Neuroengineering 2019-2020

Exam 17 September 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 <u>at the end</u> 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 novel approach for the cognitive rehabilitation of short-term memory functions is tested in a group of post-stroke patients. The duration of the rehabilitative intervention is 4 weeks.

Before and after the intervention, the patients are subjected to a neurophysiological assessment, with the aim to evaluate the changes in the connectivity occurred as a result of the rehabilitation.

EEG recordings (64 electrodes) are performed in two sessions: one immediately before (PRE) and one immediately after (session POST) the rehabilitative intervention (Fig. A1). During the screening, the patients perform a cognitive task based on short-term memory.

The neurophysiological assessment includes the following steps:

1- The pre-processing of the EEG traces

2- The analysis of brain functional networks during the task, by means of the Ordinary Coherence

3- The extraction of a subnetwork associated with short-term memory, including 6 electrodes (Fig. A2)

4- The computation of local and global indices (Degree of each electrode, Density, Global Efficiency) for the PRE and POST sessions (Fig. A3) and their comparison.

Questions

A1. For a specific subject, the graphs obtained for the PRE and POST sessions are reported in Fig. A3. *(write the answers on paper)*

A1.1. Extract the corresponding **adjacency matrices** *(0.5 points)*
A1.2. Compute the **degree** for each node *(0.5 points)*
A1.3. Compute the **Density** for each graph *(0.5 points)*
A1.4. Compute the **Global Efficiency** for each graph *(2 points)*

A2. Are there **any changes** (POST vs PRE) in these indices after the intervention? (Max 5 lines) *(write the answers in the exam.net editor)* *(0.5 points)*

A3. Indicate **which connectivity estimator** you would use to improve the **network analysis**. **Motivate your choice**, indicating the advantages of the method selected with respect to the one used in the proposed scenario. (Max 5 lines). *(write the answers in the exam.net editor)* *(1.5 points)*

Fig. A1 – Temporal organization of the study

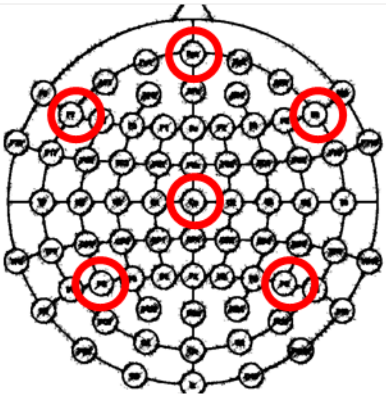

Fig. A2- The electrodes selected for the study (circled)

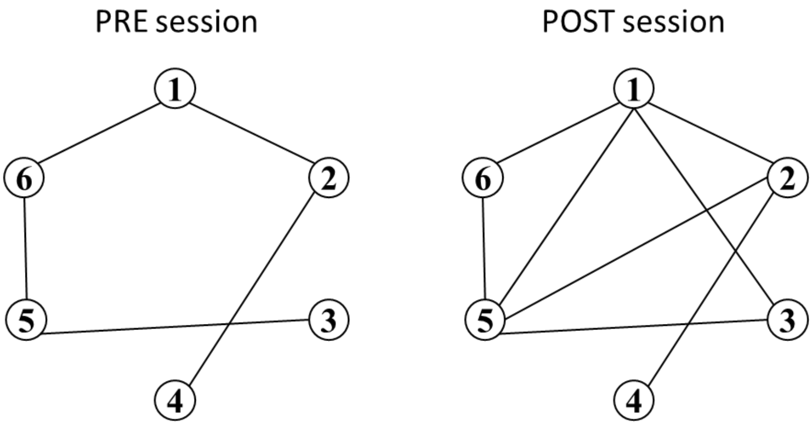

Fig. A3- Graphs obtained for a specific patient

Problem B

A single-board computer is used to perform automatic diagnosis of visual evoked potentials (VEPs) by analyzing the amplitude of the P100 potential. An example of a normal VEP is shown in *Figure B1*.
The input EEG signal is filtered to attenuate all artifacts, thus its range is $\pm 100\mu V$. The signal is then amplified; the gain is set to a value such that the range of the amplified signal matches the input range of the ADC. The board features a low quality 8-bit ADC.
The P100 potential is relevant for the diagnosis and must be acquired with a specified Signal to Noise Ratio.

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)* Concerning the quantization noise, what is the SNR of the raw, unprocessed EEG? What would the SNR be if a more expensive SBC with a 10-bit ADC was used?
Explain why.
Start your answer with a line reporting both SNR values in decibel
Justify in max 10 lines.

B2. *(2 points)* Considering all contributing noises, how many trials must be acquired so that the SNR of the VEP is greater than 10dB? Would this number change using a 10-bit ADC?
Explain why.
Start your answer with a line reporting, for both cases, the minimum number of trials
Justify in max 10 lines.

B3. *(0.5 points)* Name the three EP components marked in *Figure B1*.
Only state the three names, ordered by increasing latency. Optionally add a 1-line comment
max 2 lines.

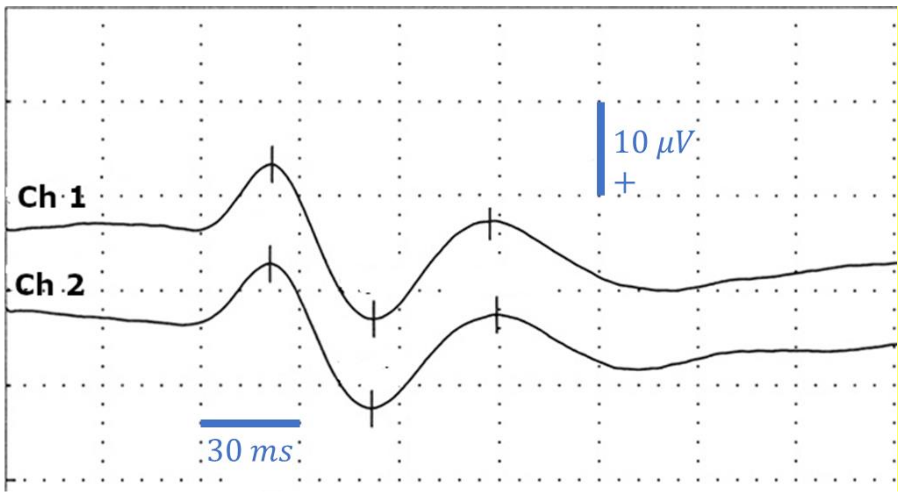

Figure B1. Example of normal Visual Evoked Potential acquired from two unspecified channels. The left margin of the figure corresponds to the stimulation time. Note on the vertical axis, positive potentials appear downwards.