Computational Neuroscience - Coursework 1

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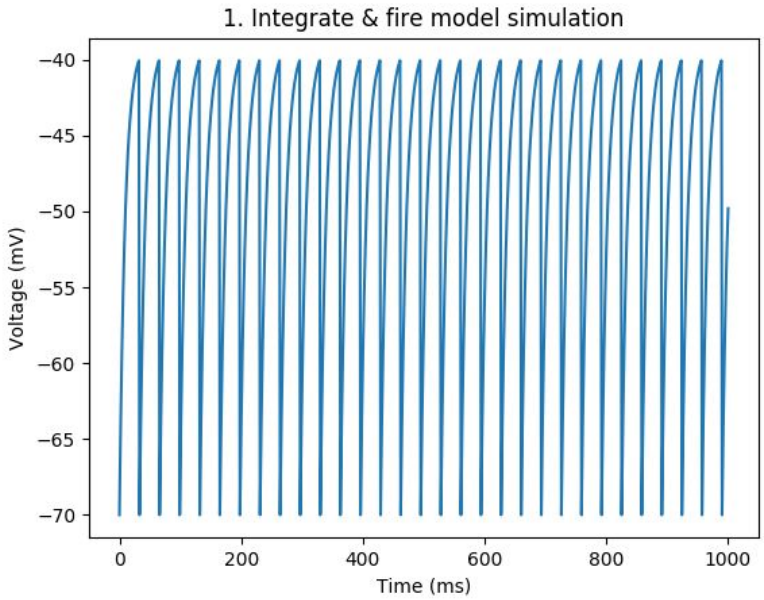
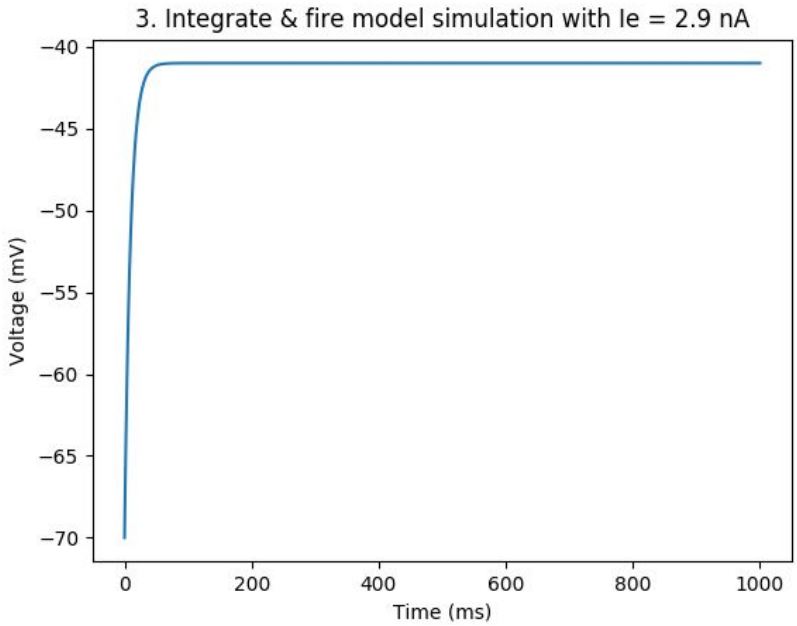
1. Integrate & fire model simulation with parameters mentioned in the work sheet. It can be seen that the value of the voltage dropped back to -70 after it reached the threshold.

