Tutorial 3.2 Report

README

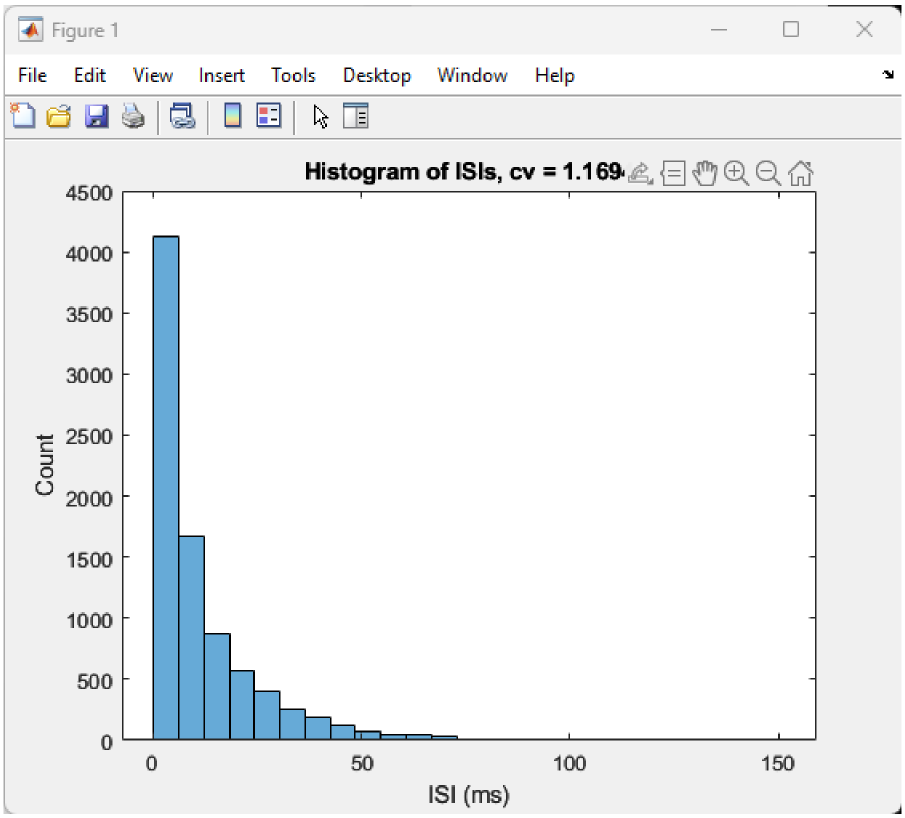
To get the plots from my code, run `part_a.m` as the main file.

Edit variable `question_number` at line 6 to either 'a' 'b' or 'c' to see the plots.

Noted for question c, please edit `Iapp_cons` at line 30 to view histograms with different input current constant values and the calculated fano factors in the console.

For each question, the console would output variance, mean, and Fano factor for numbers of spikes in 100ms time windows.

Question a) (i)



The histogram shows that ISI has a decreasing trend regarding its length. It would be rare to see long inter-spike intervals with the randomly generated input current.

(ii). CV for the inter-spike intervals (ISI) in question a is 1.1694. However, because the input current is randomly generated, this cv value would vary in a small range for each run.

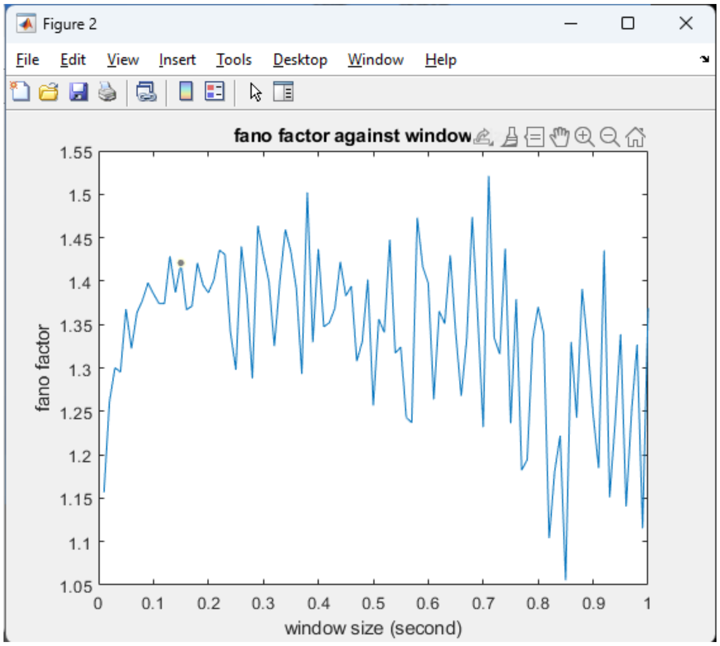
(iii) When time-bin size is 100ms:

Variance = 10.3238, Mean = 8.45, Fano factor = 1.2218,

Similar to a(ii), these three values vary slightly in different trials.

