Circuits and Computational Neuroscience
Neurosci 613 Fall 2014
Computer Lab 3

Due: Tuesday, December 2, 2014 by 5pm

1. **Investigate the effect of synaptic weight on the speed of spike propagation through an excitatory network of Izhikevich Integrate and Fire (ILIF) neurons.** Run the matlab code ConnectivityMatrix.m to construct the connectivity matrix for a 1-dimensional ring network of 50 cells with first nearest neighbor coupling (set number of cells n=50 and connectivity radius crad=1 in the section of the code for nearest neighbor coupling; comment out the remaining portions of the code). In the matlab code ILIF_ExcNetwork.m, set a constant applied current of 2 to all cells except cell 10 which should have a constant applied current of 4 (Iapp = 2*ones(50,1); Iapp(10)=4;). Set the simulation end time tend = 2000 msec and synaptic decay time constant taus = 5 msec.
    a. Vary synaptic weight gsyn from 5 to 12 and determine the time (in msec) between spikes of nearest neighbor cells (choose a pair of cells that is not close to cell 10 to compute spike time difference; if cells fire 2 spikes in close succession, compute the time difference between the first spikes neighboring cells fire). Make a plot of spike time difference vs gsyn. Also include network raster plots for 2 different values of gsyn that reflect the change of propagation speed with gsyn.
    b. Consider values of gsyn less than 5 and describe the patterns of propagation. Provide raster plots to illustrate your findings.
    c. In a few sentences, summarize your findings on the relationship between synaptic strength and speed of spike propagation through the network.

2. **Investigate reverbatory activity in an excitatory network of Wang-Buzsaki neurons.** Run the matlab code ConnectivityMatrix.m to construct the connectivity matrix for a 1-dimensional ring network of 10 cells with all-to-all coupling (set n=10, uncomment the section of code for all-to-all coupling, comment out the other portions of the code). The code WBnetwork.m (which calls WBeqns.m) simulates the 10-cell network where the applied current injected into each cell is randomly chosed from an interval near current threshold and cells 4-7 receive an additional pulse of applied current between t = [1200, 1450] msec.
    a. Investigate the effect of the synaptic decay time constant on the generation of reverberatory activity in the network induced by the current pulse to cells 4-7 by running WBnetwork.m with the computed connectivity matrix W. Set synaptic weight gsyn=0.001 mS/cm^2 and vary taus from 1 to 5 msec. Determine if the current pulse induces reverberatory activity beyond the end of the current pulse by comparing the average cell firing frequency before and after the pulse. Note that each time you run the code you will get different behavior since the cells are randomly assigned an applied current value. To determine if reverberatory activity is reliably induced, for each taus value run the simulation 5 times. Graph the average over the 5 runs of the before-pulse and after-pulse average cell firing frequencies for each taus value and include standard error bars.
    b. In a few sentences, summarize your findings on the relationship between synaptic decay time constant and generation of reverberatory activity. Also include network raster plots for different taus values to illustrate your conclusions.

3. **Investigate clustering in inhibitory neural networks.** Clustering is the existence of separate subsets (clusters) of synchronously firing neurons. Inhibitory networks can display cluster patterns for certain relative values of the intrinsic cell firing frequency and the synaptic decay time constant. Run the matlab code ConnectivityMatrix.m to construct the connectivity matrix for a 1-dimensional ring network of 50 cells with all-to-all coupling (set n=50, uncomment the section of code for all-to-all coupling, comment out the other portions of the code). In the matlab code ILIFNetwork_clusters.m, set a constant applied current of 4 to all cells (Iapp = 4*ones(50,1);). Set the simulation end time tend = 2000 msec and synaptic weight gsyn to -2.
    a. Set linearly spread initial conditions to the cells so that each cell has slightly different initial conditions (v=-70*ones(n,1) + linspace(-10,8,50)'; u=-14*ones(n,1) + linspace(1,7,50)';). Vary the synaptic decay time constant taus (above a minimum value of 0.5 msec) and identify the ranges of taus values that result in 1, 2, 3, 4 or 5 clusters of synchronously firing cells. Provide raster plots showing 1, 2, 3, 4 and 5 clusters of network firing.
    b. Verify that for a given taus value, there is a maximum number of clusters possible but not a minimum number. To show this, choose a taus value in the range identified for 3 cluster firing in part a, set initial conditions for 5, 4, 2 or 1 cluster and determine if those cluster patterns are stable patterns for the network. Provide raster plots illustrating your results.
    c. In a few sentences, summarize your findings on the relationship between synaptic decay time constant, the intrinsic cell firing frequency and the number of clusters the network can display.