Signal & Data Analysis in Neuroscience
Bar Ilan, Spring 2020 Due: July 7 10:00 AM.

Assignment 10

1) Filters

The file q1data.mat contains the representation of two filters (filtVec – 2*50, each filter is one line) and the data (dataVec – 1*10000, 1 second sampled at 10,000 samples/sec).

The filter is defined by:

$$y(n) = \sum_{k=1}^{50} filtVec(i,k) \cdot x(n-k+1)$$

i – number of the filter (either 1 or 2)

For each of the two signals:
1. Plot the impulse response.
2. Plot the original signal overlaid with the two filtered signals.
3. Plot the discrete Fourier transform of the original signal overlaid by the discrete Fourier transform of the filtered signal.
4. Is it a high pass/low pass/band pass filter? Is it an IIR/FIR filter?
5. Compare the two filters to each other and to an optimal filter.

2) Filters

Load the audio file 'audio.au' into MATLAB and listen to it using MATLAB (Sampling rate: 16,384 Hz).

[MATAB: use auread & sound]

a) Compute and plot the discrete Fourier transform of the signal, displayed in DB units.

b) The signal includes some white noise at high frequencies, and an additional noise at a narrow range of frequencies. What are the noisy frequencies/frequency-ranges?

c) Create a low-pass filter to reduce the high frequency noise and filter the signal. Plot the frequency response of the filter. Re-plot the filtered signal in the frequency domain.

d) Create a notch filter to reduce the narrow-range noise and filter the signal again. Plot the frequency response of the filter. Re-plot the filtered signal in the frequency domain.

For both filters, specify the filter design method, order and the stop and pass frequencies that you used.

Filters specifications:
•Signal magnitude (at the non-desired frequencies) should be reduced by at least 40 dB.
• Filter order: IIR of order <= 15

<u>3) PSD & Coherence</u>

The data file sig3.mat contains 2 signals. The "fwrsig_nospikes" is the background activity of the neuron activity given as spike train in the "st" array.
Both signals where sampled at 24038 samples/sec.
In this part we will spectrally analyze the signals, all plots should be in the 3-70Hz range.
a) Estimate the power spectral density (PSD) of each signal. Use Matlab's pwelch with no overlap, other parameters should be set to produce 0.5Hz resolution.
Normalize each of the PSDs (separately) to the mean power between 30-70Hz by dividing the power at each frequency by this value (mean power between 30-70Hz).
Plot the 2 PSDs on the same axes.
b) Find important oscillation frequencies by setting a threshold equal to 5 standard deviations above the mean power in the normalization range (i.e. find the mean and the standard deviation of the 30-70Hz range after normalization, and set a threshold at mean + 5SD).
c) Calculate and plot the cross spectrum density of the two signals, with the same parameters as for the PSD. (You can use cpsd function).
d) Calculate and plot the coherence between the two signals using the cross spectral density and the PSDs of the signals.
e) Explain what you found in each of the sub-questions.