Neuroengineering 2023-2024

July 4th 2024

Part II - Odd

How to submit your answers.

The answers can be typed in the provided text file, following the template. Do not modify or move the lines containing the headers.

Textual answers must be typed in the editor. When graphical elements are required in the answer, the latter can be written on paper.

Keep your answers tidy. Messy, hard-to-read answers may penalize your mark.

The maximum total score for part II is **8**.

Carefully read the following scenario and answer the questions listed below.

Electroencephalography (EEG)-based Brain–Computer Interfaces (BCIs) have been successfully employed to address upper limb motor rehabilitation after stroke. These systems allow for a real-time monitoring/reinforcement of the modulation of brain activity induced by the kinesthetic Motor Imagery (MI) practice. The latter induces changes in sensorimotor oscillatory activity (i.e. sensorimotor rhythms, SMRs, oscillations of the EEG potential in the alpha and beta frequency bands). Briefly, these changes include a desynchronization which occurs before and during the MI task and reflects activation mainly on the scalp sensorimotor areas contralateral to the imagined limb.
The EEG features fed into the BCI classifier consist of the PSD estimate performed on each relevant channel (i.e. those acquired over the brain sensorimotor areas), limited to the relevant spectral bin (i.e. those included in the alpha and beta bands). PSD estimation is performed using the Welch's method, using a Hamming window and 50% overlap between segments, yielding a spectral resolution of 2 Hz. The classifier is trained to detect MI using a calibration dataset and then used to provide real time feedback to the patient and to the therapist on the correct execution of the rehabilitative MI exercise.

Experimental subjects
Thirteen subacute stroke participants with (i) a history of first-ever unilateral stroke, (ii) hemiplegia/hemiparesis caused the stroke and (iii) age between 18 and 80 years performed a calibration session (recording of EEG signals under controlled conditions) before undergoing one month of BCI-supported MI training.

Calibration Dataset
To select the BCI control features and train the classifier's weights, we used the EEG data collected during a calibration session. Scalp EEG potentials were collected by means of an electrode cap (61 electrodes; linked ears reference, mastoid ground) and bandpass filtered between 0.1 and 70 Hz. All signals were digitalized at 200 Hz and amplified/digitized by a commercial EEG system (BrainAmp; Brain Products, Gilching, Germany). Participants were instructed to perform a visually cued kinesthetic MI of the (i) grasping or (ii) finger extension movements with their affected upper limb (experimental task). The calibration session comprised four runs (two for each MI task, grasping and finger extension) Recording runs comprised 30 trials: 15 ± 1 experimental task trials and 15 ± 1 rest trials, randomly intermingled. The trial duration was 7 s with an inter-trial interval of 1.5 s. Participants were instructed to rest for the first 3 s of each trial and then either to perform the task (MI) for 4 s (experimental task trials) or to keep resting until the end of the trial (rest trials). Visual cues displayed on a monitor provided the participants with timing and information about the type of the current trial. For each experimental task, the time interval subjected to the analysis was of 3 s: from 4 to 7 s with respect to the trial start, for the MI task; from 0 to 3 s, for the rest (no MI) task.

Questions

Write all your answer in the provided text file

Q1. (2 points) Assuming that experimental subjects were given 5 minutes breaks between runs, how long did the recording session last?
Justify in max 200 characters.

Q2. (2 points) If it was found advantageous, could the dataset be re-referenced to the CAR?
Justify in max 200 characters.

Q3. (2 points) When estimating the PSD, how many segments were extracted from each trial for the MI task?
Justify in max 200 characters.

Q4. (2 points) Which of the following artifacts would require rejecting the trial (or part of it) and which could be tolerated because they happen in a disjoint frequency band?
Type 'reject' or 'tolerate' on the same line as the artifact name

1. EMG
2. EOG
3. sweating
4. powerline
5. movement

Justify in max 400 characters.