Neuroengineering 2019-2020

Exam 27 October 2020 – Part II

How to submit your answers.

Most answers can be typed in the Exam.net editor.
Write the answers in the same sequence as the questions (A1, A2, … B1, B2, …) and write the same headers as the test on a separate line just above your answer, e.g.:

> Problem A
> A1
> *<your answer to question A1 goes here>*
> A2
> *<your answer to question A2 goes here>*
> …

Textual answers must be typed in the editor. When graphical elements are required in the answer, the latter can be written on paper and scanned using your mobile phone at the end of the exam.
It should always be possible to use a single sheet of paper for all answers to a specific problem. Anyway, always use separate sheets of paper for problems A and B.

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

Your answers should not exceed the length recommended in each question.
Answers significantly longer than requested may reflect poor understanding of the problem, and thus will likely receive a lower mark.

The maximum total score for part II is 11.

Problem A

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

A study aims to define objective measures of the brain activity and connectivity to be used in support of the diagnosis of a disorder of consciousness (DoC). A group of patients with a diagnosis of Minimally Conscious State (MCS) or Unresponsive Wakefulness Syndrome (UWS, previously known as Vegetative State) undergo a 64-channels EEG screening during the resting state. The related resting state brain networks are built by means of the Ordinary Coherence for 4 frequency bands (delta, theta, alpha and beta). Two indices are selected to discriminate MCS from UWS patients:

- The sum of all the network connections directed from the frontal to the parietal scalp regions (fronto-parietal influence)
- The average out-degree of all the electrodes in the frontal region (frontal out-degree)

Such indices are later used to classify the patients in two groups and the rate of correct classifications (in terms of true positives and false positives) is reported in a ROC curve for the two indices.

The AUC of the curve related to the first index is 0.8, while the one related to the second is 0.6.

Questions

(write all the answers in the exam.net editor)

A1. Identify the mistake in the procedure described. Indicate what is wrong and why. (Max 10 lines) *(2 points)*

A2. Indicate a possible way to improve the study. Motivate your choice. (Max 10 lines) *(2 points)*

A3. According to the ROC curve analysis presented in the scenario, indicate which of the two indices you would select as a measure to support the diagnosis of MCS/UWS and why. (Max 5 lines) *(1.5 points)*

Problem B

An EEG data set was recorded from one healthy subject. The subject sat in a comfortable chair with arms resting on armrests. Visual cues indicated for 3.5 s which of the following 2 motor imageries the subject should perform: (R) right hand, (F) feet. The presentation of target cues were intermitted by periods of random length, 1.75 to 2.25 s, in which the subject could relax. The target cues were indicated by letters appearing on a computer monitor, behind a fixation cross (which might nevertheless induce little target-correlated eye movements).
The continuous EEG is then segmented in trials, corresponding to each execution of the task.

Figure B1 shows the timecourse two EEG channels (Cz, C3) in two trials (A, B). Three signals are displayed (S1, S2, S3), either the raw signal (i.e. as acquired), or filtered with a specific bandpass filter.

Figure B2 shows the power spectrum density of the EEG on channel Cz, computed with two methods:

1) using the definition $PSD(f) = \left|DFT\left(x(t)\right)\right|^2$
2) using the averaged periodogram method (Welch's method)

Questions:
(Type all answers in the exam.net editor)
(Mathematical formulas can be handwritten and a reference to the scan can be included in the text)

B1. *(2 points)* Considering *Figure B1*, find which signal among {S1, S2, S3} is the raw signal and which is filtered; if it is filtered, state which EEG band (rhythm) is preserved by the filter. Explain why.
Start your answer with three lines reporting the associations, e.g.:
S1 = raw
S2 = delta
S3 = alpha
Justify in max 10 lines.

B2. *(2 points)* Considering *Figure B1*, in trial A and trial B the subject executed different tasks, either right hand (R) or feet (F). Assign the correct task to each trial. Explain why.
Start your answer with two lines reporting, the associations, e.g.:
Trial A = F
Trial B = R
Justify in max 10 lines.

B3. *(1.5 point)* Considering *Figure B2* find which spectrum between {A, B} is computed using the definition (DEF), and which is computed using the averaged periodogram method (APM). Explain why.
Start your answer with two lines reporting, the associations, e.g.:
Spectrum A = DEF
Spectrum B = APM
Justify in max 10 lines.

