Sharif University of Technology
Electrical Engineering School

Advanced Neuroscience HW3
Based on Spatial and temporal scales of neuronal correlation in primary visual cortex - 2008

NEURAL POPULATION NOISE ENCODING AND DECODING

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Part.0 - Pre-Processing of Data

Using the pre-processing code of the paper, at first neurons with SNR less than 1.5 and firing rate less than 1 Hz are removed.

Part.1 - Tuning Curve

The stimuli are 1s gratings with different angles, here the angles are 0:30:330. After calculating the firing rate of each neuron (spikes/sec), we find the neuron with the highest firing rate together with 5 other random neurons. Here are the results for three different monkeys:

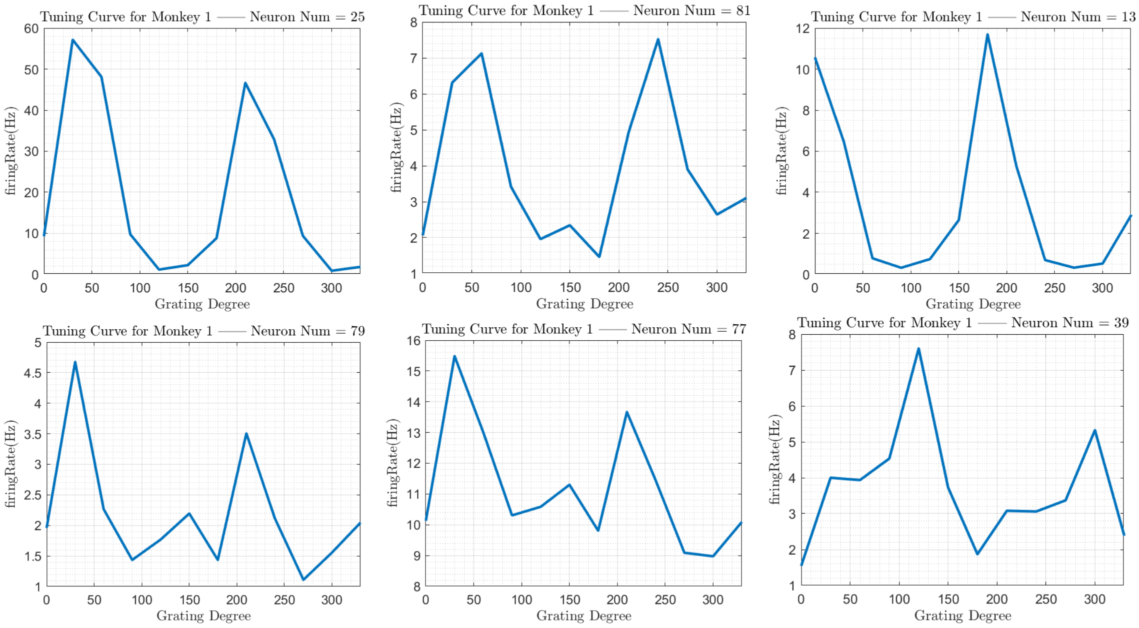

Figure 1: Tuning Curve for 6 neurons of Monkey 1

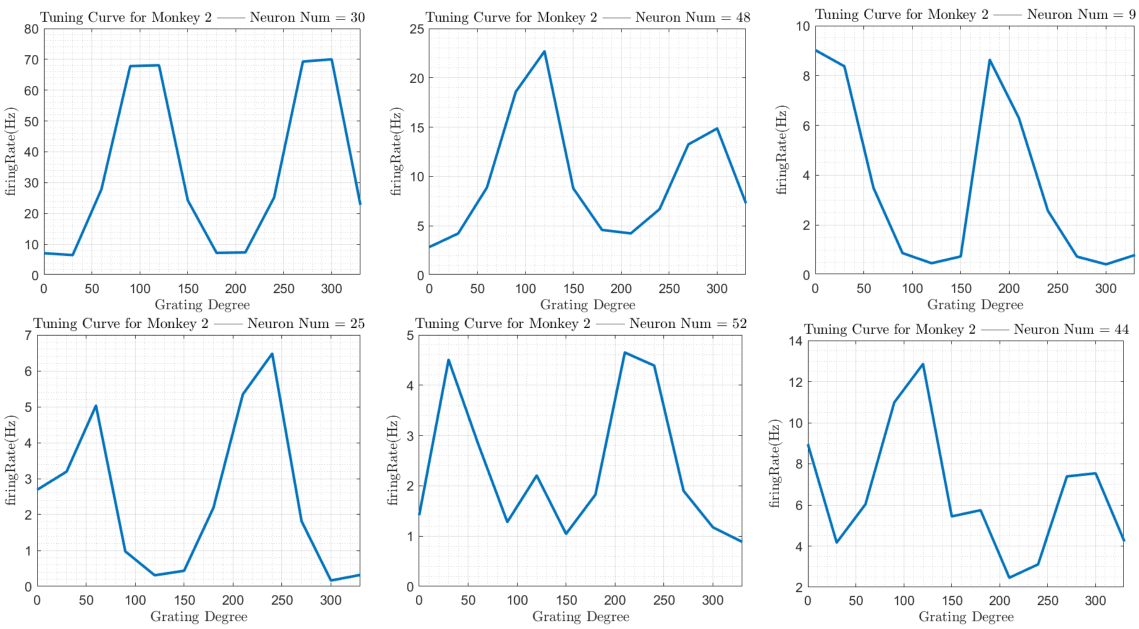

Figure 2: Tuning Curve for 6 neurons of Monkey 2

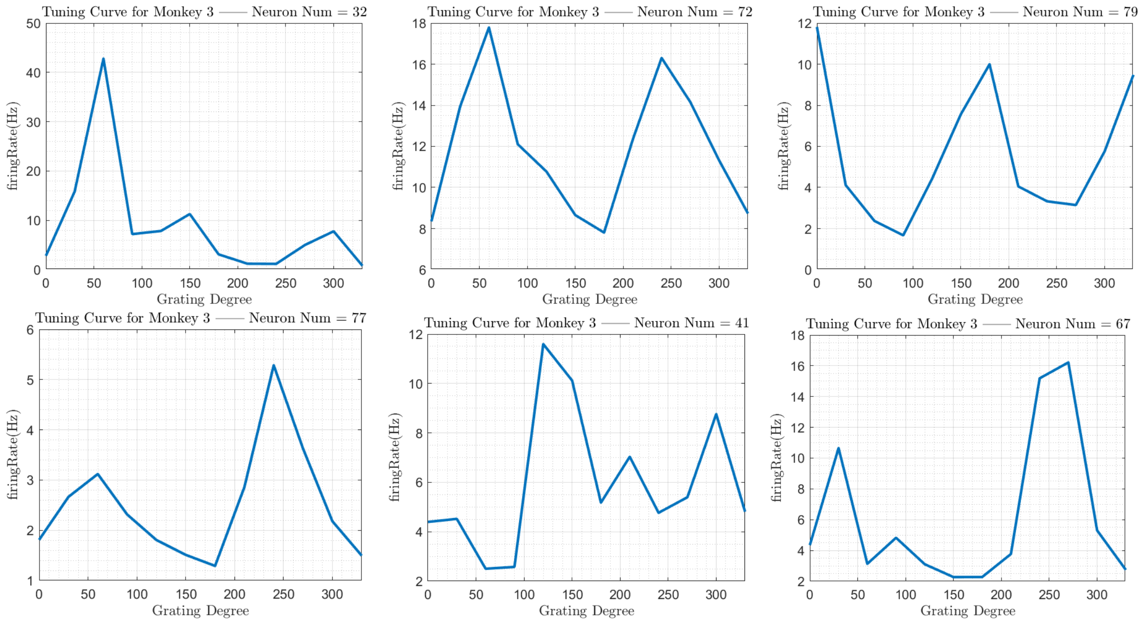

Figure 3: Tuning Curve for 6 neurons of Monkey 3

As you can see, most of the neurons have two preferred orientation which have 180 degree difference but some neurons just have one preferred orientation. So some neurons just code the sense(i.e. "jahat") of the grating which they have just one peak and some others code the direction(i.e. "rasta") which they have two peaks.

