204938203 בנימין מנשה
Signal Processing 2022

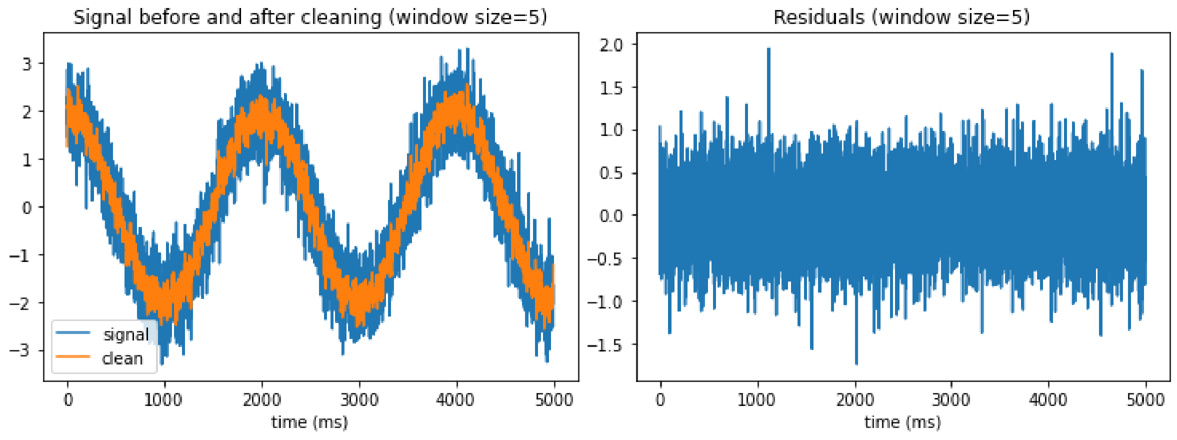
Assignment 2

1) Signal to noise ratio

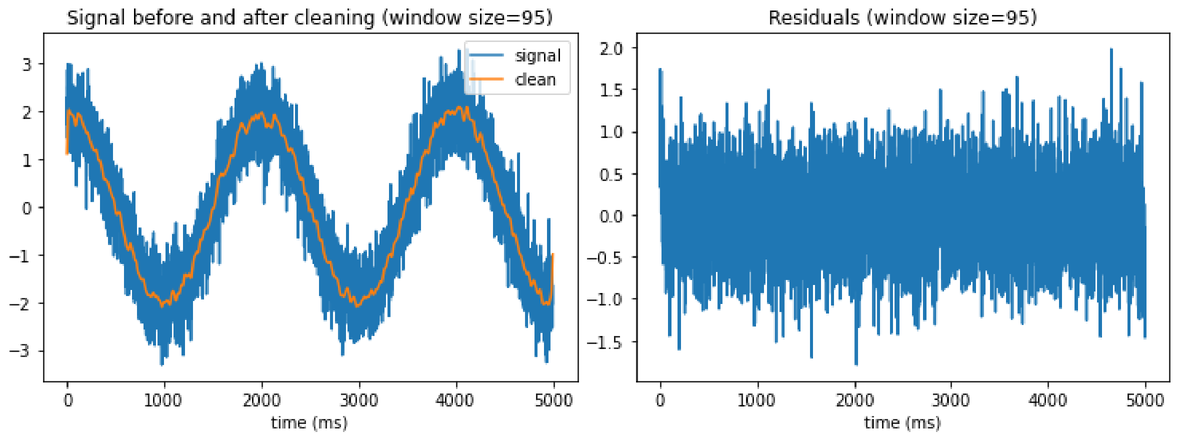
a. Did the function in python. I decided that the criteria for optimizing the smoothing window would be that which makes the SNR closes to 10db. This was done after viewing the data and seeing the amplitude of the main sinusoidal trend to be about 3 times as large as the amplitude of the noise around it, and $20*\log_{10}(3) \approx 10$. Obviously, it would be best to know beforehand the expected ratio of noise to signal, or alternatively to be an expert in the field who can identify the noise by other independent means and thus benchmark our criteria.

b. I picked the values 5, 95, 378, and 573 (Gematria for *Tlön*, *Uqbar*, and *Orbis Tertius*).