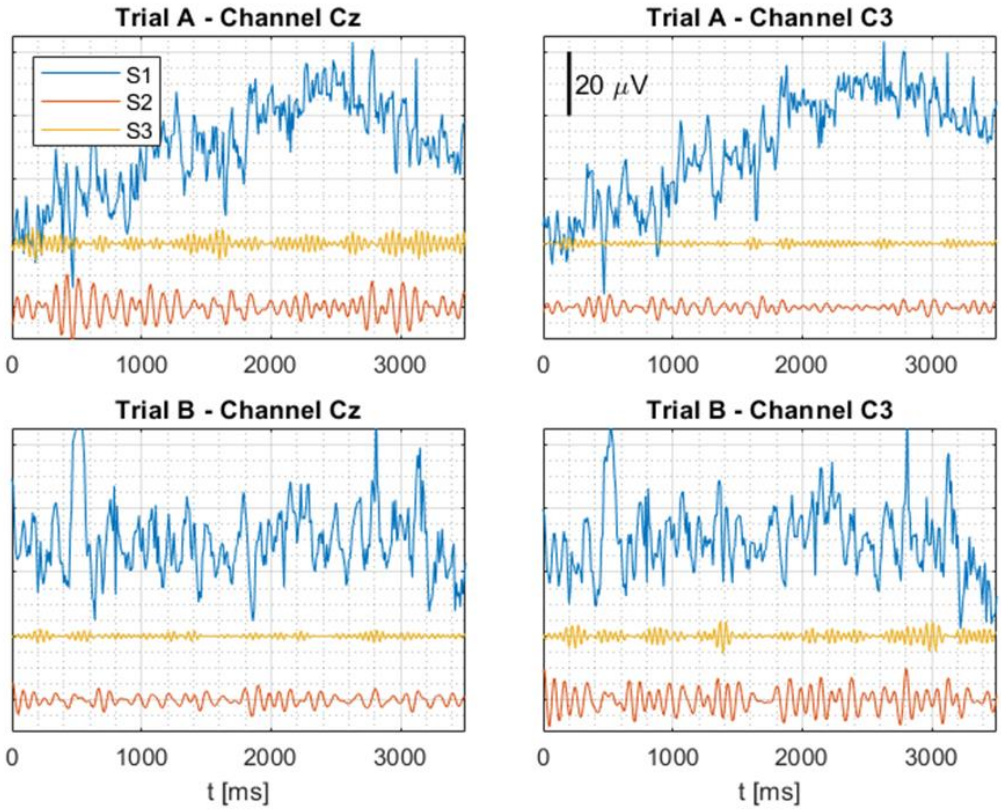

Figure B1. Time courses of raw or filtered single trials of EEG data, acquired from a specific channel.
Panels in the left/right column: data acquired from electrode Cz/C3, respectively.
Panels in the top/bottom row: data acquired in trials A/B, respectively.
Each panel contains three waveforms (S1-S3), corresponding to 1 unfiltered and 2 filtered signals.

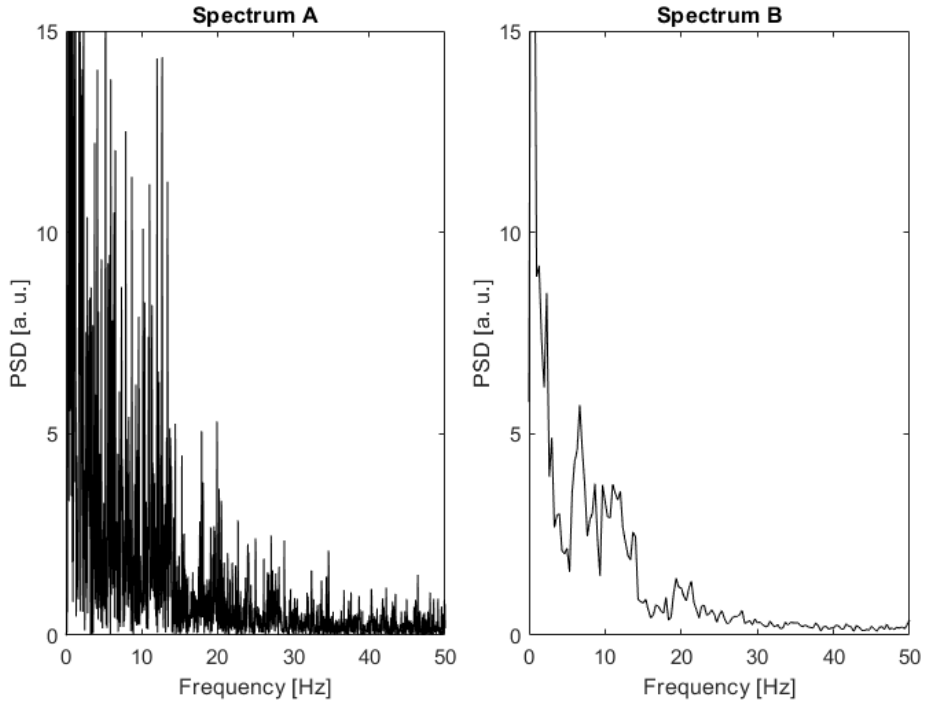

Figure B2. Power spectral density (PSD) estimates.
One panel shows the PSD computed using the definition, the other shows the Welch's PSD (averaged periodogram method).