Part.2 - Preferred Orientation Similarity

Here, we want to find each electrode‘s preferred orientation. In order to this, at first, the orientation which the maximum firing rate happens at is founded for each electrode. Some electrodes capture more than one neuron, so we assign the preferred orientation of the neuron with the maximum SNR for that electrode. Here are the results for three monkeys assuming each neuron code sense (i.e. "jahat"):

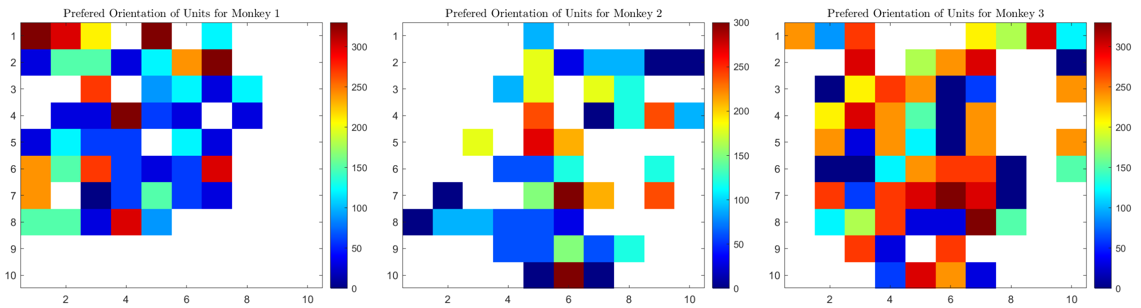

Figure 4: Preferred Orientation(0 to 330 degrees) Similarity for three monkeys

*note: White colors are electrodes which they don‘t have any neurons left after the pre-process.

Then I limited the orientations between 0 to 150 degrees and orientation bigger & equal than 180 were subtracted with 180 and here are the results again for 3 monkeys:

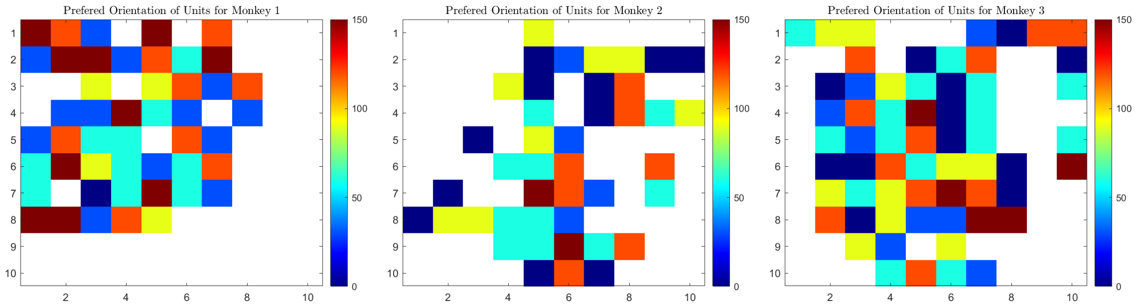

Figure 5: Preferred Orientation(0 to 150 degrees) Similarity for three monkeys

We can't see the pinwheel organization of orientation in V1 here in our meshs. It's probabilly because of the low spatial resolution we have in our data acquisition.

