Neuron Model

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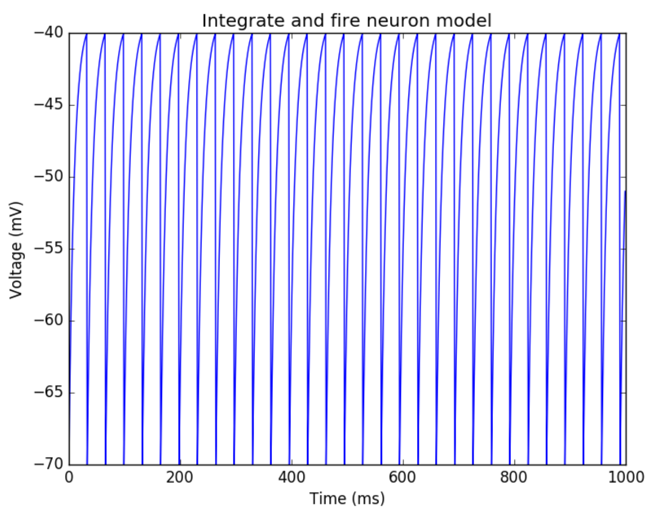
The aim of this report is to highlight different cases of neuron modelling. The analysis is largely based on graphs, and the language of implementation is Python.

Q1. Integrate and fire model



A neuron simulation with the integrate and fire model, Euler's method is used with a timestep $\delta t = 1ms$. The current is enough for multiple spikes to be produced.

Q2. Minimum current for action potential

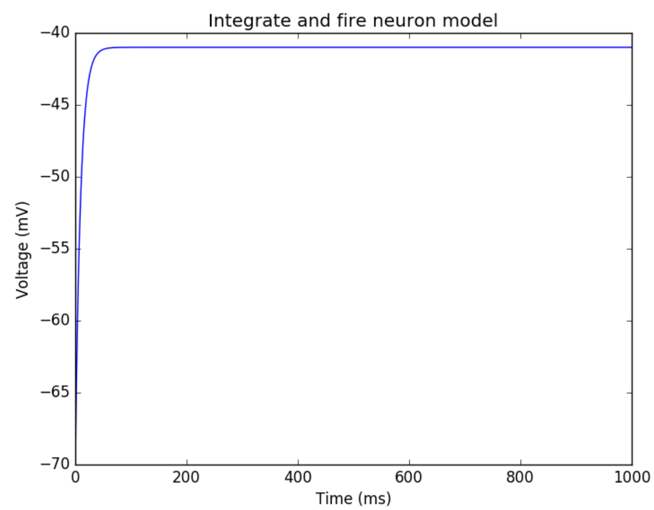
$$I_e = \frac{V_t - E_l}{R_m} \tag{1}$$

$$I_e = \frac{-40mV - (-70mV)}{10M\Omega} \tag{2}$$

$$I_e = \frac{30mV}{10M\Omega} = 3.0nA \tag{3}$$

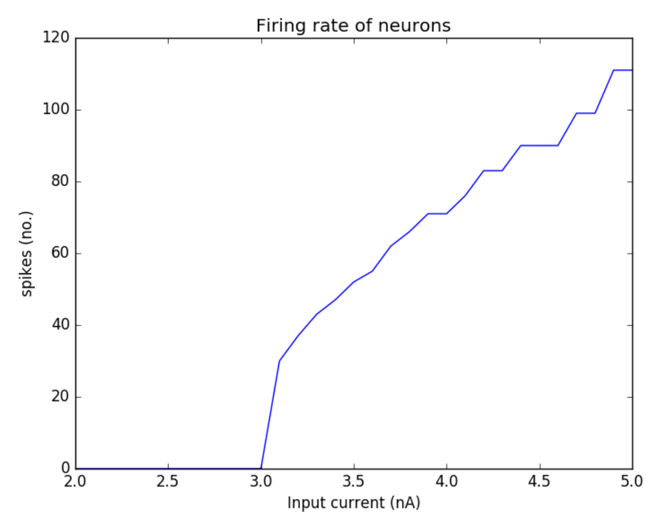
Q3. Integrate and fire model with lower than the minimum current

The current is $0.1nA$ lower that the current needed for a spike – $I_e = 2.9nA$ – hence no spikes are observed.



Q4. Firing rate as function of the input current

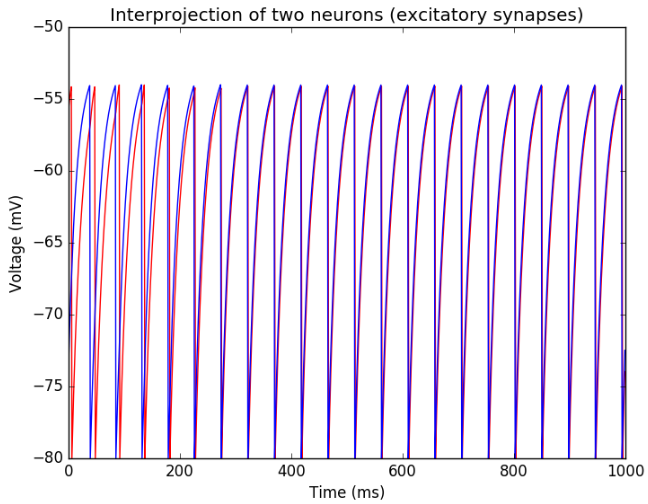
Plot of the fire rate as a function of the input current. Spikes start being produced at $I_e = 3.0nA$, which is the minimum input current for action potential.



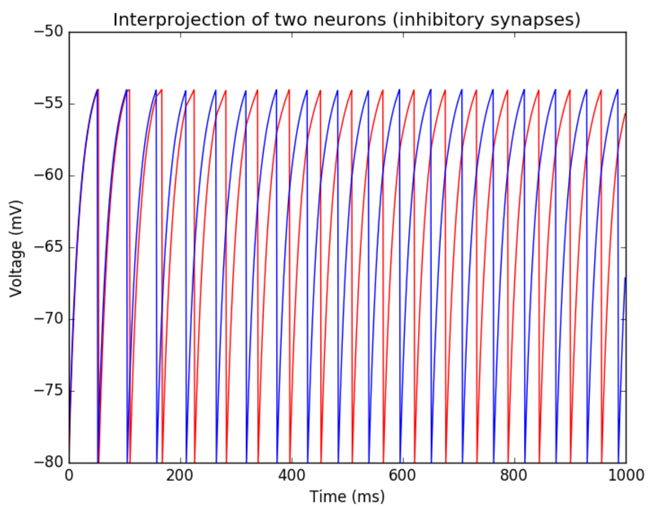
Q5. Interprojection of two neurons

In both cases two neurons with synaptic connections between each other and with the same parameters are simulated.

In the first case, the synapses are excitatory with reversal potential $E_s = 0mV$. It can be observed that the two neurons' membrane potential converges.



In the second case, the synapses are inhibitory with reversal potential $E_s = -80mV$. Unlike in the previous case, the two neurons' membrane potential diverges.



Q6. Integrate and fire model with potassium current

The neuron simulated in this question has the same parameters as the one in Q1. However, a slow potassium current with reversal potential $E_K = -80mV$ is added.