Advanced Neural Networks - Homework 3

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1 No SRA

This section contains the plots of the output neuron's average firing rate, which was modelled without spike rate adaptation (SRA).

1.1 Average spike times of excitatory neuron

The average spike times of excitatory neuron can be seen in Figure 1. The neuron does not begin firing until the input neuron fires around 28 Hz. The output neuron's firing rate increases rapidly after it begins firing, eventually reaching linear growth after 35Hz. The standard deviation remains small except around two points (28Hz and 33Hz) where it increases. These areas correspond with the times that the output neuron's firing rate increases more rapidly.
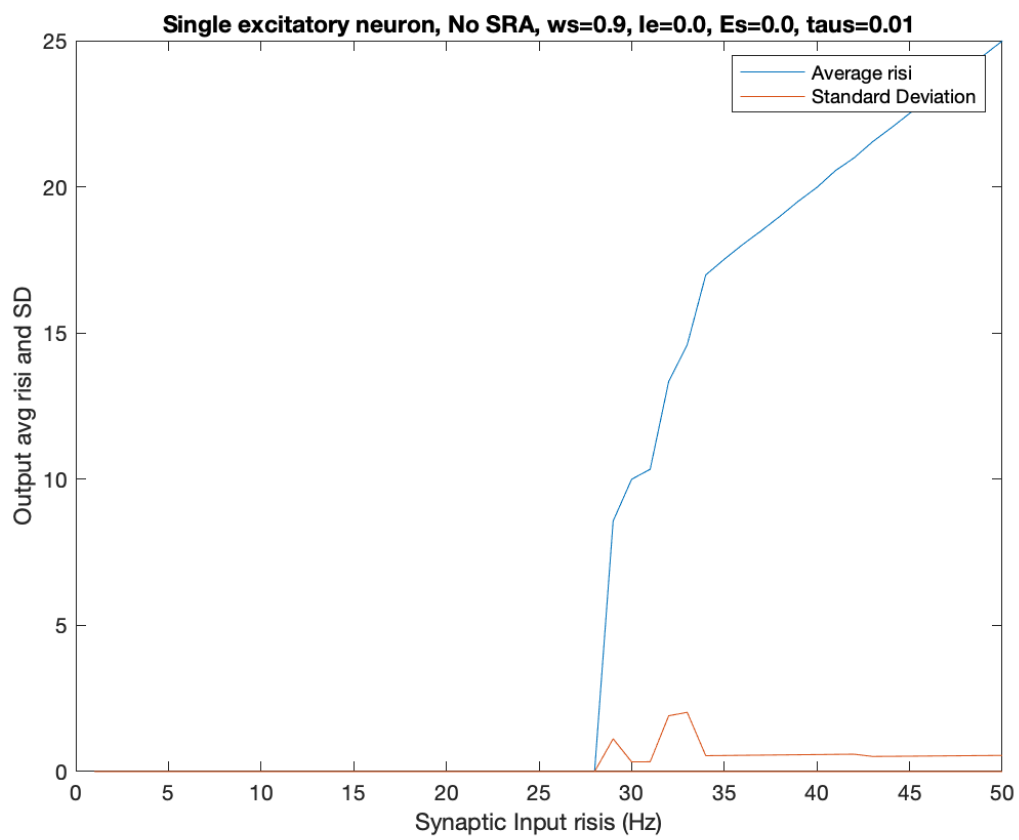
Figure 1: Average risi and standard deviation with excitatory neuron.