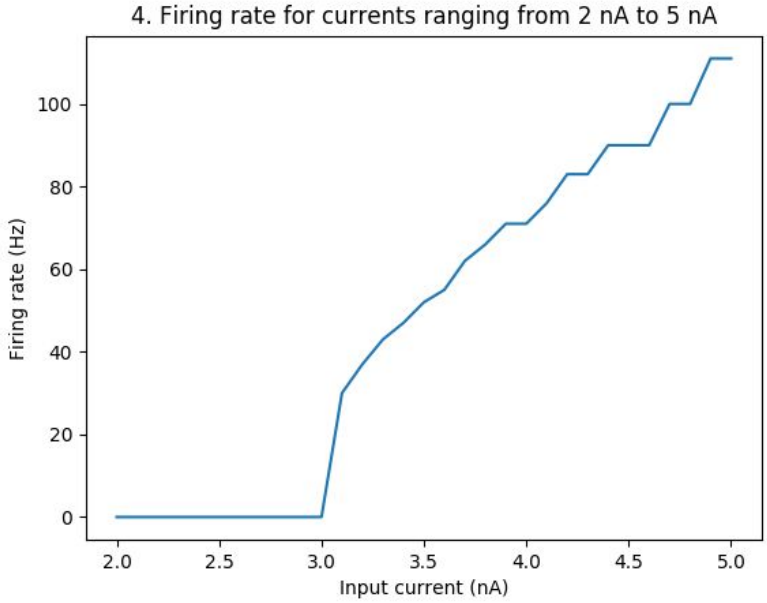


2. To compute the minimum I_e to produce action potential, modify the equation $V = E_L + R_M I_E$ become $I_E = (V - E_L)/R_M$. Then use V_T as the input for V, and we get I_E = (-40 - (-70)/10 = 3.0. The minimum current I_E for the neuron with those parameters to produce action potential is **3.0**.

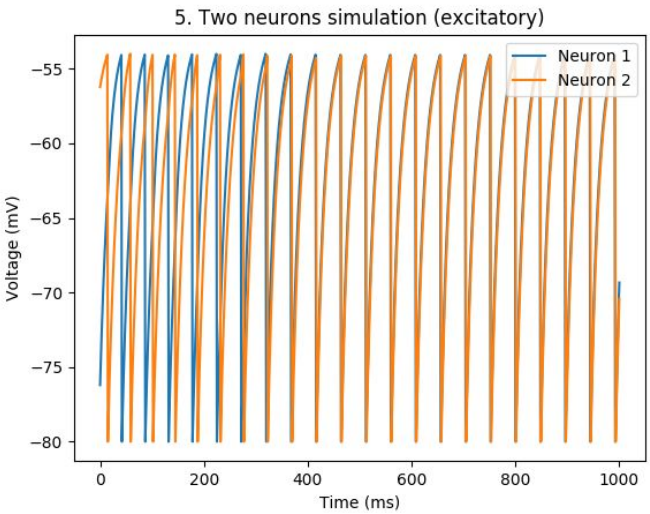
3. Integrate & fire simulation using minimum current I_E = 3.0 - 0.1 = 2.9. It is shown that the neuron never reached the threshold, therefore never goes back to initial value.

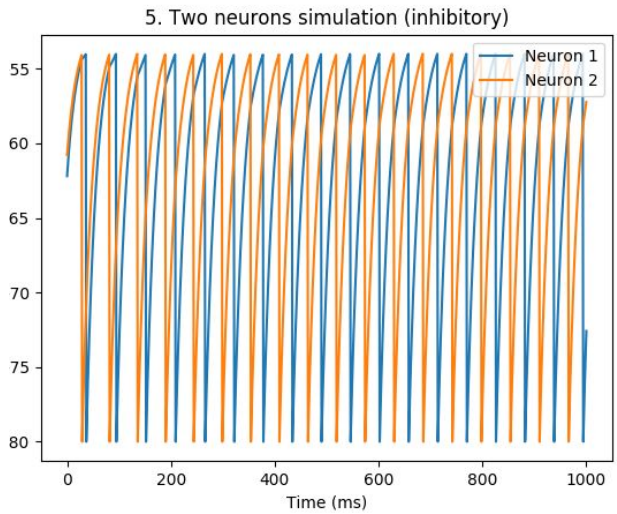


4. Firing rates for currents I_E ranging from 2.0 nA to 5.0 nA. It can be seen that spikes did not occur before the current hits 3.0, which is the minimum current to reach action potential.

