Neuroengineering 2023-2024

October 19th 2024

Part II - Solutions

Q1. Is the commercial acquisition device adequate for the purposes of this study?
   Justify in max 3 lines.
Answer: Yes.
It features enough input channels, the internal signal processing pipeline (amplification, anti-aliasing, sampling, quantization) is correct. (See notes in the next page.)

Q2. Does the proposed spectral analysis provide an adequate spectral resolution?
   Justify in max 3 lines, including your computation of the resolution.
Answer: No.
The width of sub-bands of interest is 2 Hz (or 3 Hz). The proposed spectral estimation procedure has at best a resolution of 4 Hz, the inverse of the length of the window (which is 250 samples @ 1000 S/s = 1/4 s)

Q3. What is the number of overlapping windows from which periodograms are computed in each epoch?
   Justify in max 2 lines.
Number: 7
If the overlap was 0%, there would be 4 adjacent windows (each is 1/4 s long, see above). Since there is a 50% overlap, we must add a window for each pair of adjacent window, thus 3 more.

Q4. Would you suggest using a different windowing function than the one proposed in the draft protocol?.
   Justify in max 3 lines.
Answer: Yes
The Blackman-Harris window is well suited when we need to reduce leakage on the secondary lobes to resolve low-amplitude spectral components distant from a high amplitude component. In this case, the major issue is the width of the main lobe, because the two sub-bands are closely spaced in relation to the spectral resolution of the algorithm (in fact they are too closely spaced, see Q2).

Additional notes

Q1

Based on the description, 8 monopolar channels will be acquired (F7, F3, Fz, F4, F8, C3, Cz, C4, see Figure 1), fitting the maximum number of available channels on the acquisition device. Reference and ground leads have their own independent input and do not contribute to the channel count.
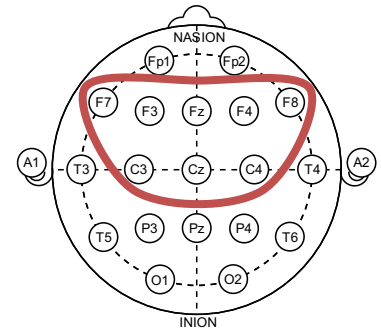

Figure 1. Selection of channels from the protocol

Q2

The width of the sub-bands in the alpha band are ambiguous (as they usually are in the literature). They can refer to:

- the interval between the two extremes, in which case the width is: $(10 - 8) = (13 - 11) = 2\ Hz$
- the interval occupied by 1-Hz-wide frequency bins, where the left- and the right-most bins are centered in the reported frequencies. In this case the total width of would be: $(10.5 - 7.5) = (13.5 - 10.5) = 3\ Hz$.

Either interpretation is considered correct. In Figure 2, the same principles applied to the whole alpha band.
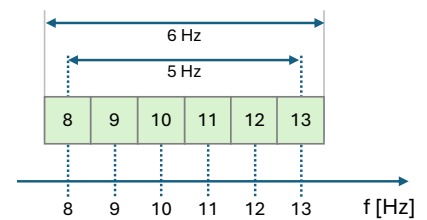

Figure 2. Width of the alpha band

Q3

The spectral analysis must be performed on each condition separately; thus, the Welch algorithm must be applied to a 1-second-long epoch each time. All windows must be contained *within* the epoch (i.e. the last one window be partially outside the epoch.

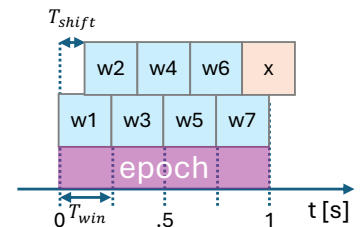In Figure 3, $T_{win} = 0.25\ s$; $T_{shift} = T_{win} \cdot (1 - overlap) = 0.125\ s$

Figure 3. Overlapping windows in the Welch algorithm