Neuroengineering 2023-2024

Exam September 10th, 2024

Part 1

How to submit your answers.

Type your answers in the provided text file.

Write the answers in the same sequence as the questions. Use a separate line for each question. Start the line with the question number. Use dashes ('--') to indicate skipped answers. For example:

```
Section A
1. T
2. F
3. F
4. --
5. T
…
Section B
1. …
```

In the exceptional case that one or more of your answers require specific assumptions that were omitted in the question, you can add short comments **at the end of each section**. Start the **optional** comment with the number of the question it refers to. For example:

```
…

Comments
Q7: I assumed that the sinewave frequency is lower than the Nyquist frequency.
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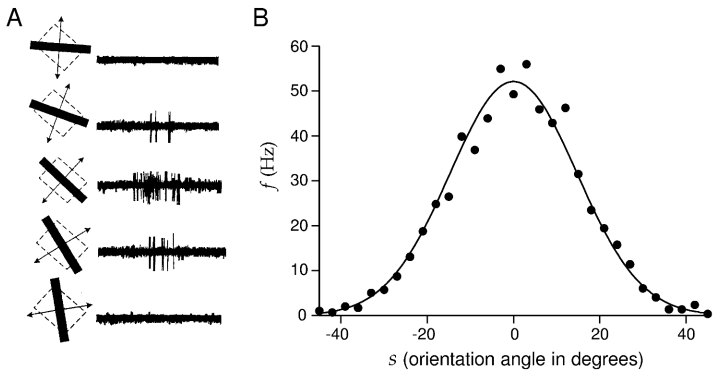
The total score will be computed summing the contribution of each answer, whose maximum partial score is shown on the right of each question, according to the following rules:

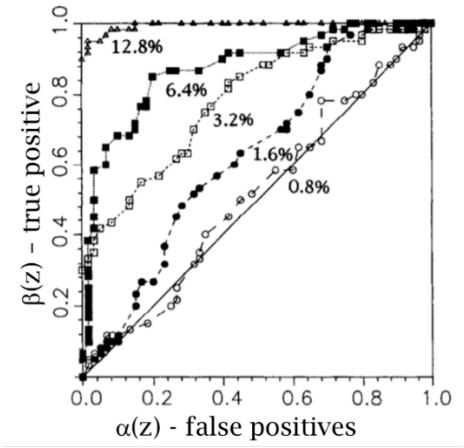
- a correct T/F answer contributes 0.5 points,
- a missing T/F answer contributes 0 points,
- a wrong T/F answer contributes -0.25 points.

The maximum total score for part I is 24.
A minimum score of 14 points in Part I is required to pass the exam.

Section A

Unless stated otherwise, each correct answer will contribute 0.5 points to the grade (yielding a maximum of 12 points for Section A). Wrong answers will receive a penalty of -0.25 points.

#	Question
1	The voltage-gated K^+ channel inactivation state is responsible for the absolute refractory period.
2	The firing rate influences the amplitude of the resulting action potential in the post-synaptic cell.
3	Temporal and spatial summation can occur simultaneously.
4	The brain operates at the temporal scale of milliseconds.
5	The frontal lobe houses the primary visual function.
6	The synchronicity of the neural activity affects the amplitude of EEG signals.
7	The neurons' spatial orientation affects the amplitude of EEG signals
8	The short-term synaptic plasticity involves a structural change in the post-synaptic membrane.
9	Scalp EEG is mainly produced by deep (subcortical) regions.
10	The part of the pyramidal neuron that acts as a current dipole is the axon
11	We need to measure the amplitude and duration of an action potential each time it occurs to understand the cell behavior.
12	The neuronal resting membrane potential is given by the sum of diffusional forces, electrical forces, and ion pumps activity
13	Given the following tuning curve, reporting the firing rate of a neuron of the primary visual cortex (B) in response to the orientation angle of a visual stimulus (A):  If the measured firing rate is 20 Hz, I can infer a univocal orientation angle that produced that response.
14	In reference to the previous figure: from the curve I can conclude that there is a preferred stimulus orientation for which this neuron is designed to respond.

#	Question
15	In reference to the previous figure: there are stimulus orientation angles to which this neuron is "blind" (i.e., it doesn't show any response).
16	Given the ROC curves in the figure, describing a threshold classification between two conditions (stimuli) at different levels of coherence of the stimulation:  The best curve is the one closer to the upper left corner.
17	In reference to the previous figure: the Area Under the Curve (AUC) for each level of coherence is proportional to the discriminability of the two conditions.
18	In reference to the previous figure: by considering only the true positives and false positives, and neglecting the true negatives and false negatives, we miss part of the results of the classification.
19	The difference between the Wiener's and Granger's definitions of causality in the statistical sense is that Granger indicated a modeling framework to be used to test causality.
20	Given the Granger Index G_{xy} between two time series x and y, a negative value of $G_{x \to y}$ means an inverse precedence between the two time series.
21	The Granger Test is more suitable than the Ordinary Coherence to obtain a spectral measure.
