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Imagined Speech EEG Signal Processing For Brain Computer Interface

Kazi Yaser Arafat S [1], Dr. Sudhir S Kanade[2]
[1] Lecturer,
Electronics & Telecommunication department
TPCT's COE Osmanabad
Osmanabad, India

[2] Head of Department,
Electronics & Telecommunication department
TPCT's COE Osmanabad
Osmanabad, India

ABSTRACT

We have performed the experiment to extract out the information related to imagination concealed in EEG signal. Whenever we speaks or just decide to speak something, our brain produces a specific EEG signal and it get decoded into our brain. So we tried to decode the EEG signal produced during the imagination of word left and right. This paper gives the short introductory work and the result out came in our research. EEG signals are recorded from 8 channels and processed to extract the features using AR model and then classified using the nearest neighbor method.

Keywords: EEG, BCI, imagined speech

1. INTRODUCTION

EEG is a recorded electrical activity produced by the brain while performing the various task.
Depending upon the frequency range brain waves are mainly divided into five categories

1. Delta waves: it ranges from 0.5-4Hz. it mainly associates with deep sleep.
2. Theta waves; It ranges from 4-7.5Hz. Theta waves are associate with creative inspiration and deep meditation.
3. Alpha waves; Range for this brainwave is 8-13Hz. Most subject produces alpha waves
4. Beta waves: Ranges from 14-25 Hz. It's a rhythm related with thinking, active attention, and focus on outside world or solving concrete problems found in normal adults.
5. Gamma waves: ranges from 30Hz.

We have selected the beta range for our experiment because Beta activity is quick-connect, fast activity and tends to dominate the normal waking state of consciousness when-attention is directed towards the outside world. The first step in experiment is the data collection and preprocessing on these data set for filtering and reducing the data size for sake of fast classification. Figure 1 illustrates the block diagram of our work. The EEG signals are collected and preprocessed, the EEG features are extracted using several methods and finally those features are classified depending on the imagined word.

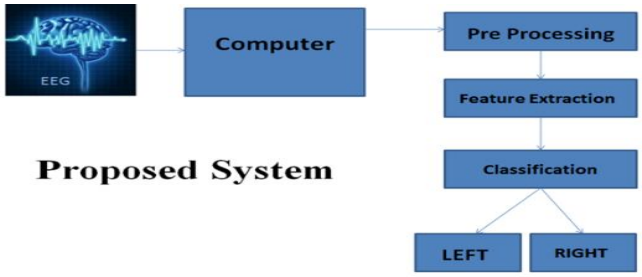


Figure 1: Block Diagram of Purposed System

2.DATA COLLECTION

We have collected EEG data available in MATLAB format. Along with the recorded EEG signal present in .eeg .cnt ASCII format. Using open source MATLAB toolbox called EEG Lab we convert them to MATLAB workspace format.These signals are of normal adult. Firstly word left is heard by subject then subject was told to imagine the word"left" When he is in relaxed state and EEG signal were recorded. Similarly the EEG signal for word "right" was recorded.The EEG potentials were recorded at 10–20 EEG electrode positions over the scalp [5], with a cap and

integrated electrodes. These electrodes measure the weak (5-100μV) electrical potentials generated by brain activity. Each electrode typically consists of a wire leading to a disk that is attached to the scalp using conductive paste or gel.

3.PRE PROCESSING

Preprocessing of data mainly involves the removal of artifact, which is the unnecessary eye and muscle movement. These artifact causes the change in amplitude so they were removed by the method suggested by D'Zmura, Katharine Brigham and B. V. K. Vijay Kumar [2,3]. Means electrodes near to eye, neck and temple should be discarded. Since we choose the Beta waves so signals are filtered in 14-25 Hz frequency range.

4.FEATURE SELECTION

We have selected simple time domain as well as frequency domain Features.