1.2 Average spike times of excitatory with varying weight

In figure 2, we varied the weights in order to view the effect on the output neuron's average firing rate. Overall, the higher weight of 1.0 corresponded with a higher firing rate, but it also had the highest standard deviation. The lower rate of 0.8 corresponded to the lowest average firing rate. Higher weights also correspond to earlier firing times in the output neuron, while lower weights appear to make the neuron fire later.
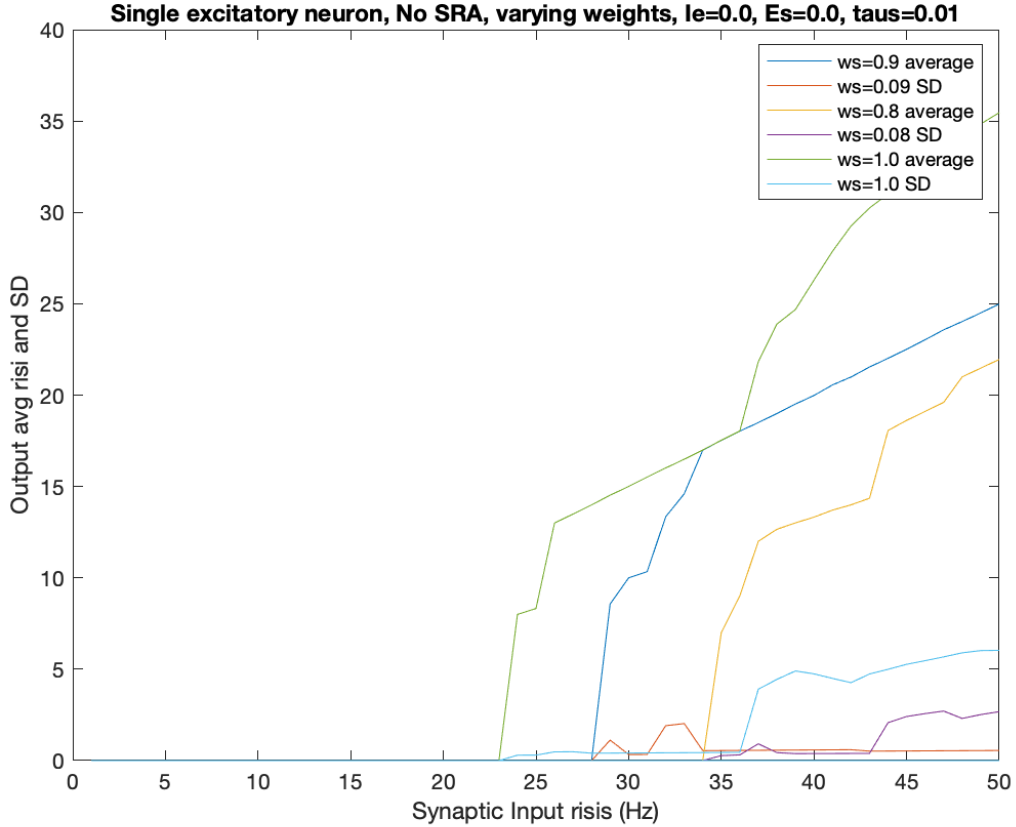

Figure 2: Average risi and standard deviation with varying weight of 0.8, 0.9, and 1.0.