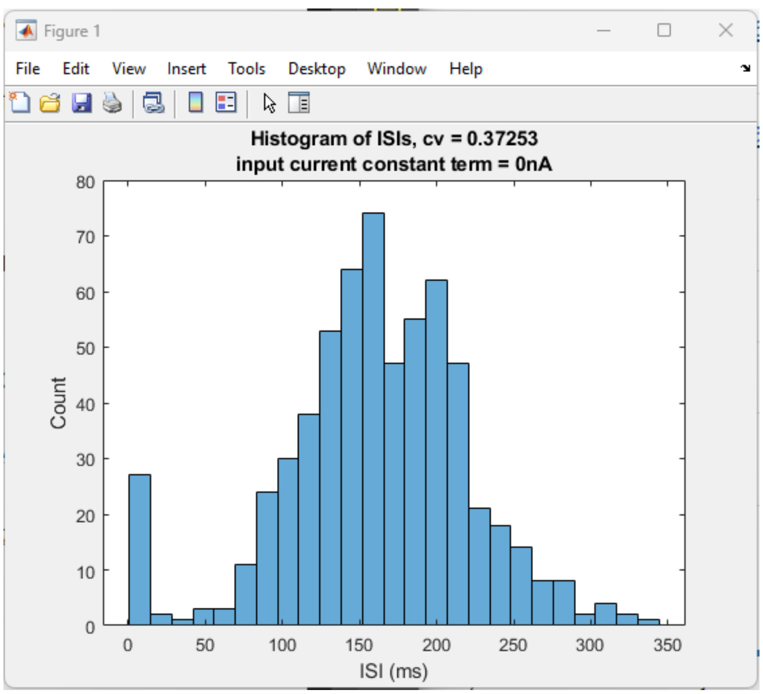
This slight variation would apply to all the following questions.

(iv)



The Fano factor has an increasing trend in variation as window size increases from 10ms to 1s. This is because of the noise. Here's the explanation. The occurrence of spikes is a probabilistic event, and the probability of observing multiple spikes within a time window increases with the time window size. As the spike number in each window increases, the number of possible spike configurations also increases, resulting in a larger range of variance. In addition, this set of a parameter has a weak influence on temporal correlations in spike trains as window size increases. Such a trend of increased variation in the Fano factor is due to the nature of probability.

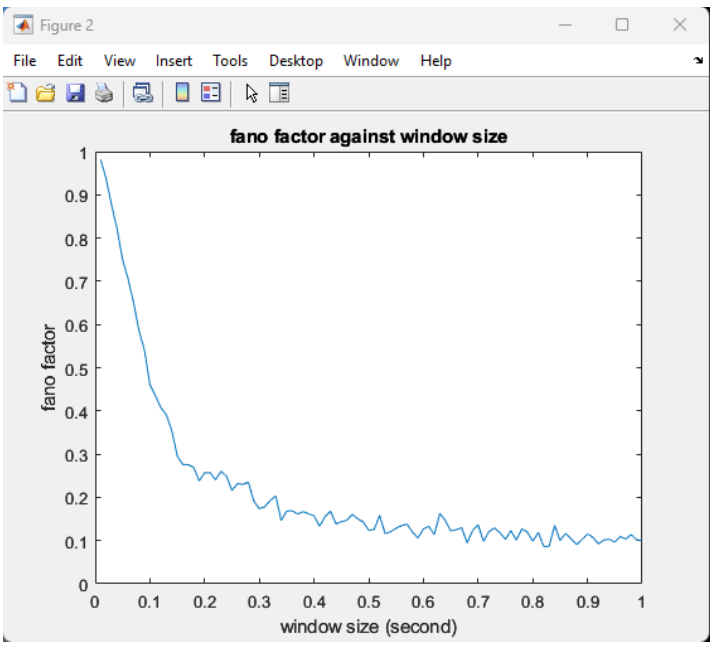
Question b) (i) (ii)

