BME 503 : Exploration 3
Due Oct 3 on sakai: 7:00 pm

Part 1: Using the parameters of the Low Threshold Spiking (LTS) Izhikevich model (a=0.02, b=0.25, c=-65.0, d=2) http://www.izhikevich.org/publications/spikes.htm, develop a model of three neurons. Use the basic alpha conductance ,g, to connect the neurons with the equations

$$\dot{g} = \frac{dg}{dt} = \frac{-g}{\tau_{syn}} + z(t)$$

$$\dot{z} = \frac{dz}{dt} = \frac{-z}{\tau_{syn}} + \bar{g}_{syn} u(t)$$

where

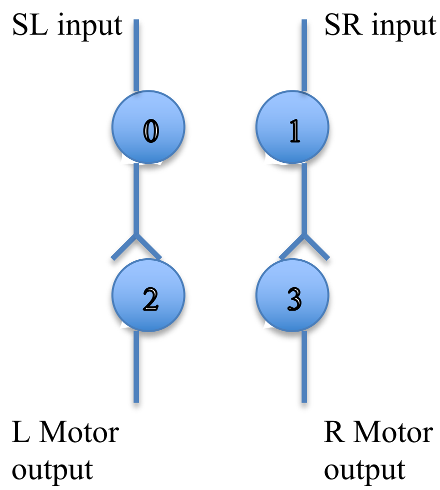
$$\bar{g}_{syn} = g_{peak} / \left(\tau_{syn} \exp(-1)\right)$$

and g_{peak}, and τ_{syn} are user determined. Modify the code LIAFwSYNskel.py from Exploration 2 where all the neurons are in a single group to complete the following. Make everything dimensionless.

1) Connect neuron 0 to neuron 1 and neuron 1 to neuron 2 with excitatory connections with a synaptic time constant of 5ms and a reversal potential of 0. Establish a steady state with no input current to any neurons for 200 ms. Apply a suprathreshold stimulus for 20ms neuron 0. Show how the response changes in neurons 1 and 2 as you change g_{peak} from 0.01 to 0.08.
2) Incorporate synaptic delays to the case above of 5ms. How does the response change?
3) Connect neuron 0 to neuron 1 with inhibitory connections with a synaptic time constant of 5ms and a reversal potential of -80. Do not connect any cell to neuron 2. Reach steady state at 200ms with no stimulus and apply the same suprathreshold input currents to each cell. Here neuron 0 and 2 should generate the same response. What happens to neuron 1 as g_{peak} is varied from 0.02 to 0.12
4) Incorporate synaptic delays to the case above using a 5ms time constant. How does the response change?
5) Design several interesting circuits using excitatory AND inhibitory connections with 4 neurons. Note that one cell type should be able to produce only one type of

synapse (inhibitory or excitatory) but a cell can receive both types. Explain the output based on your design.

Part 2: Use the framework of synaptic connections to form a network of 4 neurons to actuate the bug as a coward. Modify braitenbug_brain_skel2020.py to have 4 different groups with 1 neuron in each group. Here you must use Izhikevich neurons and exponential synapses.



Build the circuit above and use the spike times from neurons 2 and 3 to drive the motor velocities through the equations

$$\dot{v}_L = \frac{dv_L}{dt} = \frac{-v_L}{\tau_{motor}} + \eta d(t - t_L)$$

$$\dot{v}_R = \frac{dv_R}{dt} = \frac{-v_R}{\tau_{motor}} + \eta d(t - t_R)$$

where the delta function correspond to the spike times of 2 and 3. These equations operate in a manner similar to exponential synapses. The inputs to SL and SR are currents. Modulate the strengths of the inputs and show the velocity response of neurons 2 and 3. Find synaptic conductances that give you a large dynamic range.

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