1.3 Average spike times of inhibitory neuron

The average firing rate with an inhibitory neuron can be seen in Figure 3. To get the neuron to fire, we added an external stimulus (Ie) of 4e-10. With the inhibitory neuron and the external stimulus, the firing rate decreases over time, though it does not not decrease at a monotonic rate.
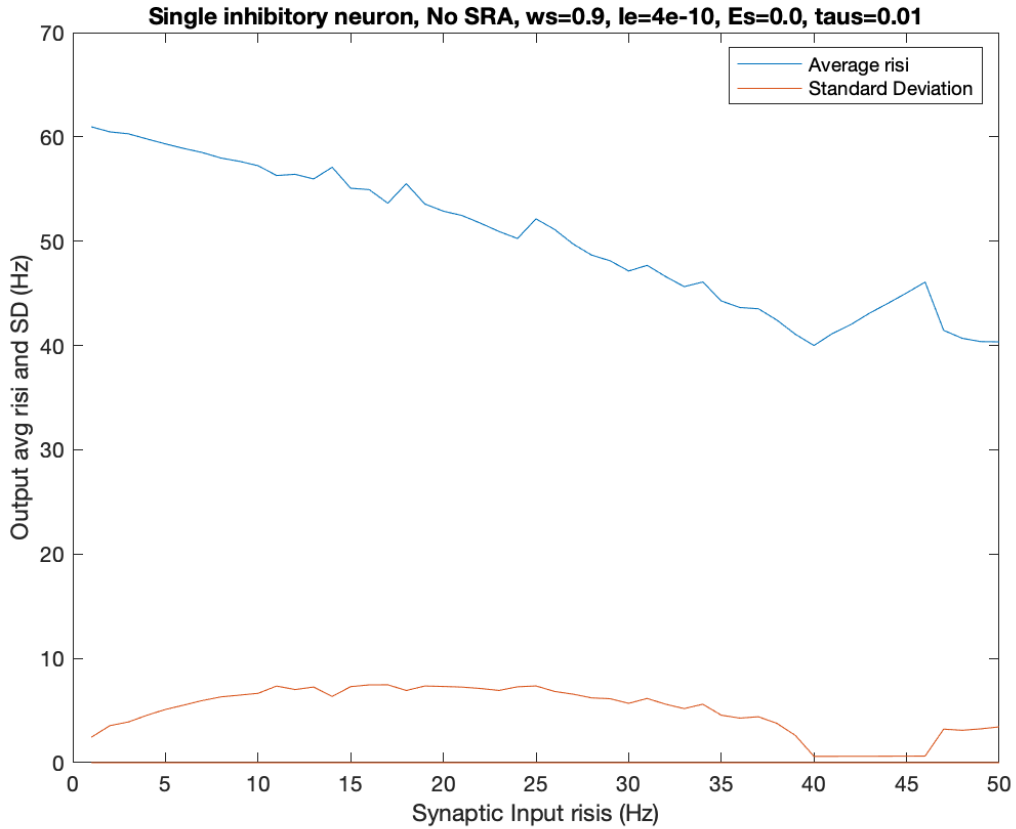
Figure 3: Average risi and standard deviation with inhibitory neuron.

2 With SRA

This section contains the plots of the output neuron's average firing rate, which was modelled with spike rate adaptation.

2.1 Average spike times of excitatory neuron

In Figure 4, we can see the average firing rate of the neuron with excitatory input and SRA. In this model, the neuron's firing rate is significantly lower than the firing rate in the model without SRA. Despite the fact that the firing rate is overall lower in the model with SRA, the average firing rate has similar characteristics, in that the rate increases rapidly after it first starts firing. Eventually the rate of increase slows down, and appears to approach a linear rate.
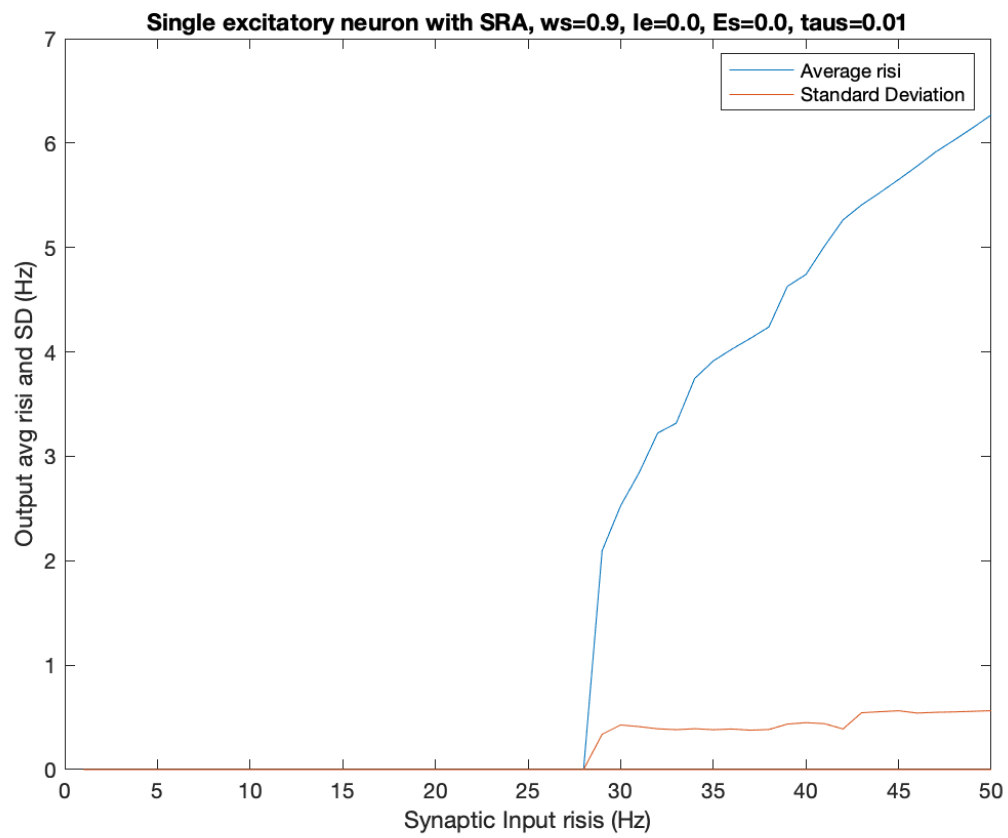
Figure 4: Average risi and standard deviation with excitatory neuron and SRA.