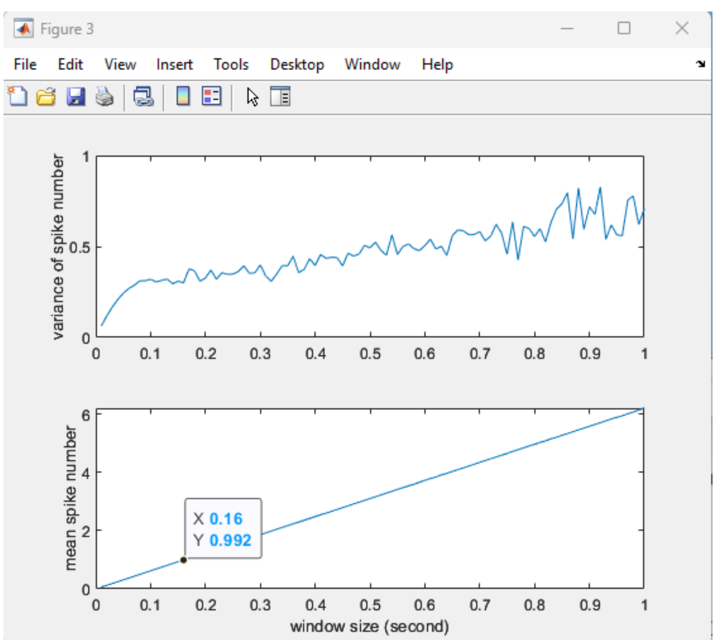


For question b(i), the ISI has a normal distribution, while ISI is distributed at around the 100-250ms range. Its CV is around 0.37253, more than twice the distribution from question (a). The parameter only has one difference two questions: the b value increased from 0 to 1nA. Parameter b contributes to the increment of I_SRA when the neuron fires. I_SRA has negative effects on membrane potential: the rise of I_SRA would decrease the membrane potential gradient, causing the neuron to have a slower increase in membrane potential, and therefore letting the neuron to fire at lower frequencies. This causes the ISI distribution to shift right towards a normal distribution, with the mean ISI around 160ms. There's a relatively high count in the first histogram box, which ISI in the range of 0.77-14ms range. This is due to the relatively large sigma value (i.e., the random input distribution range). Even if the mean input current is 0, increasing the distribution range also increases the range of Iapp rise. It would be more possible to have a large enough current rise, within a small period, that causes the two adjacent spikes to fire in an interval of less than 14 ms. When you decrease the sigma to less than 40pA at line 25, you can observe that this abnormal bump at the beginning almost disappears; if you increase the sigma value by step of 10pA, you can observe that such bump would be higher, and gradually disturbing the normal distribution.

(iii) When time-bin is 100ms: Variance=0.31191, Mean=0.62, Fano factor=0.50308

(iv)

