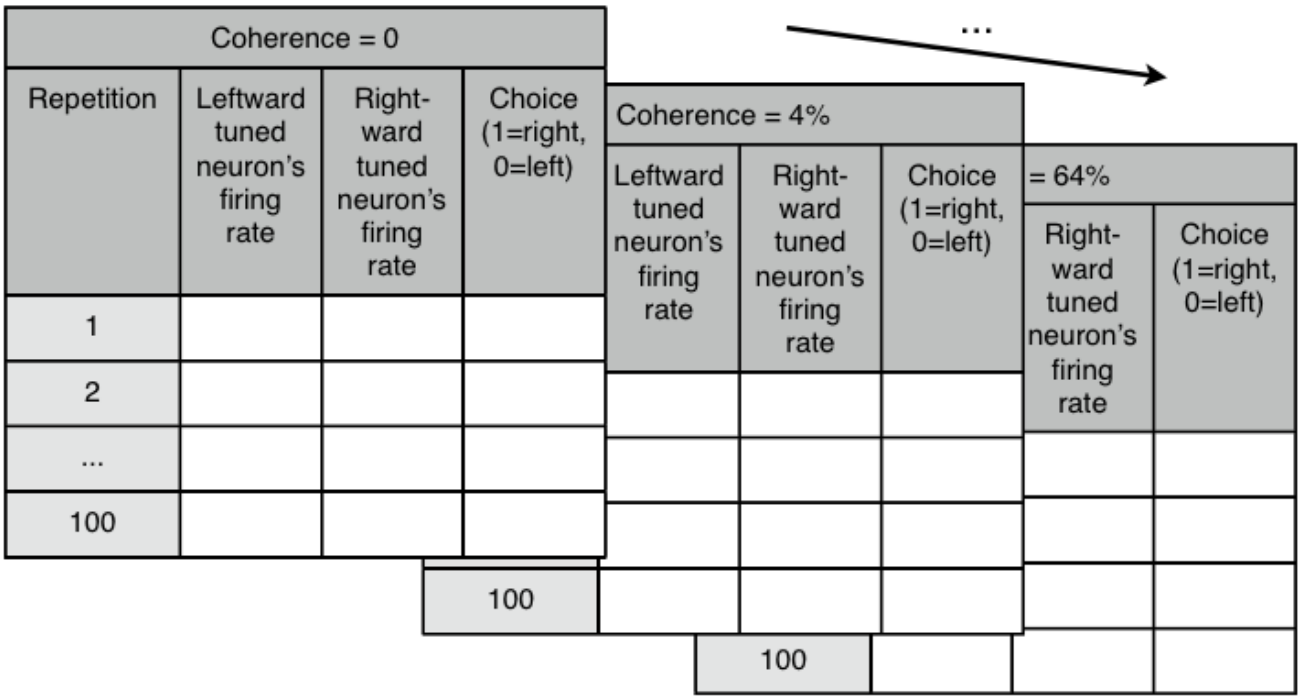
BioE 1586
Homework: Area MT and Motion Perception

In this problem set, you will recreate the analyses performed by Britten, Newsome and colleagues in their 1992 and 1996 papers. You will compare the activity of MT neurons to the monkey's behavior. You will observe how fluctuations in the neurons' responses influence the monkey's judgements. You'll also determine some properties of the monkey's perceptual abilities: his threshold and bias.

The dataset MTdata contains "real" data from an MT recording experiment. Two "neurons" were isolated, that (remarkably) were tuned for perfectly opposite directions. They were recorded while the monkey viewed a moving dot pattern. Simultaneously, the animal made perceptual judgements about the direction of dot motion, and reported them with a saccadic eye movement. The "monkey" performed 200 repetitions of each task condition while the neurons were recorded. Six different dot coherences were used: 0, 4%, 8%, 16%, 32%, 64%. At 0% coherence, the monkey just had to guess (and he was rewarded randomly), and at 64% coherent, the task was easy.

The three-dimensional matrix MTdata is structured like this:



Data for 100 repetitions per coherence are given to you. To simplify I've only given you the data collected when the motion was actually to the right. (Note that for the 0% coherent stimulus, a randomly-selected 100 trials is provided.)

1) Construct a psychometric curve for the monkey's behavior. Fit it with a Weibull function,

$$p = 1 - 0.5e^{-(\frac{c}{\alpha})^{\beta}}$$

There are many ways to do this in Matlab. Nlinfit is an excellent option. I don't mind if you use the curve fitting toolbox, cftool. Plot the choice data, and write down your estimates of alpha (the animal's psychophysical threshold) and beta (the animal's sensitivity to coherence).

2) Construct a neurometric curve from the pair of neurons. To do this, implement an ROC analysis. For each coherence, slide a criterion from 0 to 100, and calculate what percentage of the null and preferred distributions are greater than that criterion (an easy way to do this is to use the commands sort, find, and sum). Plot those values against each other, and when you connect those points, it yields a curve. Calculate the area under that curve. You don't have to cut out the shapes on a piece of cardboard - trapz is a good way to do numerical integration. These "area under curve" measurements (normalized to be a fraction of the whole box) for each coherence yield a neurometric curve. Fit it with the Weibull function to determine alpha and beta for the neuron.

3) Using this pair of neurons, calculate the "choice probability". That is, to what degree can you predict the monkey's choice on a trial-by-trial basis based on the fluctuations in the firing rates of the rightward-tuned and leftward-tuned neurons?

There are a couple different ways to solve this problem - please mention your approach, and if you do something different from the following, try to give some intuition for your choice. Here's one way:

For each cell, split the data into rightward choices and leftward choices, for each coherence. Of course, 0% coherence and other low coherences will be the most informative.

Perform the ROC analysis for each cell separately, comparing rightward choices to leftward choices, and take the area under the curve.

For each coherence, compute the area under the ROC curve. It will give you a single number, between 0.5 and 1. Generate a histogram of the 12 values you get (6 coherences * 2 neurons) and call the mean of that distribution the "choice probability" for this monkey. What is it?

4) (Extra question - please attempt, but it's worth fewer points than the preceding three) Does the animal have an internal bias that affects his choices? If so, what do you estimate it to be?