RESEARCH ARTICLE

Classification of Motion and Speech Based Brain EEG Signals using Bilayer Bayesian Classifier with Association Rule (BBC-AR)

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Abstract—This paper aims at developing Brain Computer Interface (BCI) system which uses EEG signals. In this, user thinking is extracted from brain activity of healthy person. Features are extracted from pre-processed signals and classify them into their respective alpha, beta, delta and gamma signal classes. Main intension of this work is to provide better communication interface to a person using brain signals. This is helpful to patients who have severe motor impairments and also unable to speak. This system can be used as an alternative form of communication by using mental activity.

Keywords— Brain Computer Interface (BCI), Electroencephalogram (EEG), Association rules

I. INTRODUCTION

The patients who suffer from severe motor impairments (like late stage of Amyotrophic Lateral Sclerosis (ALS), cerebral palsy, head trauma and spinal injuries) cannot express their thoughts as healthy human beings, because they are not capable of talking or moving. But still they are conscious and capable of performing mental tasks equivalent to healthy individual, using brain signals. The communication system for person with severe disabilities helps him/her to express thoughts for translating their actions into activity using BCI. This improves the quality of life of dumb people. The advantage of this proposed work is that the patient can speak digitally using Digital Speech. It uses EEG signals as input and produces output signals in Analog Signal Format(ASF), where we will be processing the signal in the required format.[10] . A BCI is a communication system between human brain and computer. It enables to capture message from brain signals and also other signals. Signals such as speech data, sensory motor rhythms and evoked potentials. It constitutes a novel communication aid for people who is having severe motor and speaking disabilities.
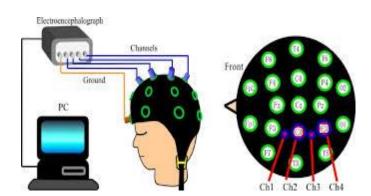
Fig.1:BCI [EEG and Data Processing]
[Image Courtesy: MIZOUE PROJECT JAPAN (Kouji MIZOUE)]

They need a way to express their thoughts and feelings. This does not rely on the brain's normal output ways which involves peripheral nerves and muscles. So to process the Brain wave signal, they have to express their feelings and speech in mind. Those signals will be processed and converted into speech. Hence, their feelings and thoughts can be expressed through Digital Speech.

II. LITERATURE SURVEY

[Evolving Signal Processing for Brain–Computer Interfaces]
Building robust and useful BCI models from accumulated biological knowledge and available data is a major challenge, as are technical problems associated with incorporating multimodal physiological, behavioral, and contextual data that may in the future be increasingly ubiquitous. Here authors discuss the current neuroscientific questions and data processing challenges facing BCI designers and outline some promising current and future directions to address them.[3]

[EEG Signal Classification using Linear Predictive Cepstral Coefficient Features]
In this study an effective algorithm is proposed to automatically classify EEG clips into two different classes: normal and abnormal. For categorizing the EEG data, feature extraction techniques such as linear predictive coefficients (LPC) and linear predictive cepstral coefficients (LPCC) are used. Support vector machines (SVM) is used to classify the EEG clip into their respective classes by learning from training data.[4]

[Characterization of human emotions and preferences for text-to-speech systems using multimodal neuroimaging methods]
This paper describes the impact of natural and text-to-speech (TTS) signals on a user's affective state (valence and arousal) and their preferences using neuroimaging tools (EEG and fNIRS) and subjective user study. The EEG results showed that the natural and high quality TTS speech generate "positive valence", that was inferred from a higher EEG asymmetric activation at frontal head region. fNIRS results showed the increased activation at Orbito-Frontal Cortex (OFC) region during decision making in favour of natural and high quality TTS speech signals. But natural and TTS signals have significantly different arousal levels.[6]

III.   METHODOLOGY

Epoch is a device which is in the form of headset used to extract EEG signals. Each EEG signal can be captured in 10sec. Signals are captured by placing two electrodes at T7-T8, FT7-FT8 locations of scalp signals as shown in Fig.2.
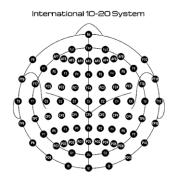

Fig.2: Electrodes Placement[Electrodes are in parietal Positions on head]
[Image Courtesy: bindcenter.eu]

On human brain, these signals are placed in the T7, T8, FT7, FT8 Parietal positions. The function of this lobe is to integrate sensory information from various parts of the nodes which is shown in fig 2 and is given for processing the data. The methods represented in Fig. 3 are explained in detail below.

A.   Brain Signal Acquisition

EEG headset is used to capture signals corresponding to various mental tasks. Subject is asked to wear EEG headset which is non-invasive. Subject(s) are instructed to do any one from the following tasks during which signals are acquired.

