work is that the user thought is extracted from his brain activity. Pre-processing is performed using filters and wavelet transforms to extract the features and classify them to their respective class. The intention of this work is to enhance human interaction with computers, providing a communication channel between human brain and computer.*

I.INTRODUCTION

Electroencephalogram (EEG) was first recorded by Berger in 1929 by externally attaching several electrodes on the human skull. Such signals generally deliver an indirect way information about physiological functions, which are related to the brain. Possible applications using such signals are in numerous. There is also an important demand in the medical domain for automatic signal interpretation systems. BCI is composed of signal collection and processing, pattern identification and classification.

Brain computer interface (BCI's) sometimes called as Brain Neural interface is a direct communication link between the functioning human brain and outside world. BCI uses brain activity to command, control, actuate and communicate with the world directly through brain integration with peripheral devices and systems. Brain–computer interfaces give their users communication and control channels that do not depend on the brain's normal output channels of peripheral nerves and muscles.

Most of the cerebral signal observed in the scalp EEG falls in the range of 1–20 Hz. Delta is the frequency range up to 4 Hz. It is usually most prominent frontally in adults and posterior in children. Theta is the frequency range from 4 Hz to 7 Hz. Theta is seen normally in young children. It may be seen in drowsiness or arousal in older children and adults; it can also be seen during meditation. Alpha is the frequency range from 7 Hz to 14 Hz. This is the "posterior basic rhythm" seen in the posterior regions of the head on both sides. It emerges with closing of the eyes and with relaxation, and attenuates with eye opening or mental exertion. Beta is the frequency range from 15 Hz to about 30 Hz. It is usually seen on both sides in symmetrical distribution and is most evident frontally. Beta activity is closely linked to motor behavior and is generally attenuated during active movements. Gamma is approximately in the frequency range of 30–100 Hz. Gamma rhythms are thought to represent binding of different populations of neurons together into a network for the purpose of carrying out a certain cognitive or motor function. μ ranges between 8–13 Hz., and partly overlaps with other frequencies. It reflects the synchronous firing of motor neurons in rest state.

EEG based BCI is a communication system that extracts specific features online and automatically from EEG signals that can be detected on the scalp, and uses these to operate external devices, such as computers, switches. The messages or commands that a user wishes to convey does not pass hrough the brain normal output pathways, but are instead extracted directly from brain signals. The basis for this phenomenon is that mental activity (e.g. thought) is directly reflected in bioelectrical brain activity and is therefore encoded in recorded signals.

II.DESIGN METHODOLOGY

The EEG signals are collected and pre-processed using special filters. The EEG features are extracted using several methods and finally those features are classified depending on the mental task they represent. This includes:

1. Signal acquisition
2. Signal pre-processing
3. Feature extraction
4. Classification
5. Output speech.

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Fig.1 illustrates the block diagram of BCI.

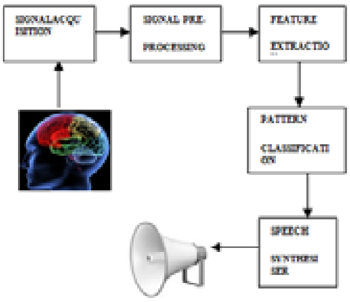

Fig. 1 Block diagram of Brain computer interface

Signal acquisition

Signal acquisition is the measurement of the neurophysiologic state of the brain. In an EEG test, electrodes (flat metal discs) are placed onto the scalp using a sticky substance. These electrodes pick up the electrical signals from the brain and send them to an EEG machine, which will record the signals as wavy lines onto paper or on a computer. The EEG machine records your brain's electrical activity as a series of traces; each trace corresponds to a different region of the brain.

The acquisition of the signal is done by two methods: 1) Invasive method and 2) Non-Invasive method. Invasive BCIs generally use electrodes (sensors) that are implanted directly into the grey matter of the brain during neurosurgery. Since they lie in the grey matter of the brain, invasive BCI produce the highest quality signals. Non-invasive BCI has minimum signal clarity but it is considered to be the safest. This type of BCI has been found to be successful in giving a patient the ability to move muscle implants. In the non-invasive technique, medical scanning devices or sensors are mounted on caps or headbands and they help to read the brain signals. Less signal clarity in non-invasive BCIs is because; the electrodes cannot be placed directly on the desired part of the brain.

Signal Preprocessing

The removal of noise and artefacts is done in this process. This stage includes decomposing or de-noising of the captured signal in order to remove noise and to enhance the EEG signal. Wave Decomposition –The length of the wave is decreased by reducing the number of values in signal and retaining the original waveform. Here the signal is reduced to 1/4th of the original signal using Discrete Wavelet Transformation (DWT) function. In the current work EEGLAB has been used to obtain to get the raw signal produced from emotive headset and for further processing of the signal.