1. **Mean: -** The mean of an EEG signal is calculated by adding the values of all observation in a data set and then dividing that sum by the number of observations in the set. This provides the average value.

$$mean = \frac{sum\ of\ observation}{total\ number\ of\ observation} \quad (1)$$

2. **Standard Deviation: -** based on the mean value of signal the standard deviation is calculated.

$$\sigma = \sqrt{\frac{1}{N}\sum_{i}^{N}(x_i - \mu)^2} \quad (2)$$

3. **Energy: -** The energy of the EEG signal can be calculated in time domain.

$$energy = \sum_{n=-\infty}^{\infty} |x(n)|^2 \quad (3)$$

4. Power Spectral Density: PSD is one of the most common feature selected for bio signal. In our work we adopted the AR method to compute the PSD of the EEG signal. Spectral estimation with AR method does not suffer from frequency resolution problem (like those based on Fourier transform) and is better when the signals have a very narrowband (i.e. limited to a small frequency range) [4].

5.FEATURE EXTRACTION & IMAGINED WORD CLASSIFICATION

We had used the following model for characterization of the signal, It is nearly equivalent to the AR model used by Katharine Brigham, B.V.K. Vijaya Kumar [3] Orders 3 through 10 were tested to see which gave the better classification accuracies, and several plots of different types of PSD estimates were also compared and inspected. On the observation basis we select the order 5 for more accurate result.

$$x[n] = \sum_{k=1}^{p} a_k x[n-k] + e[n] \quad (4)$$

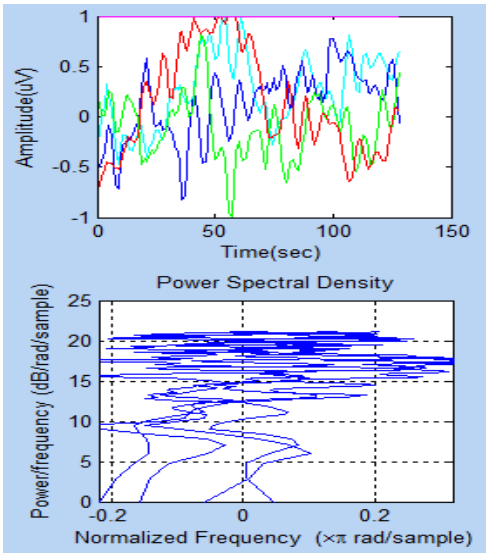
Classification of the imagined syllables was performed using a Nearest Neighbors classifier based on the Euclidean distance between AR model coefficients in the training and testing set. Each electrode's AR coefficients in the testing set were compared with only the same electrode's AR coefficients in the training set, and the mode of the predicted class labels from each electrode classification was taken across all possible class labels to obtain the final prediction.

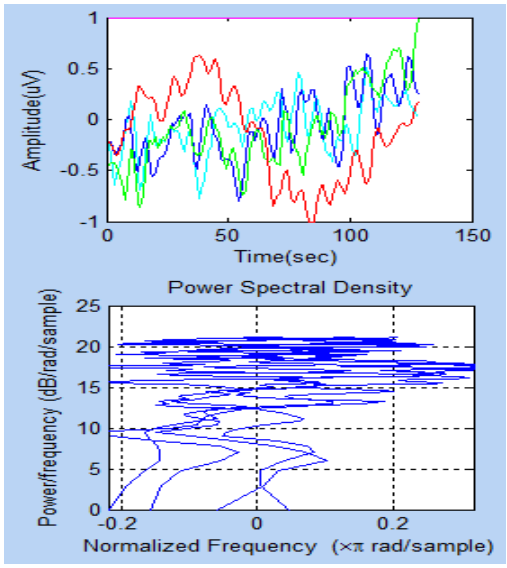
6. RESULT AND ANALYSIS

The result for subject 1 and subject 2 are obtained with the help of Matlab 2014a by applying the purposed feature extraction method and the classification of signal is done by the nearest neighbor method algorithm.

