BME 503 : Exploration 1- Biophysical Models
Due for class discussion,
Due on Sakai, Sept 19, 7:00PM

The goal of this exploration is to begin using Brian 2 and to understand how the magnitude of the current input affects the firing rate of a neuron. You will implement the classical HH model, the Connor Stevens modification of HH, a more realistic HH-like model of a Pyramidal neuron and a simple Linear Integrate and Fire Model (LIAF). As in all explorations, you are asked to generate nice looking plots AND to briefly describe the results. You should use 1-2 paragraphs for each Part. Append your code to what you hand in on sakai.

Part 1): Classical HH Model

1. Using HodgkinHuxleyOriginalV2.py, implement the classical HH model as described in the handout HodgkinHuxley.pdf. In the classical model, the rest potential is 0.0 mV.
2. Change the model so the rest potential is -60.0 mV. You will need to change the rate constants and the Nernst potentials.
3. After 5msec, apply a 1 msec pulse and determine the threshold current in nA. What is the threshold.
4. Apply a long (2000 msec or longer) pulse with amplitudes ranging from 0.0 nA to 7nA. What is the firing rate as a function of current amplitude? Use the updates made to your code or modify IF-HodgkinHuxleyOriginal-skel2.py to implement 100 neurons in a group and apply a different current to each cell from 0-99 with the expression

   group.I = '(7.0*nA * i) / num_neurons'

   where i denotes the neuron number.

Part 2): Connor Stevens Model

Modify IF-ConnorsStevensOriginal-skel.py to become the Connor Stevens Model- see handouts connorstevens.pdf and ConnorStevensEqns.pdf. This will involve adding the variables for the A current. The A current is given in terms of a_{∞}, τ_a, b_{∞}, τ_b. The infinity values are unitless , while the taus have units of ms. Recall that the differential eqn is of the form

$$\frac{dy}{dy} = \frac{y_{\infty} - y}{\tau_y}$$

Reproduce as best you can – Figure 6.1 in connorstevens.pdf. When turning off the A current, set gA=0 and EL=-70mV. Explain the effect of the A current on the firing rate using group.I = '(7.0*nA * i) / num_neurons'

Use the approach in part 1 to obtain the I vs Firing rate plot.

Part 3) Pyramidal Neuron

Using IF-Pyramidal-skel.py, reproduce the model from the Regular-spiking (RS) E-cell in the paper “Input-Dependent Frequency Modulation of Cortical Gamma Oscillations Shapes Spatial Synchronization and Enables Phase Coding” (BiophysicalPyramidal.pdf on sakai)

Use the approach in part 1

group.I = '(7.0*nA * i) / num_neurons'

obtain the I vs Firing rate plot.

Explain how the firing rate plot compares with Hodgkin Huxley or Connor Stevens.

Part 4) Linear Integrate and Fire Neuron

Remove the Sodium and Potassium currents from the HH model, leaving just the leakage current. Set EL=-10.0 mV. Compute the I vs Firing rate plot again using

group.I = '(7.0*nA * i) / num_neurons'

Show an example output from neuron 75.