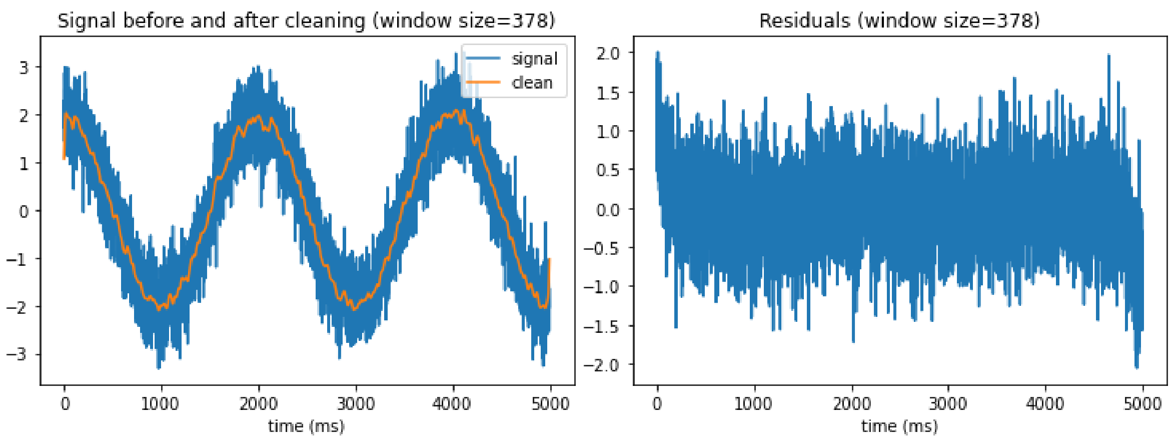
<u>5ms:</u> STD of window = 500, SNR = 10.6db



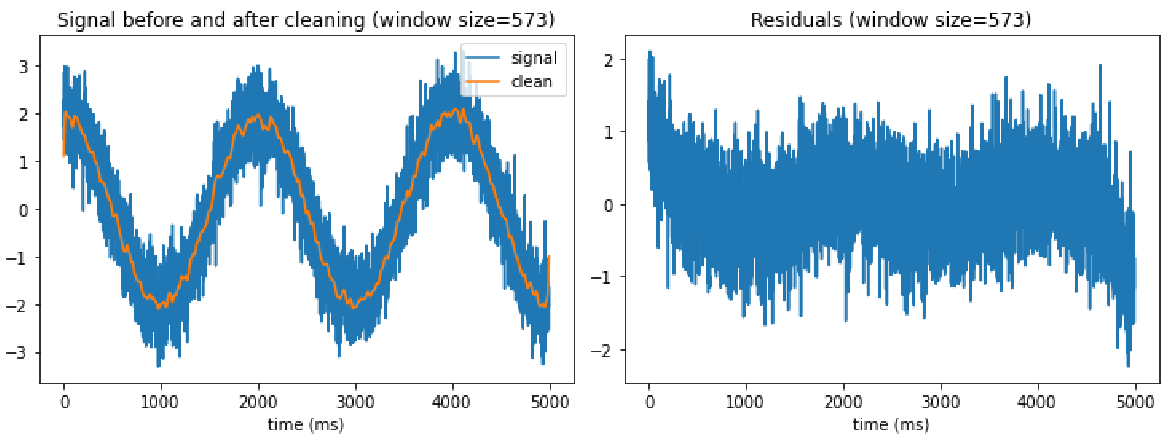
<u>95ms:</u> STD of window = 10, SNR = 9.9db