2.2 Average spike times of excitatory with varying weight

As seen in Figure 5, we varied the weights to view the effect on an neuron with excitatory inputs and SRA. With each of the weights, there is a similar pattern of growth as the risi increases rapidly and then eventually reaches a linear rate of growth. Higher weights correspond to earlier firing and an overall higher average firing rate. Lower rates correspond to later firing and an overall lower average firing rate. The standard deviations look similar across the three weights, which is unlike the model without SRA.
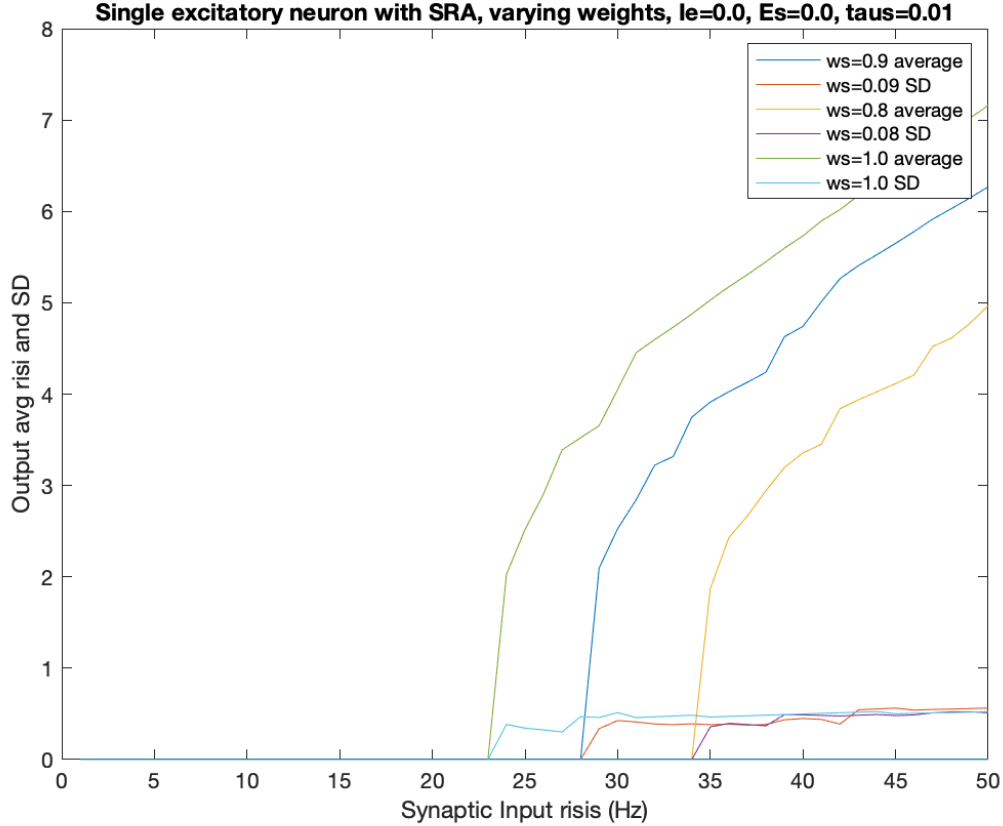

