Lab 5 **BMES 477/710 Fall 2023**

In this lab you are required to design MATLAB functions to generate the auto-correlogram (Problem 1) and the cross-correlogram (Problem 2). For each problem, you will find a respective dataset on Bb Learn. A description of the dataset organization is provided for each problem.

Please upload a document with your figures and answers, and upload your MATLAB code on BB Learn. **Your code must be commented.**

Problem 1 – Autocorrelations.

***Dataset organization*:** the file Correlations.mat contains 2 variables called *neuron1* and *neuron2*. One of the neurons is a pyramidal cell from the hippocampus, and the other is an interneuron. One of your tasks will be to determine which is which. These variables each represent a sequence of times where spikes occurred for each neuron. The units are in seconds. The total length of the recording is 1 hour (3600 seconds). In the journal article by Csicsvari et al., the first section of the results "Physiological Identification of Pyramidal Cells and Interneurons" will give you some important differences between these two cell types. Pay special attention to the auto-correlograms in figure 1. You don't have to read the entire paper, but if you're lost it might give you some insight.

***Auto-correlogram algorithm*:** This is actually the same algorithm as the PSTH (from your last homework), except that here your reference events are the same as the target events. In other words, you want to build a histogram of the spike times for a neuron, referenced to each individual spike from that neuron.

1) Take the first spike from one neuron as the reference point.
2) Count all other spikes from the same neuron in bins 100 ms before and 100 ms after the reference event, using a bin size of 1 ms.
3) Repeat using the next spike from that neuron as the reference
4) Be sure not to count the reference spike in your histogram. This is a problem specific to auto-correlograms. You can either choose not to take the reference spike in each iteration, or just subtract the total number of spikes from the center bin before normalization.
5) As for the PSTH algorithm, make sure to normalize by dividing by the total number of spikes emitted by the neuron. This will give you a probability unit of measure.
6) Specify the units of measure on each axis.

1. Autocorrelograms

a. Calculate average firing rate for these two neurons separately (number of spikes divided by the total time of recording, 1 hour. Final unit: spikes/s)
b. Generate auto-correlograms for the two neurons in the data set (-100 ms to 100 ms; 1 ms bin size)
c. One of these neurons is a pyramidal cell and the other is an interneuron. Based on these measures and what you've read about the differences between cell types, which of these is more likely to be a pyramidal cell and which is more likely to be an interneuron? Please support your answer with at least two reasons from the data.

Problem 2- Cross-correlograms.

***Dataset*:** Use the data set from problem 1.

***Cross-correlogram algorithm*:** This is actually the same algorithm as the PSTH, except that here your reference events are spikes from one of the neurons. In other words, you want to build a histogram of the spike times for one neuron, referenced to each individual spike from the other neuron.

1) Take the first spike from one neuron as the reference point. It actually doesn't matter which neuron you choose as a reference, as long as you stay consistent.
2) Count all other spikes from the other neuron in bins 100 ms before and 100 ms after the reference event, using a bin size of 1 ms.
3) Repeat using the next spike from the first neuron as the reference.
4) As for the PSTH algorithm, make sure to normalize by dividing by the total number of spikes emitted by the reference neuron. This will give you a probability unit of measure.
5) Make sure you specify which neuron you used as the reference and specify the units of measures on each axis.

2. Cross-correlograms

a. Generate the cross-correlogram between these two neurons in the data set (-100 ms to 100 ms; 1 ms bin size)
b. Now concentrate on the center of the cross-correlogram (-5 ms to 5 ms). Are any of these bins above or below the expected value? Hint: Combine the first 50 ms and the last 50 ms from the cross-correlogram. This data is far enough away from the reference that we can reasonably assume the probabilities are independent of the reference events. You can use this part of the data to extract the mean of the probability.
c. Are any of these bins statistically significant? Find the standard deviation from the first and last 50 ms of the cross-correlogram and use the mean +/- 3*SD as thresholds for significance.
d. What is the lag time between the highest bin and the reference event?
e. Based on your conclusions about cell type from part 1 and this cross-correlogram, can you make any conclusions about the relationship between these two cells? Do they tend to fire at the same time or not? Does one tend to fire before or after the other? If so, which one? Can you speculate about what this could mean in an anatomical sense?