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# Analysis of EEG Signals for Brain Computer Interface

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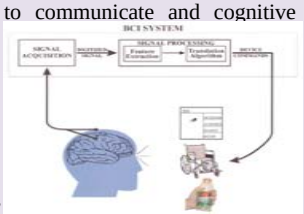
**Abstract:** Advancements in biomedical signal processing techniques have led Electroencephalography (EEG) signals to be more widely used in the diagnosis of brain diseases and in the field of Brain Computer Interface(BCI). The aim of this work is to analyze the EEG data thereby studying how EEG activity changes with right and left hand movements and also to determine whether similar changes occur in both imagination and actual hand movements thereby determining whether humans can control machines using their thoughts in EEG based BCI. In this work ,the reactivity of EEG rhythms in association with normal, voluntary and imagery of hand movements were studied using EEGLAB, a signal processing toolbox under MATLAB. These analysis have shown that an imagination or a movement of right hand cause a decrease in activity in the hand area of sensory motor cortex in the left side of the brain which shows the desynchronization of Mu rhythm and an imagination or a movement of left hand cause a decrease in activity in the hand area of sensory motor cortex in the right side of the brain. This implies that EEG phenomena may be utilized in a BCI ,operated simply by motor imagery and the present result can be used for classifier development for an EEG based BCI.

## Theory

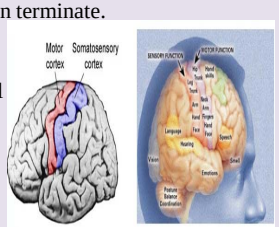
**Brain Computer Interface:**
• Direct communication system between brain & external device in order to restore sight, hearing, movement, ability to communicate and cognitive function restoration.



**Who needs a BCI:**
• Patients who lose all the voluntary muscle control due to brainstem stroke, brain or spinal cord injury, cerebral palsy etc.

**Sensorimotor Cortex:**
• **Somatosensory cortex:** Immediately posterior to the central fissure where sensory signals from all modalities of sensation terminate.

**•Motor cortex:** Anterior to the central fissure & constituting posterior half of the frontal lobe of the Cerebral cortex.

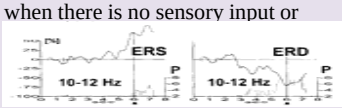



**EEG Based BCI:**
• uses Electro Encephalographic (EEG) signals from the scalp

**Why EEG based BCI :**
• Ease of use, non-invasive, low setup cost
• EEG activity can be quantified in the time domain or in the frequency domain.

**Brain signals used for EEG based BCI:**
• Visual evoked potentials, Slow cortical potentials, P300 potentials, Mu and Central Beta rhythms.

**Mu Rhythm and Central Beta Rhythms:**
• EEG activity(Mu:8-12 Hz ,central beta:18–26 Hz ) occurs in primary sensorimotor cortical areas in awake people when there is no sensory input or motor output




**Event related desynchronization/synchronisation:**
• **ERD**: Movement or imagination of movement is accompanied by a decrease in mu &beta rhythms
• **ERS:** Rhythm increase which occurs after movement and with relaxation.

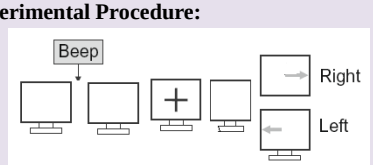
## Materials & Methods

**Subjects:**
• Four healthy subjects, three males & one female, age ranges from 18-25, first time EEG users.

• Each subject participated in 2 sessions.
In each session, 3 types of task: Imagery(Im), Voluntary (V) and Normal (N).

• Task is Pressing a key with a finger and motor imagery of it.

**Experimental Procedure:**




Blank Screen-Beep-Blank Screen-Cross-Blank Screen-Arrow
Experiment order : S1N-S1V-S1Im-S2N-S2V-S2Im.
Timings:2000ms-500ms-500ms-1000ms-500ms-1000ms

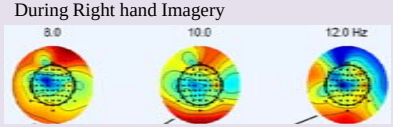
**EEG Recording:**
• Used an EEG cap having 64 Ag/AgCl scalp electrodes & placed according to 10-20 lead system
• EEG signals were recorded in the Biosemi format
• Sampling rate :- 2048 Hz

**Preprocessing of EEG data:**
• Referenced to Cz electrode, resampled to 256Hz
• Band pass filtered :1-50 Hz
• Epochs of left and right hand events with 3 sec long were extracted

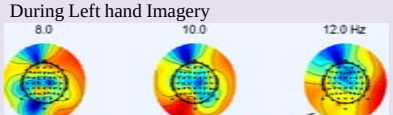
**Analysis of EEG Signals:**
Epoched data were analyzed by the following ways:-
> Power Spectrum Analysis
> Event Related Potential (ERP) plots
Channel ERP Image plots
ERP Comparisons
> Independent Component Analysis
> Independent Component Clustering
> Dipole localization

## Results

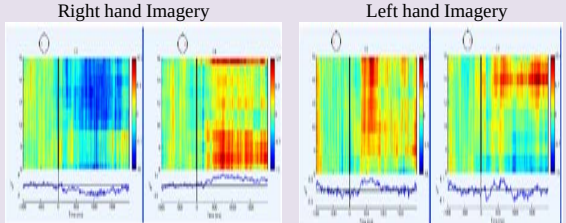
**Power Spectral Plots**
During Right hand Imagery



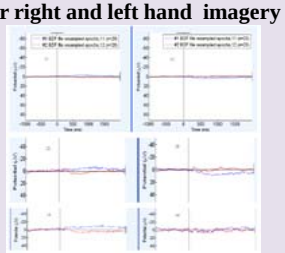

During Left hand Imagery



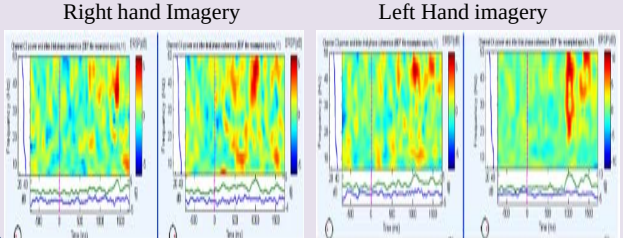

**Channel ERP Image plots**
Right hand Imagery | Left hand Imagery



**Comparison of channel ERPs for right and left hand imagery**



**Time frequency Plots-Event Related Spectral Perturbation**
Right hand Imagery | Left Hand imagery



**Conclusions and future work:**
This analysis proved that an imagination of right hand movement will desynchronize the mu rhythm (8-12 Hz)and central beta rhythms (16-26 Hz)in the sensorimotor hand area of left side brain and an imagination of left hand movement will desynchronize these rhythms in the sensorimotor hand area of right side brain. Also similar changes happens for both movement and imagination of movement. This result can be used for classifier development using neural networks, support vector machines, hidden markov models etc. and develop an EEG based BCI for motor restoration which will be the future work.