Part.3 - Noise Correlation Analysis

Here we find the correlation between the spike counts for all neurons on their 2400 trials. each condition's trials are z-scored like paper. Then we calculate correlation between tuning curves of all neurons as the signal correlation. Finally, we calculate the distance between each pair of neurons by their electrodes. So we have three matrices here and we plot three different plots for each monkey. Here are the results:

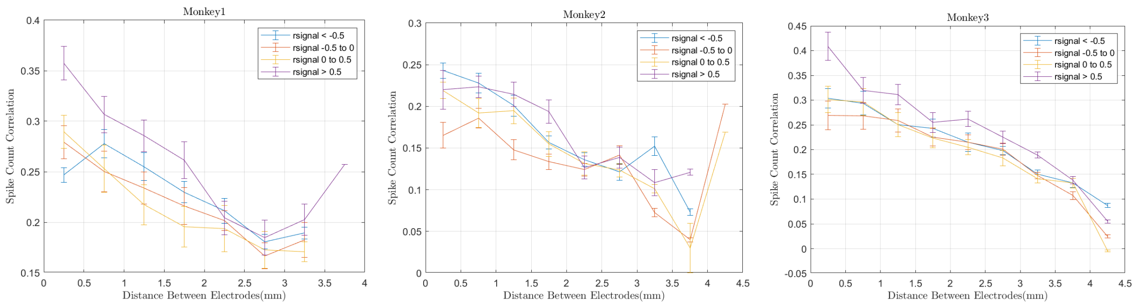

Figure 6: Noise Correlation vs Electrode distances in 4 different groups

Here the electrode distances are separated to bins each 0.5mm long and the mean and variance of each bin is plotted. As you can see, spike count correlation (noise correlation) decays as the distance between neurons increases. Another indication that we can see is that, as the rsignal (signal correlation) increases, we will have higher spike count correlation values.

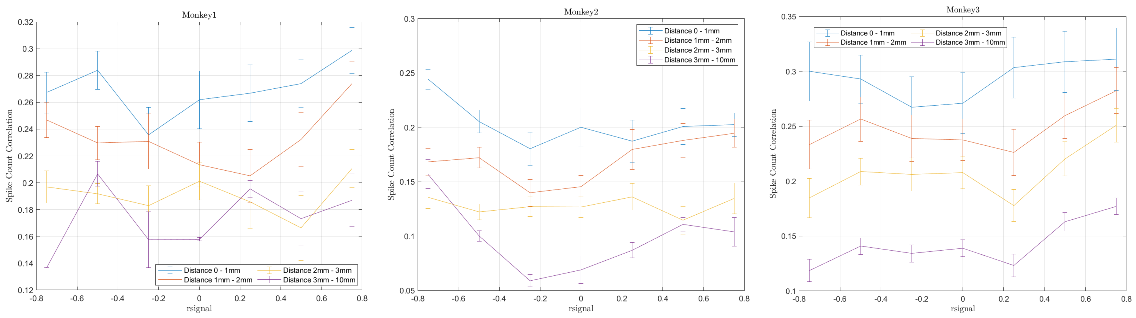

Figure 7: Noise Correlation vs Signal Correlation in 4 different groups

Here the signal correlations are separated to bins each 0.25 long and the mean and variance of each bin is plotted. As you can see, spike count correlation increases as the signal correlation gets bigger. Another result that we can indicate is that the less the electrode distances, the higher the spike count correlations would be. These results confirms the results we get from the previous three plots.

