EEG & motor-imagery papers

EEG-Based Brain-Computer Interfaces Using Motor-Imagery: Techniques and Challenges

MI=Motor-Imagery
EEG=ElectroEncephalography
BCI=Brain Computer Interface

- **MI data is generated when a subject imagines the movement of a limb**
- EEG signals pose processing challenges; since they are non-stationary, they can suffer from external noise and are prone to signal artefacts
- **EEG signals can be affected by the posture and mood of a subject**
- EEG-based BCIs can be classified into two types: evoked and spontaneous
- In evoked systems, external stimulation, such as visual, auditory or sensory stimulation, is required. The stimuli evoke responses in the brain that are then identified by the BCI system in order to determine the will of the user
- In spontaneous BCIs, no external stimulation is required, and control actions are taken based on activity produced as a result of mental activity
- Despite having higher throughput and needing less sensors and training, evoked systems require users gaze to be fixed on stimuli which can be exhausting
- **spontaneous BCI such as MI BCI monitor sensorimotor rhythms (SMRs), which are oscillatory events in EEG signals originating from brain areas associated with preparation, control and carrying out of voluntary motion**
- **Here, alpha activity recorded from the sensorimotor region is known as mu activity**
- **Changes in mu and beta activity within EEG signals are used to identify the type of motor imagery task being carried out**
- **Gamma activity is reliably used in MI BCIs which use internal electrodes, since gamma signals do not reach the scalp with high enough integrity to be used for MI task identification when recorded using scalp EEG**
- **When activity in a particular band increases, this is called event-related synchronization (ERS), while a decrease in a particular band is called event-related desynchronization (ERD). ERSs and ERDs can be triggered by motor imagery, motor activity and stimulation of the senses**

- **The performance of SMR-BCIs is heavily dependent on the neurophysiological and psychological state of the user, with the control of SMR activity being found to be challenging for many users**
- **generic technical challenges in MI BCI: such as high dimensionality of multichannel EEG data, the choice between averaged and single-trial results and the choice of pre-processing approach**
- **some preprocessing techniques under consideratoion are: linear-denoising, multiscale principal component analysis**

Mu rhythm (de)synchronization and EEG single-trial classification of different motor imagery tasks

reactivity of mu-rhythms studied with the imagination of right hand, left hand, foot, and tongue
60 electrodes, 9 subjects
hand motor imagery, the hand mu rhythm blocked or desynchronized in all subjects, whereas an enhancement of the hand area mu-rhythm was observed during foot or tongue motor imagery in the majority of the subjects.
The frequency of the most reactive components was 11.7Hz+-0.4
Desynchronized components were broad banded and centered at 10.9+-0.9
Synchronized components were narrow banded and displayed higher frequencies at 12.0+-1.0

- planning and execution of hand and/or finger movement block or desynchronize the mu rhythm
- inhibition of motor behavior synchronizes the SMR
- ask subjects to imagine the (kinesthetic) experience of movement (rather than a visual type of imagery)while remaining relaxed and avoiding any motion during performance
- motor imagery sequence is random, so as to avoid adaptation

Motor Imagery Classification Using Mu and Beta Rhythms of EEG with Strong Uncorrelating Transform Based Complex Common Spatial Patterns

- Common spatial patterns (CSP) algorithm is another widely used feature extraction method, which is based on the fact that such(mototr-imagery) neural activities are spatially distributed on the cortex areas [11,12]
- In addition, the power sum of the mu and beta rhythms closely related to the event-related phenomena.
- Due to the synchronization in neuronal activities, the phenomena of a decrease (event-related desynchronization, ERD) [14, 15] or an increase (event-related synchronization, ERS) [16] in power of frequency components were found [17]. The brain lateralization of ERD [18] of the EEG activity during motor imagery tasks of the left- and right-hand is also well known [13, 19]

- analyze EEG signals by investigating the different frequency band components of EEG separately, such as the mu (8–13 Hz) and beta (13–25 Hz) rhythms. This is based on the fact that the beta rhythm has distinct topographies and responses to the limb movements, compared to the mu rhythm, and thus the mu and beta rhythms should be individually considered [20, 21]
- the oscillatory power of the mu rhythm in the sensorimotor cortex ipsilateral to the tasks increased, while that of the beta rhythm in the contralateral sensorimotor cortex decreased simultaneously [22]