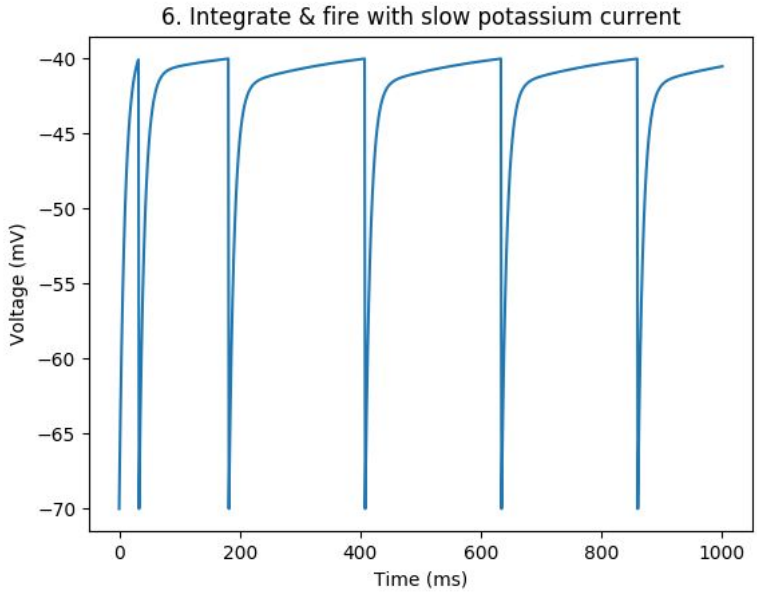


5. Simulation of two neurons with synaptic connections between each other. The left graph shows the excitatory synapses with initial potentials for neuron 1 = -76.21 and for neuron 2 = -56.23. The right chart shows the inhibitory synapses with initial potentials of neuron 1 = -62.19 and for neuron 2 = -60.78. The graphs show that in the excitatory simulation, the two neurons initially reached the threshold at a slightly different time, but eventually they spiked at almost the same time. On the other hand, the inhibitory neurons show that the time difference between the two neurons spiked gradually increased and became stable until the end.

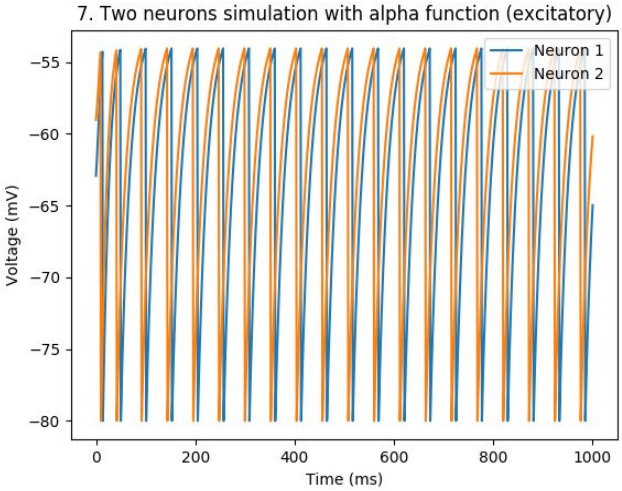


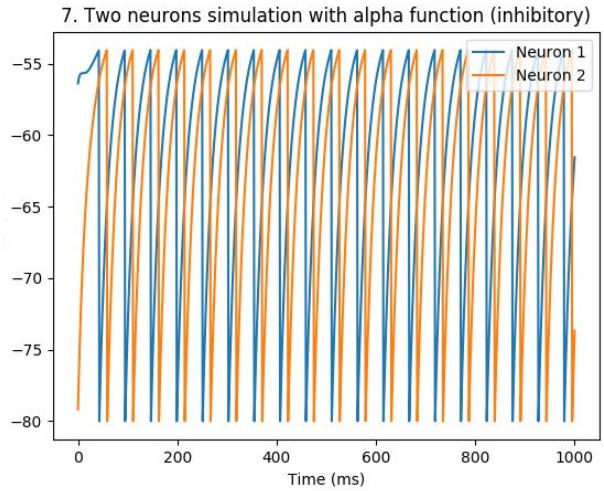


6. Neuron simulation with slow potassium current. With initial value of -70, the membrane potential initially spiked quickly, but then it took more time as it got closer to the threshold.



7. Simulation of coupled neurons using alpha function. Left graph is the excitatory neurons with initial V1 = -62.92 and V2 = -59.02, and right graph is the inhibitory neurons with initial V1 = -56.37 and V2 = -79.17. Based on these graphs and comparing them to the ones in question 5, the alpha function produced neurons with a stable time difference between spikes of the two neurons.





In my submission I included this report and 4 python files:

- **cw1_1_2_3_4.py** for questions 1-4
- **cw1_5** for question 5
- **cw1_6** for question 6
- **cw1_7** for question 7