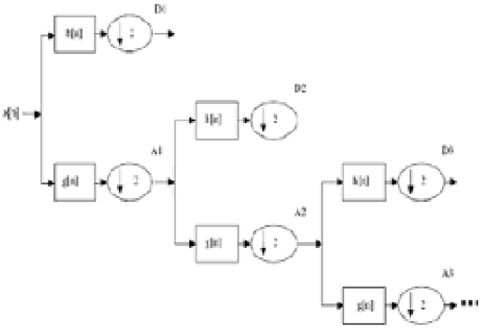

Fig.2 Decomposition of DWT implementation

Considering an example of pre-processing steps of an EEG signal:

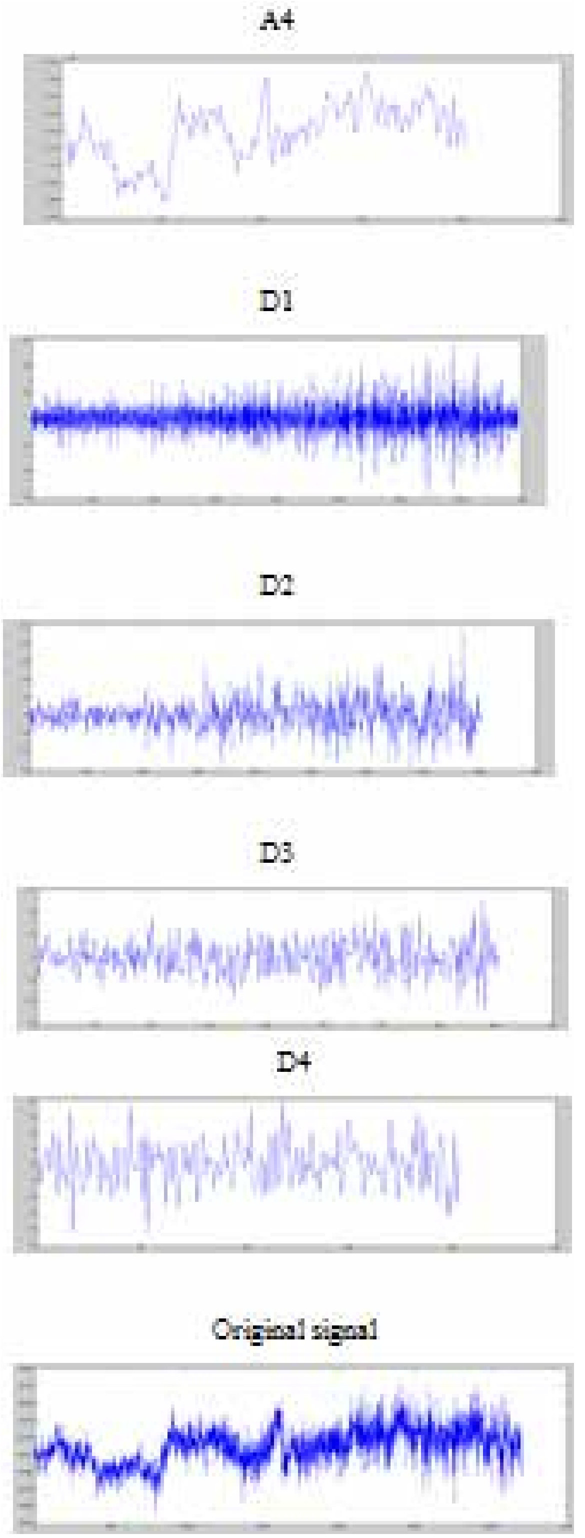

Fig.3 Approximated and detailed signal of EEG signal

Feature Extraction

The extracted wavelet coefficients provide a compact representation that shows the energy distribution of the EEG signal in time and frequency. Table 1 presents frequencies corresponding to different levels of decomposition for

Daubechiesorder-4 wavelet with a sampling frequency of 128 Hz. In order to further decrease the dimensionality of the extracted feature vectors, statistics over the set of the wavelet coefficients was used. The following statistical features were used to represent the time frequency distribution of the EEG signals:

- Maximum of the wavelet coefficients in eachSub-band.
- Minimum of the wavelet coefficients in eachSub-band.
- Mean of the wavelet coefficients in each sub-band
- Standard deviation of the wavelet coefficients in each sub-band.

The level of decomposition is done based on the matrix column as shown in Table 1.

Tabel 1: Different level of decomposition

Decomposed signal	Column of the signal matrix
D1	2828-5632
D2	1417-2827
D3	710-1416
D4	355-709
A4	1-354

Extracted features from electrodes class p7 and p8 shown in Table 2. The data was acquired using a standard electrode net covering the entire surface .The DWT was performed at 4 levels, and resulted in five sub-bands: d1-d4 and a4 (detail and approximation coefficients respectively).