22	In an undirected graph, I cannot compute the indegree and the outdegree.
23	Regular networks have a smaller Local Efficiency than random networks
24	In a graph, the minimum Divisibility is equal to zero.

(continues on the next page)

Section B

Unless stated otherwise, each correct answer will contribute 0.5 points to the grade (yielding a maximum of 12 points for Section B). Wrong answers will receive a penalty of -0.25 points.

#	Question
1	The proper (visual) alpha rhythm is modulated (synchronized, desynchronized) by opening and closing the eyes. This phenomenon is best observed on the frontal EEG channels.
2	The alpha rhythm can be observed by filtering the spontaneous EEG signal using a narrowband filter, with cutoff frequencies at 14 and 30 Hz (approximately)
3	Evoked potential is synonymous of Event-Related Potentials
4	Despite being more expensive, gold electrodes should be preferred to Ag/AgCl electrodes since they allow recording of extremely slow-changing EEG potentials.
5	The CMRR of a bipolar amplifier measures the ratio between the gain of their average with respect to the electrical ground and the gain of the potential difference between the input electrodes.
6	The measurement of two monopolar EEG channels requires four electrodes – two collecting the potentials fed to the non-inverting input of the differential amplifier, one providing the reference potential and one providing the ground potential.
7	If the electrodes' contact impedance is not much lower than the amplifier's input impedance, the amplitude of the measured potential is closer to zero than the actual value.
8	EEG electrodes whose first letter of the label is "C" (e.g. "Cz") are located on the central region of the head, i.e. the region between the left and the right hemisphere
9	The artifact generated by eye movements can reach amplitudes up to $5\mu V$ in the EEG recordings
10	The heart activity is likely to contaminate an EEG recording if the reference electrode is not placed on the head.
11	In ERP analysis, the EEG continuous recording must be segmented into epochs (trials) of fixed duration, each aligned to a repetition of the event
12	A negative peak in a ERP recorded on a specific subject with a latency of $108ms$ may still be named N100, if it matches the physiological phenomenon of the nominal N100 component.
13	In an ERP, the response to a stimulus has a reduced amplitude when the SOA is too short.
14	Induced activity is often examined by analyzing the envelope of the EEG in a relevant frequency band, i.e. by rectifying or squaring the pass-band filtered trials before averaging them.

#	Question
15	The reconstruction of an analog signal from its sampled version is equivalent to the sum a set of $sinc(\cdot)$ functions, one for each sample.
16	Aliasing occurs when an analog signal is sampled using a limited input range of the ADC.
17	In an ADC, quantization introduces a noise whose amplitude is proportional to the width of the quantization interval (V_{LSB}): $\sigma_{quant} = \frac{1}{\sqrt{12}} \cdot V_{LSB}$
18	$ARV_x = \sqrt{\frac{1}{N}\sum_i (x[i])^2}$, where the sum extends on the N samples of the signal x[i]
19	It is more likely that samples of zero mean a gaussian noise will have amplitude in the range [-0.5,+0.5] rather than in [0.5,1.5]
20	The Central Limit Theorem (CLT) states that the average of N zero-mean independent identically distributed signals approaches zero for $N \to \infty$.
21	The DFT of a signal represents the amplitude A_i and initial phases ϕ_i of sinewave components of the signal at frequencies f_i ranging from $0Hz$ (included) to the sampling frequency (excluded).
22	The frequency response of a filter in the stopband should be plotted in a graph whose vertical axis has a logarithmic scale (i.e. the gain is expressed in dB).
23	An IIR filter can be designed to have “linear phase”, so that they do not introduce time- domain distortions in the waveform of the output signal.
24	The amplitude of a P300 event related potential be voluntarily modulated through the exercise of motor imagery, to build a cursor control based on a BCI.

(end of Part I)