Neurophysiology and Computational Neuroscience
Neurosci 613 Fall 2020
Computer Lab 6
Due: Saturday, October 3, 2020

For this lab, simulate a network of excitatory (E) cells and inhibitory (I) cells to investigate the PING synchrony mechanism by using the matlab files in the zipped folder PING_CODE 613. Parameters for the cells and network are set in the numbered params*.m (* = 0, 1, 2 or 3) files. We will consider a network of 80 E cells and 20 I cells with the following synapse types: E-to-I, I-to-E and I-to-I (we will not include synapses between the E cells). To run the code, set parameter values in the appropriate params*.m file and save the file; in lines 11-14 of gamma_simulator.m uncomment the name of the correct params*.m file; save and run gamma_simulator.m using the RUN (green arrow) button in the matlab editor.

1. **(25 pts) In the PING network, investigate different mechanisms to vary the frequency of synchronous firing of the E cells.**
   a. Investigate the prediction of the PING framework that changing the time constant for the decay of the inhibitory synapses will change the frequency of synchronous E cell firing. In the file params2.m, set applied current to the E cells Iapp_e to 2 and the applied current to the I cells Iapp_i to 0. Vary the time constant for the decay of the inhibitory synapses tau_d_i_value from 9 to 60, running the file gamma_simulator.m for each value. Make a plot of the average network frequency of the E cell network as a function of tau_d_i_value. Explain why the time constant for the decay of the inhibitory synapses changes frequency of the E cell network in the way you obtained.
   b. Investigate how the intrinsic firing frequency of the E cells affects their synchronous firing frequency in a PING network. In the file params2.m, set the time constant for decay of the inhibitory synapses tau_d_i to 9 and the applied current to the I cells Iapp_i to 0. Vary the applied current to the E cells Iapp_e from 2 to 10, running the file gamma_simulator.m for each value. Make a plot of the average network frequency of the synchronous E cell firing as a function of Iapp_e. Explain why the intrinsic frequency of the E cells changes frequency of the E cell network in the way you obtained. What will be the effect of increasing tau_d_i on the change in network frequency with variations in Iapp_e? Explain why and provide some evidence for your explanation.
   c. Investigate how the intrinsic firing frequency of the I cells affects the frequency of synchronous E cell firing in a PING network. In the file params2.m, set the time constant for decay of the inhibitory synapses tau_d_i to 9 and the applied current to the E cells Iapp_e to 5. Vary the applied current to the I cells Iapp_i from 0 to 10, running the file gamma_simulator.m for each value. Make a plot of the average network frequency of the synchronous E cell firing as a function of Iapp_i. Explain why the intrinsic frequency of the I cells changes frequency of the E cell network in the way you obtained.
   d. Based on your findings, discuss which of these mechanisms can most robustly vary E cell network firing across the range of frequencies in the gamma band and explain why you came to that conclusion.

2. **(25 pts) In the PING network, investigate how the density of I-to-E synapses and the density of E-to-I synapses affect the generation of coherent synchronous firing of the E cells.** The parameters p_ie and p_ei, which vary between 0 and 1, set the connection probability for the I-to-E

and E-to-I synapses, respectively. Low values result in fewer synapses (lower synaptic density) from one population to the other while 1 results in all-to-all coupling from 1 population to the other.

a. Investigate the effect on synchrony of the E cells of varying the density of I-to-E synapses. In the file params3.m, vary p_ie while keeping p_ei = 1. Quantify the changes in E network synchrony using the cross-correlation and bursting measures based on the continuous spike traces for the E cells (for input to PINGSynchronyMeasures.m use num_e and spiketimes_e2 which contains the times of E cell spikes for time greater than 50 ms). Make a plot of the mean pairwise cross-correlation values and Golomb bursting measure B as a function of p_ie. Provide some raster plots to illustrate the effect of p_ie on E cell firing.

b. Investigate the effect on synchrony of the E cells of varying the density of E-to-I synapses. In the file params3.m, vary p_ei while keeping p_ie = 1. Here, make a plot of the mean pairwise cross-correlation values and Golomb bursting measure B for the E cells as a function of p_ei. Include some raster plots to illustrate the effect of p_ei on E cell firing.

c. Discuss which synaptic pathway is more important for generating synchronous E cell firing in the PING network. Explain why this is the case.