Table 2: The extracted features of hand rotate channel p8

Features _hand_rotate_p8				
	Min	Max	Mean	SD
A4	1.6079	1.9476	1.7620	0.0514
D4	-134.9	165.997	0.0256	26.3403
D3	-58.62	70.1909	-0.255	14.1829
D2	-42.31	46.3621	0.2692	8.0391
D1	-37.61	30.9387	0.0032	4.0017

Total recording time was 10sec, corresponding to 1x5632 matrix for p7 and p8 channel respectively. The sample was partitioned into window to reduce the volume of data. From these sub-samples, we perform the DWT and derive statistics. The type of wavelet used is daubechies wavelet transform of order 2. The number of decomposition level is chosen to be 4. Here EEG signals are decomposed into various sub bands through fourth level wavelet packet decomposition and wavelet coefficients are computed using db2. The four features considerd are maximum, minimum, mean and standard deviation of the wavelet coefficients in each sub-band.

Pattern classification

Classification is done based on Euclidian distance and neural network. Euclidean Distance method is the most commonly used algorithm in commercial spectral library search software packages. It is very similar to the Correlation algorithm and in cases where the submitted spectrum has no negative spikes and a good signal-to noise ratio, it will produce equivalent results. The main advantage of the Euclidean Distance method over the Correlation method is that it is reportedly slightly faster.

The term neural network was traditionally used to refer to a network or circuit of biological neurons. The modern usage of the term often refers to artificial neural networks, which are composed of artificial neurons or nodes.

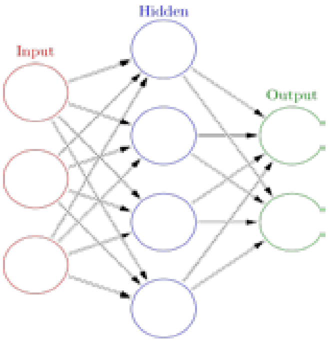

Fig 4 Layers in the artificial neural network

The commonest type of artificial neural network consists of three groups or layers; a layer of 'input' units is connected to a layer of 'hidden' units, which is connected to a layer of 'output' units. The activity of the input units represents the raw information that is fed into the network. The activity of each hidden unit is determined by the activities of the input units and the weights on the connection between the input and the hidden units. The behaviour of the output units depends on the activity of the hidden units and the weights between the hidden and output units.

E. Speech Synthesis

The textual data corresponding to the trained signal is given to the speech synthesizer. Speech synthesizer is the component that produces artificial speech for the given text as input. This allows java applications to incorporate speech technology in to the user interface. It defines a cross platform API to support to command and control dictation system. Speech synthesis is the artificial production of human speech. A computer system used for this purpose is called a speech synthesizer, and can be implemented in software or hardware. A text-to-speech (TTS) system converts normal language text into speech; other systems render symbolic linguistic representations like phonetic transcriptions into speech.

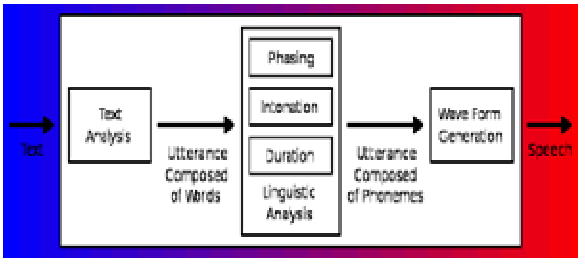

Fig 5 Overview of text to speech conversion

III.APPLICATIONS

- Provide disabled people with communication, environmental control and movement restoration.
- Provide enhance control of devices like wheelchair and vehicles or assisting robots for disabilities.
- Addition channel of control in computer games.
- Monitor attention in long distance drivers or aircraft pilots and send out alert and warning.
- Develop passive devices for monitoring function such as monitoring long term drug effects, evaluating physiological state etc…
- Create a feedback loop to enhance the benefits of certain therapeutic methods.

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- Monitor stages of sleep
- Dream capture
- BCI can provide remote control in situational disability purposes such as astronauts and surgeons improve cognitive functions such as improving attention, working memory and executive functions etc…

IV.CONCLUSION

Electroencephalograph was invented nearly a century ago, it is only recently that researchers have begun to apply it to problems outside the medical and neuroscience domains such as the brain computer interface systems. The role of signal processing is crucial in the development of a Brain Computer Interface system. We process the signal acquired and some features of these signals are extracted and classified based on Euclidian and Neural network. Then using the speech synthesizer the speech output is obtained. BCI is an advancing technology promising paradigm shift in areas like machine control , human enhancement, virtual reality etc… so it is a potentially high impact technology. Several potential applications of BCI hold promise for rehabilitation and improving performance, such as treating emotional disorders (for example depression or anxiety) , easing chronic pain, and overcoming movement disabilities due to stroke. It also enables us to achieve singularity very soon.

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