378ms: STD of window = 10, SNR = 9.9db



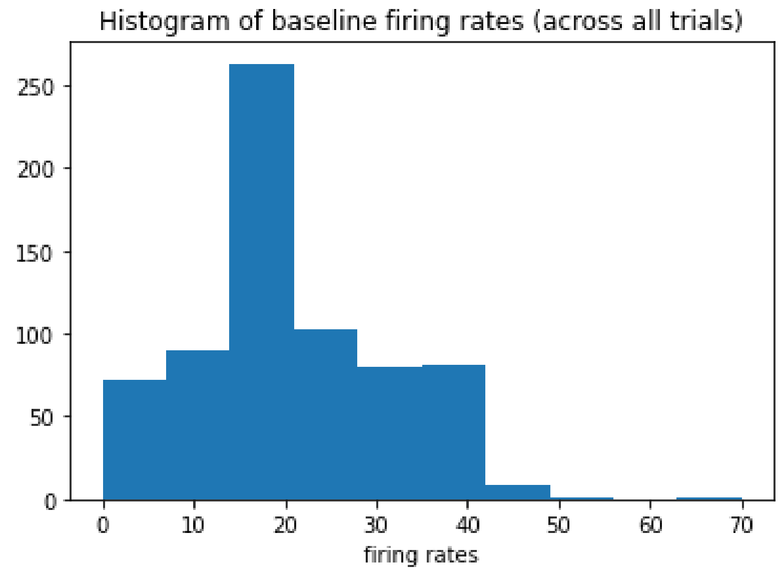
573ms: STD of window = 10, SNR = 9.9db



There are not a lot of differences between the results because I think a gaussian of 10 std will reach the optimal SNR (as we determined in our criteria), and so past a certain window size (probably around 60ish ms) there is no difference between the windows (since Gaussian tails fade after 3 stds). In conclusion, out of the four possibilities we checked, I think it best for Dr. Borges to use a 95ms window: this is both the smallest one which comes closes to our target SNR, and it mostly preserves the signal around the 100ms resolution he is interested in. I can also tell by eye that the noise in the larger windows appears to have a slight sinusoidal trend, which we assume comes from the signal, so that's not good.

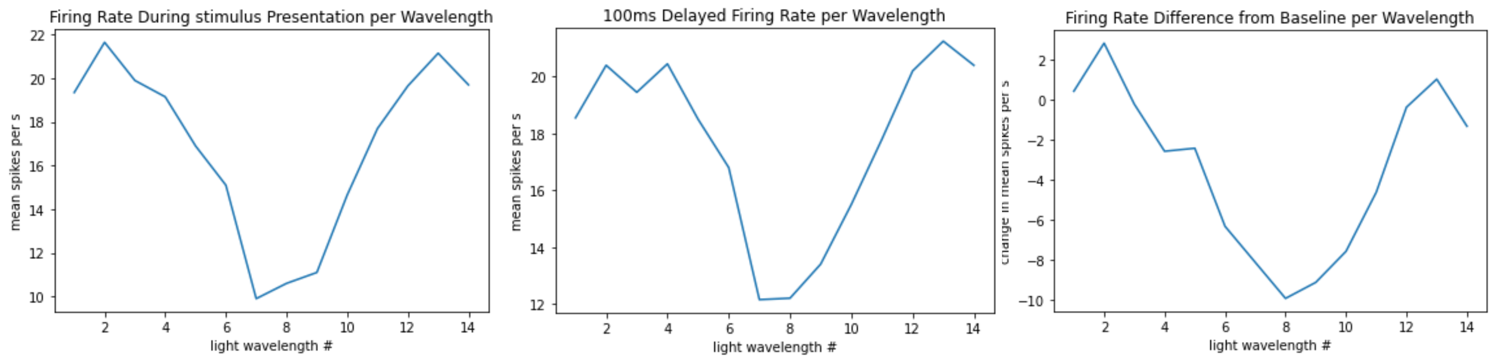
2) Tuning curves

a. I took the first 199ms for each trial (right before stimulus appeared) and calculated the average firing rate = **20.32 spikes per second**.