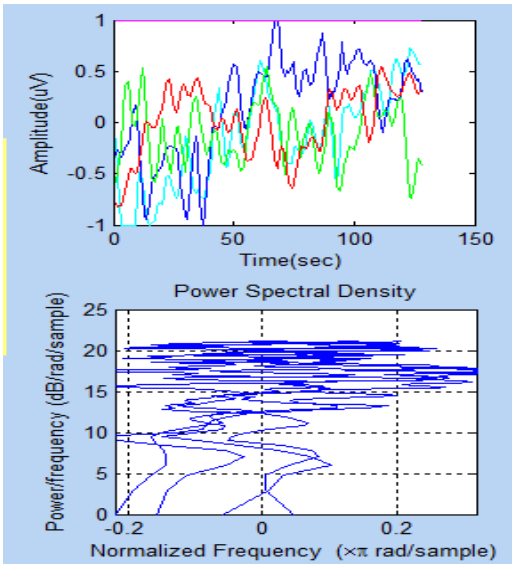
TABLE I: FEATURES OF SIGNAL

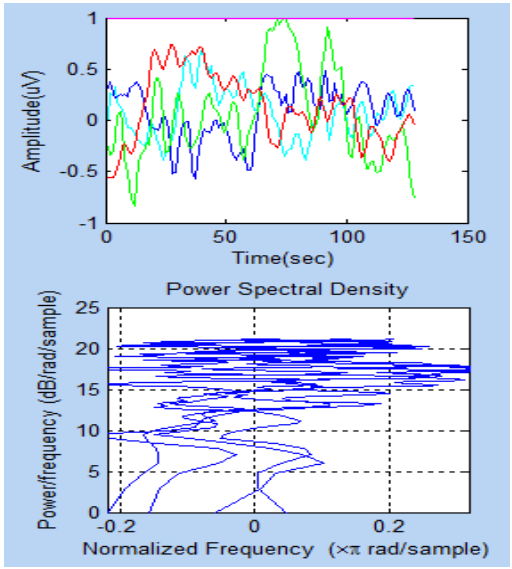
Subject	values	Mean	Standard deviation	energy
Sub 1	***Left***	***0.814724***	***0.905792***	***12.6987***
	Right	0.913376	0.632359	43.5292
Sub 2	***Left***	0.278498	0.546882	129.526
	Right	0.964889	0.157613	130.834





Result for Subject 1





Result for Subject 2

7 .CONCLUSION

Classifying EEG data from imagined speech is a difficult task, as it is currently unknown if and how imagined speech manifests in EEG data. The data is preprocessed through several stages in an attempt to extract any information that may be present in the signals since they are typically buried in noise and dominated by artifacts. The final classification results demonstrate that there is indeed some discriminative information present in imagined speech EEG signals, and the proposed method is able to classify the imagined speech for several subjects. Furthermore, this approach is also able to generalize and distinguish imagined speech across subjects as well. Our Purposed method can be utilized in EEG speech signal decoding for the brain computer interface.

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AUTHOR

ZI Yaser Arafat received his B. E. (Electronics & Telecommunication) degree in 2011 from Dr. Babasaheb Ambedkar Marathwada University, Aurangabad, (India) and pursuing M. E. (Electronics & Telecommunication) from TPCT's COE, Osmanabad (India). His research interests include brain computer interface, EEG signal processing.

Sudhir Sidheshwar Kanade received his B. E. (Electronics) degree in 1992 from Marathwada University, Aurangabad, (India) and M. E. (Electronics) degree in 1999 from Swami Ramanand Tirth Marathwada University, Nanded, (India). From 1993 to 2003 he worked as Lecturer and Senior Lecturer, from December 2003 to 2011 Assistant Professor and Associate Professor in department of Electronics and Telecommunication Engineering. Presently he is working as Professor and Head of Electronics and Telecommunication Engineering at College of Engineering, Osmanabad, (India). He received his Ph.D. degree in Electronics Engineering in 2013 at Dr. Babasaheb Ambedkar Marathwada University, Aurangabad, (India). He is member of various professional bodies like IE, ISTE and IETE. His current research interests include content-based video retrieval and image processing. His work has been published in various international and national journals and conferences.