Assignment 3 – Local Field Potential

DUE DATE: May 16, 2021 @ 11:59 PM. Total Marks: 20

Grading Policies:

1. **Please upload the assignment on Teams directly. Do not send it to me by email.**
2. **Copying the answer from a colleague will result in zero marks both to you and the person from whom you have copied.**
3. **Please submit on time (submission time is recorded in Teams directly). You will be penalized 1.5% of your total marks for every hour of delay. So if you submit 12 hours late, your marks will be reduced by 18%. After 3 days you will be penalized 100% of your marks.**

You have both LFP and spike data from two neurons. Use the following analysis periods: Baseline: [-0.3 -0.1] seconds. Stimulus: [0.2 0.4] seconds.

1. Consider the first trial of LFP1. Compute the Fourier transform of the first 2 seconds (4000 data points; 0.5 Hz resolution).
    a. Write a program which takes any frequency F0 (multiple of 0.5 Hz) as an input and returns the Fourier component corresponding to that frequency (a sinusoid with appropriate amplitude and phase). To do this, you need to find out the position of F0 as well as its mirror image (Fs-F0) in the FFT spectrum, set all other values to zero, and then compute the iFFT. Make sure that if you run this function in a for loop and obtain all the components from 0 to 1000 Hz, they add up to the original LFP. (4)
    b. The component at line noise or monitor refresh rate (at 100 Hz) can be computed this way and removed from the signal. This is a perfect notch filter, since other frequencies are not affected at all. However, while doing actual recordings, we often use an "online" notch filter that is not perfect. Why is the method described above not used? (1)

2. Compute the FFT of the LFP segments in the baseline and stimulus periods. At each frequency, we get 76 values (one for each trial). Assuming that the pdfs at each frequency differ by just a scaling factor, normalize the values at each frequency such that the mean is 1. Pool these values to get a single pdf. Compare the pdfs of power and amplitude with exponential and Rayleigh distributions, respectively. From this, show that the amplitude CV should be ~0.53. (2)

3. Generate the time-frequency energy distribution of LFP1 using
    a. Multi-taper method (single taper)
    b. Wavelet Transform
    c. Matching Pursuit with 500 iterations (this will take a long time)
    d. Hilbert-Huang Transform (4)

Use the codes available at https://github.com/supratimray/SpectralAnalysisCodes. No need to submit the codes for this one since they are already available.

4. Explain why you need a lot of iterations for MP when you want to work with LFP data. For example, what happens to the time-frequency spectrum if you use only 50 atoms? (1)

5. Given a time-frequency plot of the energy distribution using the multi-taper method, write an algorithm to show the time-frequency change in power spectrum, where each time-frequency point shows the change in power (on a log scale) from some pre-specified baseline power. See page 166 for steps. (2)

6. The coherencyc command in Chronux return the coherence between two signals. However, it is possible to also get the phase coherence using the cross and auto-spectra (also obtained using coherencyc). Write a program that computes the phase coherence and show the coherence as well as the phase coherence between the LFPs during baseline and stimulus periods. (2)

7. Slides 176 and 184 show 'rose plots' for field-field coherence (FFC) and spike-field coherence (SFC) that display the phase angles in a polar plot at a particular frequency. Make this plot for a single pair of electrodes by first computing the phase angle for each trial (you may use the Chronux toolbox for this) and then using the 'rose' command in Matlab. Also show the mean phase angle across trials (this requires the circular mean instead of the normal mean). Show the rose plots at peak gamma frequency for the following:
    a. FFC: LFP1 & LFP2
    b. SFC: Spikes and LFP from same electrodes
    c. SFC: Spikes and LFP from different electrodes
    d. Explain the differences, if any, between b and c. (4)