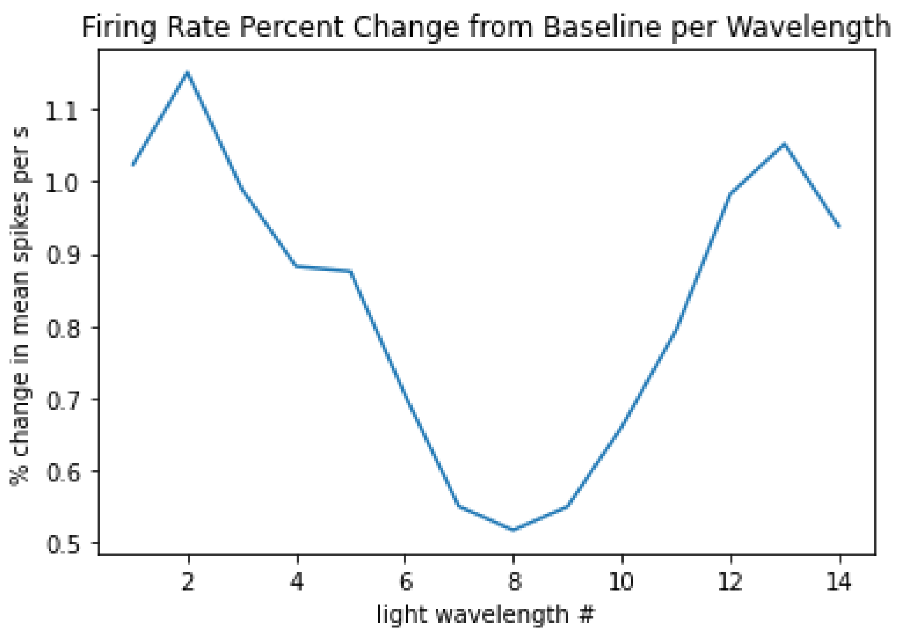


b. Wrote the functions in python.

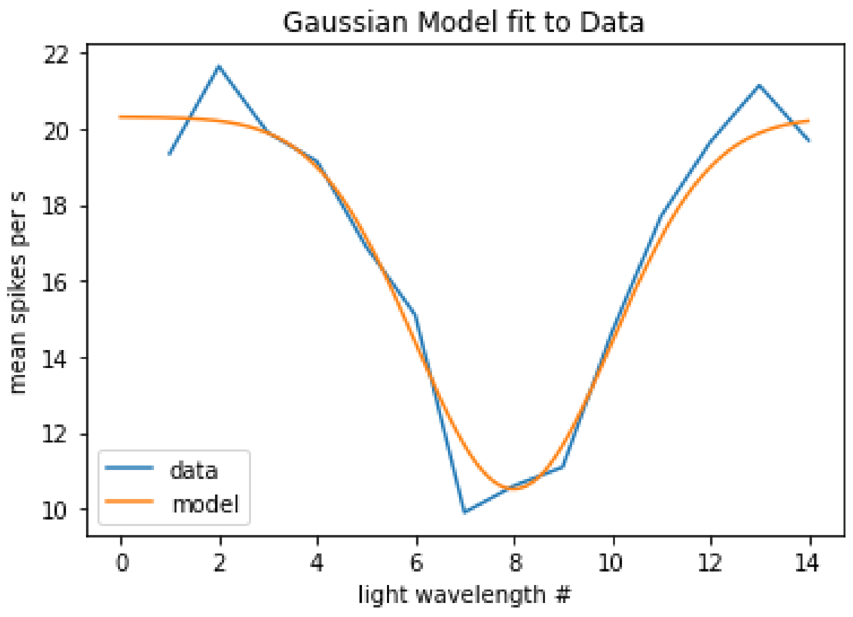
c. It seems clear that the neuron is most sensitive to wavelength #8, as it reduces its firing rate the closer the wavelength is #8, and it doesn't change its firing rate much for far away wavelengths such as #1 or #2 or #14 (it might even increase its firing rate a bit for wavelength #2, although this might be due to random sampling). Since all 3 graphs are more or less similar, they are all equally relevant.



However, a graph which displays best the change in rate of firing in response to each wavelength would be one which actually shows the percent change in firing rate from baseline. This is meaningful, in my opinion, because I don't care much about the actual firing rate values (a drop in 10 spikes per second is meaningless to me), but I can appreciate that a 0.5 reduction in firing rate means half as many spikes per second compared to baseline.



d. The model I found to fit is gaussian model with mean = 8 and std = 2. I multiplied the model by -10 and added the baseline rate (20.32), and as can be seen from the graph I think it fits rather well. (I did not calculate any loss)**.**