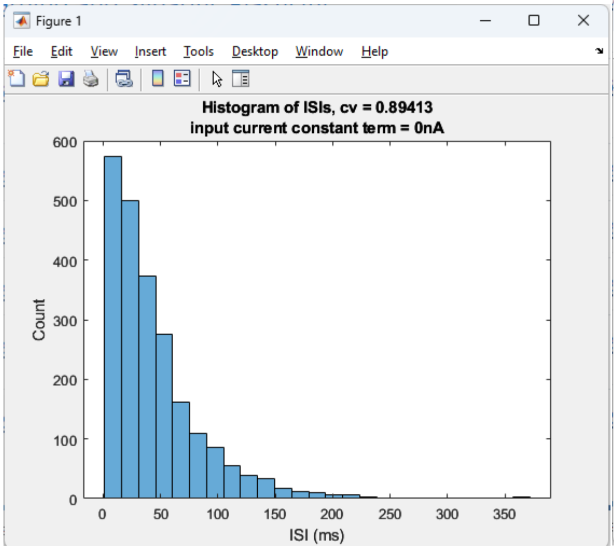


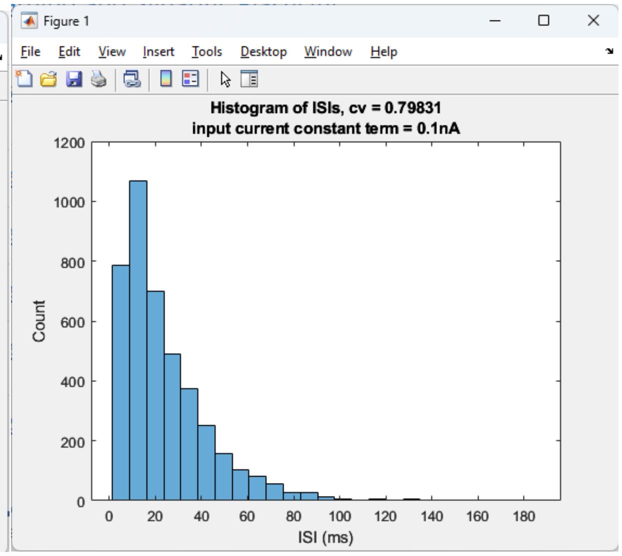


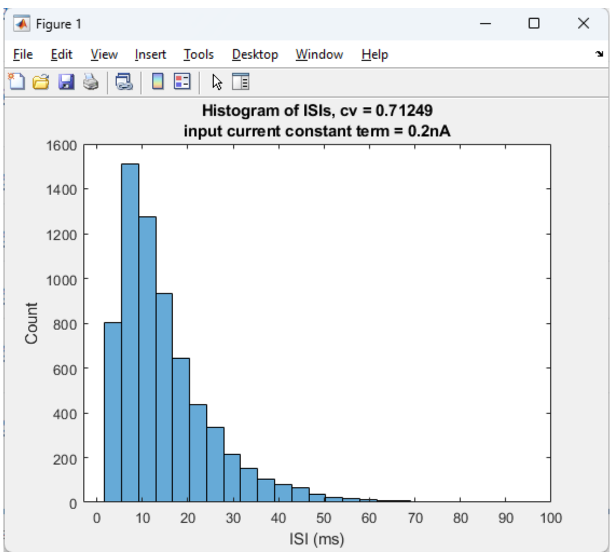
The Fano factor decreases as window size increases and gradually stabilizes at around 0.1. The decrease was fast when time windows increased from 10ms to around 160ms. 160ms is the mean of ISI distribution. This also means that when ISI=160ms, there's 1 spike in each time window on average. When we plot the average number of spikes in time windows dependent on the time window size, the window size is around 160ms when the mean is 1 (look at figure 3 at the left, the coordinate highlighted indicates the window size is 160ms when the mean is around 1). Considering the neuron is constantly firing with 160ms ISI, a window size below this value would disturb the ordinary firing window and have plenty of windows with no spike and rest with 1 spike within the window, which would largely increase the Fano factor. The neuron with a general normal distribution would be similar to the constantly firing neuron. When the time window is larger than the mean of the distribution, it would be more likely to segregate the interval between two adjacent spikes. As window size increases, the number of spikes within the window would also have less variance due to the normal distribution.

In addition, as the window is small enough, the mean could approach zero. As window size grows from 10 to 160ms and the mean spike number grows from 0 to 1, numerically, the Fano factor should decrease drastically as the mean spike number is the divisor.

Question c) (i)







(ii) When Iapp constant term = 0nA, CV is 0.89413

When Iapp constant term = 0.1nA, CV is 0.79821

When Iapp constant term = 0.2nA, CV is 0.71249

(iii)

When Iapp constant term = 0nA and window size = 100ms:

Variance=1.6813, Mean=2.231, Fano_factor=0.75362

When Iapp constant term = 0.1nA and window size = 100ms:

Variance=2.6123, Mean=4.159, Fano_factor=0.62812

When Iapp constant term = 0.2nA and window size = 100ms:

Variance=3.646, Mean=6.66, Fano factor=0.54745

Some comments on the change:

Changes observe when increasing the Iapp baseline:

- Total spike number increases dramatically
- The distribution of ISI is shifting rightwards as the input current constant term increases.
- The CV of ISI decreases as input current rises.
- Decrease in Fano factor at 100ms time window.

Here are my explanations for some changes.

Input current is positively correlated with dV and firing rate; it's evident that the count for each ISI is increasing. The total spike count increases, indicating the firing rate is increased when Iapp increases. When Iapp=0nA, we can see that the peak of the distribution lies at 1.7-18ms range with about 600 counts. When Iapp=0.1nA, the distribution peak lies in the 7.8-14.2ms range (second bar) but with an even higher count than 0 input current. The increase in the average ISI, followed by increased total spiking counts, could explain the decrease in CV. More of the time (count*mean_ISI) during the simulation the neuron is firing at this relatively constant rate means the distribution of ISI would be narrower: the maximum ISI decreasing from 360ms to 100ms as the Iapp baseline increases from 0 to 0.2nA.

The increasing average firing rate brings the increase of mean spike number within the time windows. Even the smallest time window size would contain more than 1 spike when the firing rate is high enough. This means that with raised input current baseline, the Fano factor curve (mentioned in question b(iv)) would enter the "gradual decreasing stage" sooner than those neurons without raised input current baseline. When we increase the Iapp to even larger cases, say 1nA, the Fano factor at time window=100ms would be about 0.14, and the final stabilize state back in question b(iv) is reached with the 100ms window. Therefore, the increase if Iapp const value would move the Fano curve leftward---less variation when Iapp increases.