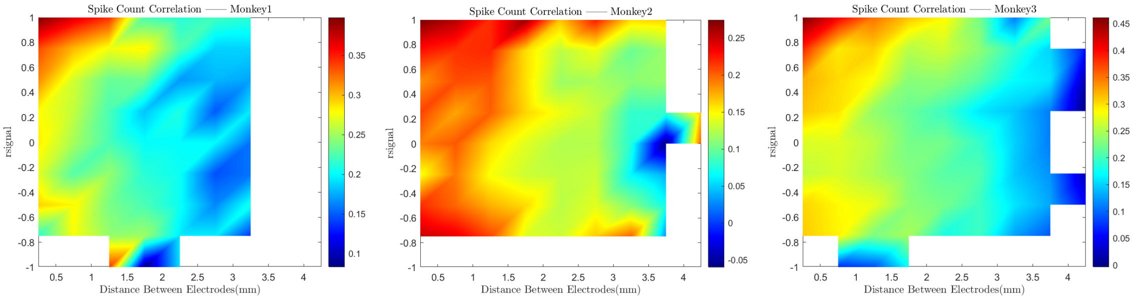

Figure 8: Noise Correlation vs Electrode distances & Signal Correlation

Here we plot spike count correlation vs electrode distances and signal correlation. As we see in previous plots, it's the same here, by increasing the signal correlation and decreasing the electrode distances, we will have higher spike count correlations.

As we saw, all of our results were similar to papers results.

Part.4 - Comparing Spontaneous & Evoked Activity

As we saw in the lectures, when we have no stimuli and we are recording spontaneous activity, neurons behave more randomly so the noise correlation will have higher values but when we have a stimuli and we are recording evoked activity, neurons' behaviours get more similar to each other and their noise correlation decreases:

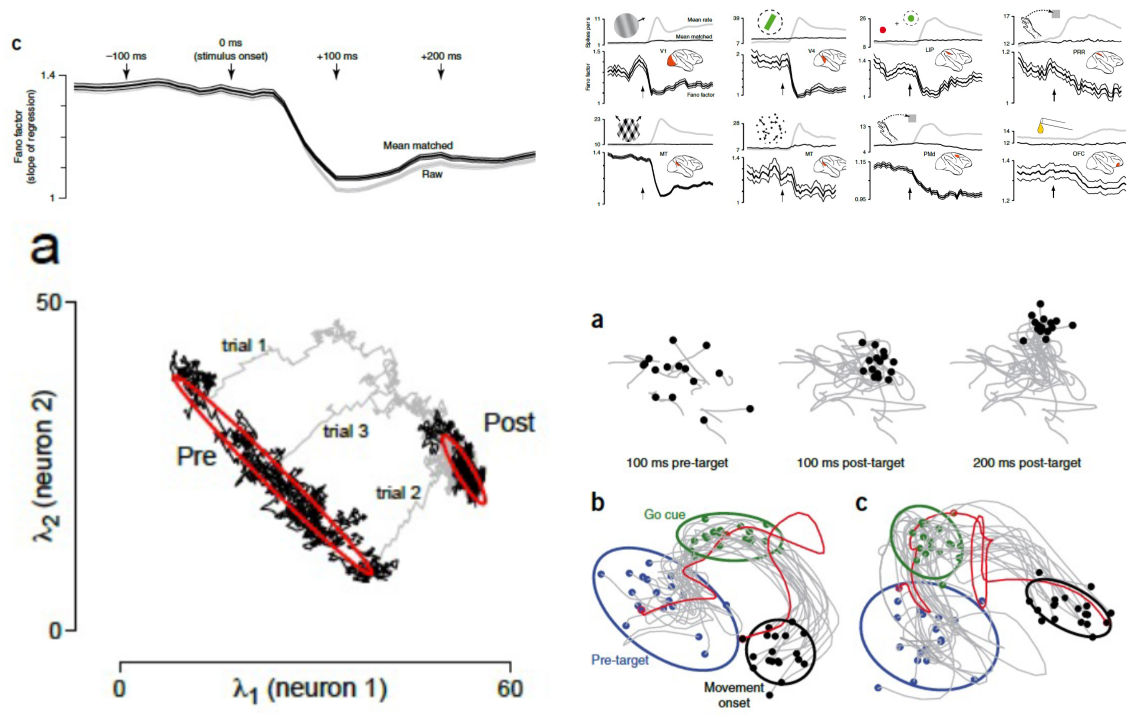

Figure 9: Pre vs Post Stimuli Noise Correlation

As you can see in these plots, when we have stimuli, the Fano-Factor and noise correlation decreases confirming the paper results which spike count correlation is more in the spontaneous activity than the evoked activity.