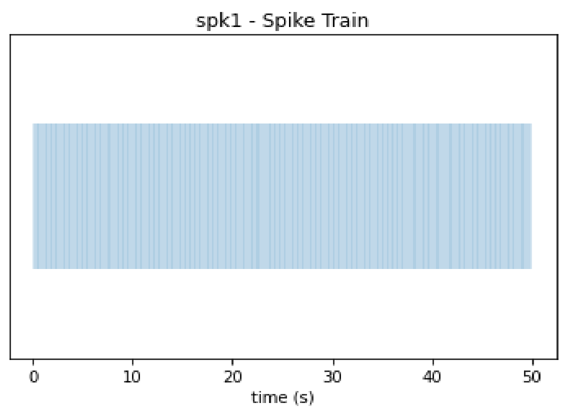
$$\hat{y} = 20.32 - 10 \cdot \exp\left(-\frac{(x-8)^2}{2 \cdot 2^2}\right)$$

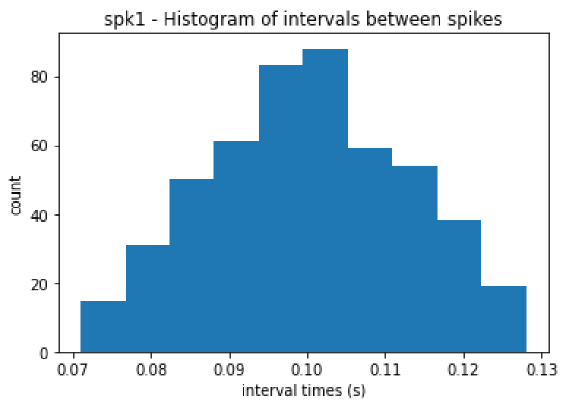
where 20.32 is the baseline firing rate, 8 is the mean, and 2 is the std

3) Stochastic point processes

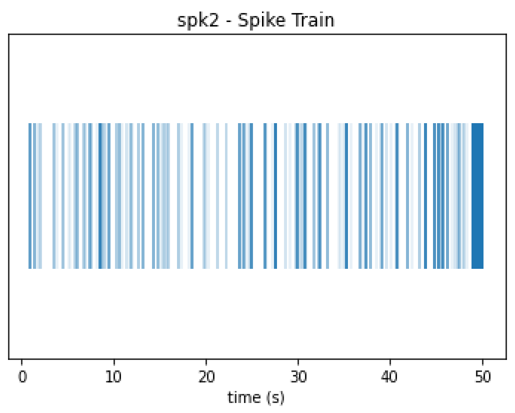
a. Wrote the function in python.

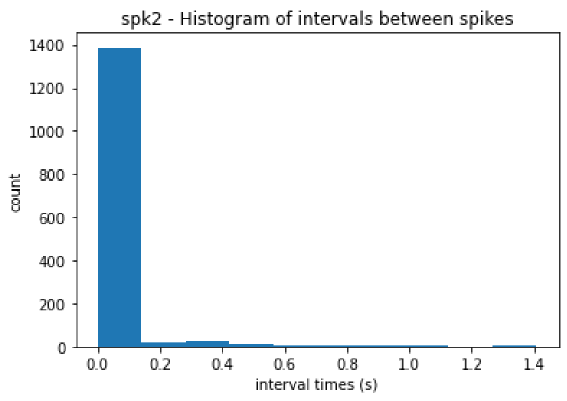
b. <u>Spk1 – Not Poisson-like ("pacemaker"):</u>
window 1s: FF = 0.058
window 0.5s: FF = 0.111
window 0.1s: FF = 0.472
CV = 0.126
Overall, very low variance in the intervals between spikes and thus between different windows (especially when we choose larger windows). This neuron is reliably consistent, firing more or less every 0.1 s. This can be seen from the histogram plot of the intervals.





<u>spk2 – Not Poisson-Like ("burster"):</u>
window 1s: FF = 608.216
window 0.5s: FF = 306.272
window 0.1s: FF = 63.954
CV = 4.216
Overall, huge variation in the intervals between spikes, and very large Fano Factor (even for larger windows), this suggests the neuron is highly inconsistent, firing mostly in bursts, as can be seen from the spike train and the intervals histogram (mostly short intervals, and few large intervals).


spk2 - Spike Train
time (s)


spk2 - Histogram of intervals between spikes
count
interval times (s)