> Baseline Task – In this, subjects should relax. This state of relaxation should be retained.
> Hand Rotation Task – Here, subject should imagine about rotating this/her hand.
> Leg Rotation Task – The subject should just imaging to rotate their legs or they should actually rotate leg.
> Object Pushing Task – The subject will be asked to imagine a ball in empty room and push it with some pressure. The corresponding signals should be captured during the push imagination.
> Object Viewing Task – The signals are captured when subjects are asked to view an object.
> Words Reading Task – The subject will either read the given words or sentences during which signals are captured.

B.   PreProcessing of Signal

The captured signals are raw signals. It contains lots of noises and artifacts. There will be many signals generated related to each mental tasks happening. Frequency of these signals will be very low. Preprocessing of these signals forms a very important step. This avoids errors and misinterpretations during classification.
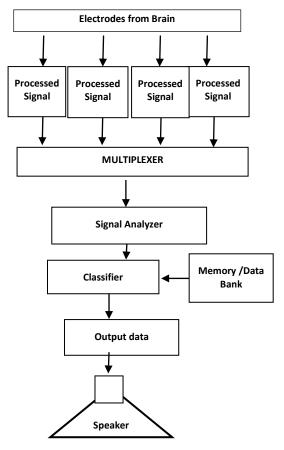
Fig.3: Schematic diagram [working of proposed methodology]

Efficient filtering techniques like wavelet transform, signal filtering, amplification will be used. After removing spikes and other artifacts, signal will be ready for classification.

C. Multiplexing
This is used for transmitting signal through BCI system. Also to combine the signals and make them to be in uniform distribution range so that it will be helpful for classification.

D. Signal Analysis
Signals are analysed to know their features and characteristics which are helpful for classification and further implementation.

E. Data Bank
Training data sets will be stored in this. This dataset is used by classifier to map input signal features with prestored features which helps to take decision about which signals component belongs to which particular class. Training dataset looks like this-

Table1
Data set of EEG signal classification

Frequency	Amplitude	Class/label
8-13	2-100	Alpha
13-22	5-10	Beta
0.5-4	20-100	Theta
4-8	10	Delta

F. Training

This step consists of training the classifier with many samples of data collected by acquiring mental tasks of various subjects.

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      FEATURE
     EXTRACTION
                          TRAINED
                          DATA SET
     CLASSIFIER

     Mental Tasks
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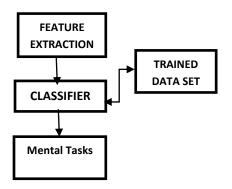
Fig.4: classification [classification of mental tasks]

G. Classification

Associative rules will be used in combination with Bayesian classifier. Association rules describe association relationships among the attributes in the set of relevant data. The rules will be of the following form:

Body ==> Consequent [Support , Confidence]

Body: represents the examined data, Consequent: represents a discovered property for the examined data. Support: represents the percentage of the records satisfying the body or the consequent. Confidence: represents the percentage of the records satisfying both the body and the consequent to those satisfying only the body.

Association rules used in the proposed work will be of the form:

Signal. Type = { frequency, amplitude}

For Example,
   signal.class = Alpha [percentage of occurrence of frequency between 8-13 , percentage of occurrence of amplitude range 2-100]

Here classifier will
   Find all possible sets of signal items (signalsets) that have support (number of signals) greater than the minimum support (large signalsets).
   Make use of large signalsets to generate the desired rules.

H. Bi-Layer Classification

Classification is achieved by applying associative rules in two layer-

   Layer 1: rules are applied to classify raw incoming signal in to different bands of EEG signal like alpha, beta, gamma and detla. Each of these classes of signals corresponds to particular cognitive tasks.
   Layer2: classification task-specific signals from the above classes like HL-signals corresponding to task when hand is rotated left. HR-when hand rotated right.LR-leg rotated right, LL-leg rotated left. SP-speech. Where, SP class signals are converted into audible range and announced as speech through speaker.

IV. IMPLEMENTATION

Authors have planned to implement few steps in hardware like amplifiers, mux, signal analysis, and filter especially preprocessing. Whereas classification will be done using Scilab which matlab component. For some intermediate processing tools like SigView (filtering) will be used.

V. CONCLUSION

In this paper proposes a brain computer/mobile interface for captures meaning full mental tasks. Cognitive tasks captured will be used for computer interface. Main goal of the proposed work to convert mental task related to text into speech. Here input to the proposed system will be brain signals, output will be analog speech signals which are audible through speakers. This is helpful to people especially who cannot walk and also speak.

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