Figure 5: Average risi and standard deviation with varying weight of 0.8, 0.9, and 1.0, and SRA

2.3 Average spike times of inhibitory neuron

The average spike rate of the inhibitory neuron is much less in the model with SRA than without SRA, as seen in Figure 6. Though the average spike rate decreases over time with the inhibitory input, there are still periods of decrease followed by periods of increase, and then decrease again. The line is very jagged.
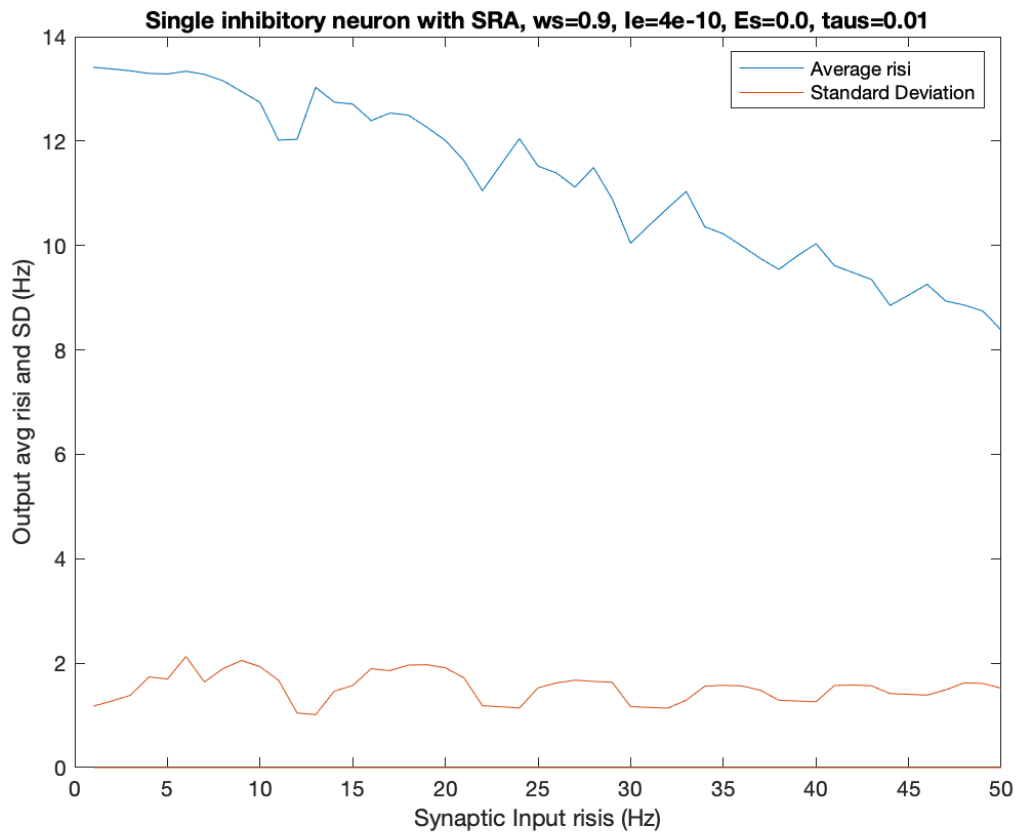
Figure 6: Average risi and standard deviation with inhibitory neuron.