

Working together is encouraged. Please do not refer to previous years' solutions.

Turn in a write-up of your solutions including discussion/analysis AND plots, neatly organized together with all code you wrote/used for the assignment. Full points require that writeup be legible, understandably explained, and reasonably organized.

On the website will find, among the posted codes, the following:

matlab codes: cockroach_tuning.m, generate_noisy_data_cockroach.m, generate_v1_white_noise_exp.m, v1_white_noise_exp.m. Please download all these to a folder.

PART 1

We are now going to try describe the responses of a V1 neuron (early visual region of the brain in primates). Since it is visual we will deal with many more parameters than just the one we had for our cockroach (direction). For a 32X32 pixel image there are 1024 dimensions (each pixel). It won't be easy interpreting a histogram with 1024 axes! Not only will we be figuring out what the neuron prefers in an image, but also what it prefers in time, another dimension!

We will simulate what is called a white noise experiment. In this experiment an electrophysiologist will be recording from a visual neuron while 'white noise' is shown in that neurons receptive field. Essentially each frame looks like random static on a television screen. Our frame rate will be 60 Hz so in only 1 second you're shown 60 images to the neuron. All the while the neuron will occasionally be responding when by chance it is shown a preferred series of images.

Let's get the data!

Run the code v1_white_noise_exp.m

put in the number of seconds you want to run the experiment (Remember 60 Hz frame rate, so you will get 60 Hz * Number Seconds = total frames, so start with a smaller number (200 say)). Eventually we would recommend you run for around 1000 seconds to get nice results.

The results of the experiment will be in 'spikeTrain', and 'stim'. Stim will be a 11 X 11 X second*FrameRate frames array where each of the Frames is one image shown to our V1 neuron. spikeTrain is a vector with N entries (same as the number of frames) where 0 indicates there was no spike during a frame and 1 indicates there was.

1. Plot average images with respect to a reasonable delay (0.5 sec) between the image and the spike. This is the average preferred stimuli. Find a delay that resolves the clearest image report this delay in seconds. Describe in two sentences what this average image would suggest the neuron prefers. Describe in one sentence what features of a natural image this preference might cause the neuron to respond to.

2. What you have discovered and described is the average preferred stimuli. Describe in three sentences or so a hypothetical neuron for which this average would be misleading, and why (add a hand-drawn diagram or picture if this helps to explain).

PART 2

Running `generate_noisy_data_cockroach.m` as in the first HW, you will be able to run an experiment giving you a 300 ms spike train in response to your input. Think of the input as the direction in which you have deflected a cockroach spine (analogous to a hair from the cricket cercal ganglion discussed in class), measured in degrees, and use values between 0 and 90. You can ask for as many repetitions as you like. The data will be in the variable “spiketrain” and will consist of a matrix of trials, each of which has millisecond timebins which are either zero if there was no spike in that bin, or one if there was.

1. Take one of your inputs to be 50, and study cell number 1. Explore how discriminable responses to stimuli close to 50 are, given the spiking output. Specifically, use maximum likelihood discrimination to distinguish responses to stimulus 50 and a stimulus close to 50. Answer: (a) What is the resulting error probability (or percent correct)? (b) How much higher or lower does the closeby stimulus need to be to get an error probability of 10%? (c) How does that compare with the case when the “starting” input is 20 rather than 50? Show all code and plots, and explain what you did in a few sentences for each problem part. Start by plotting the **normalized histograms**, or distributions, of the spike counts, summed over the full trial, in response to 50 and in response to $50 + x$, where you choose x .

A hint / review: to think about what this means, make sure you are taking the “organism’s point of view:” that is, you have only the summed spike count that occurred over a single trial, and you must make the best possible inference as to whether one stimulus (“50”) vs another (“50+x”) occurred.

2. Can you change the tuning curve for cell number 1 so that the neural system gives a more discriminable response near the input value 20? To do this, open and edit the file `cockroach_tuning.m`. Demonstrate your findings with (generated) data, and give a complete description in a paragraph of what you did and why it worked.

Change the average firing rate to reduce the variance?