Computational Neuroscience
-COMS30127-

Coursework 1: Integrate and fire neurons

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Q1. Single integrate-and-fire neuron simulation

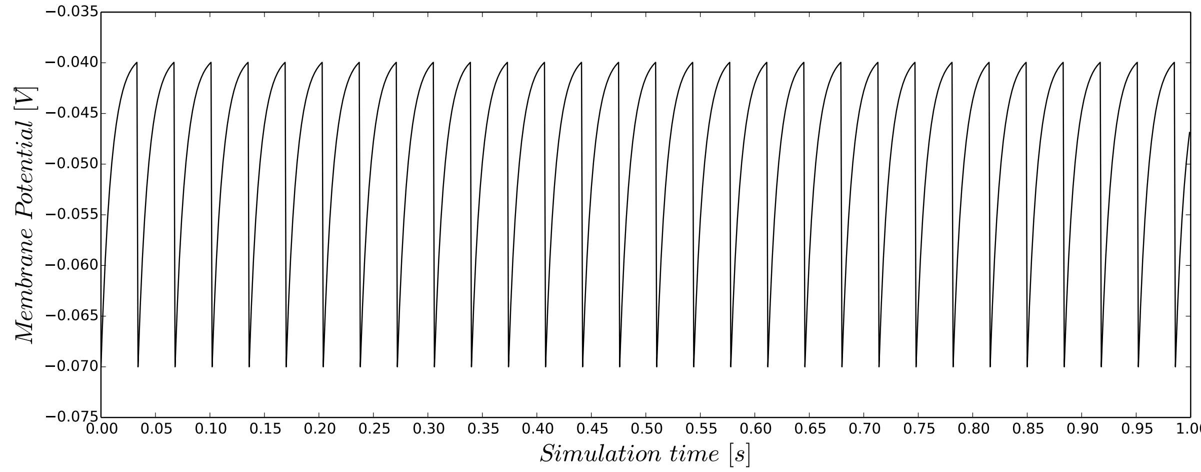

Figure 1: Leaky integrate-and-fire neuron simulated over a period $T = 1s$.

Q2. Minimum input current necessary for spike production

1. Set the potential higher than the threshold
   $E_l + R_m * I_e > V_{thresh}$
2. Rearange to express I_e
   $I_e > (V_{thresh} - E_l)/R_m$
3. Substituting in
   $I_e > (-40 + 70)/10 = 3$ $[nA]$
   $I_{min} \approx 3.001$ $[nA]$

Q3. Under-minimum input current simulation

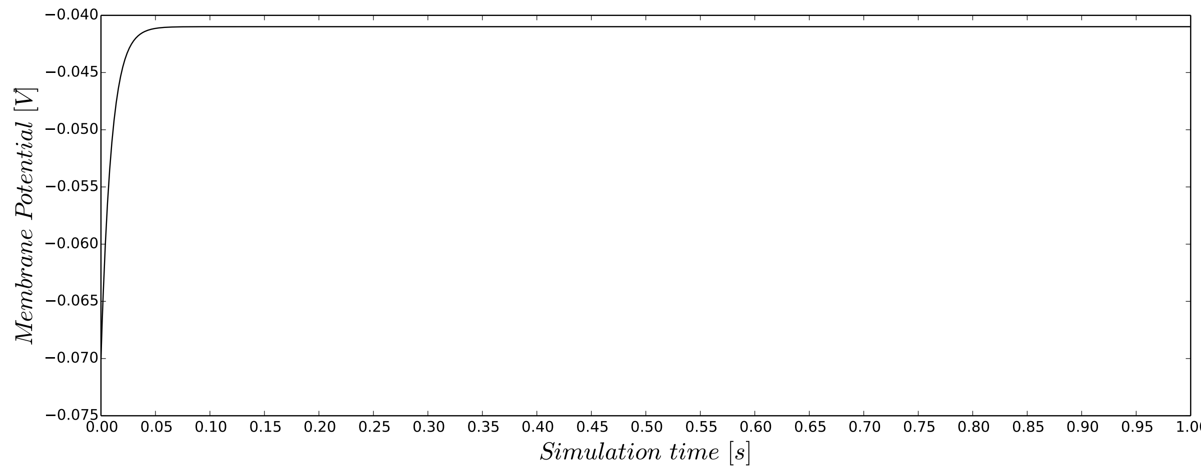

Figure 2: Leaky integrate-and-fire neuron simulated with input current $I_e = 2.901$ $[nA]$ over a period $T = 1s$.

Q4. Spiking rate as a function of input current

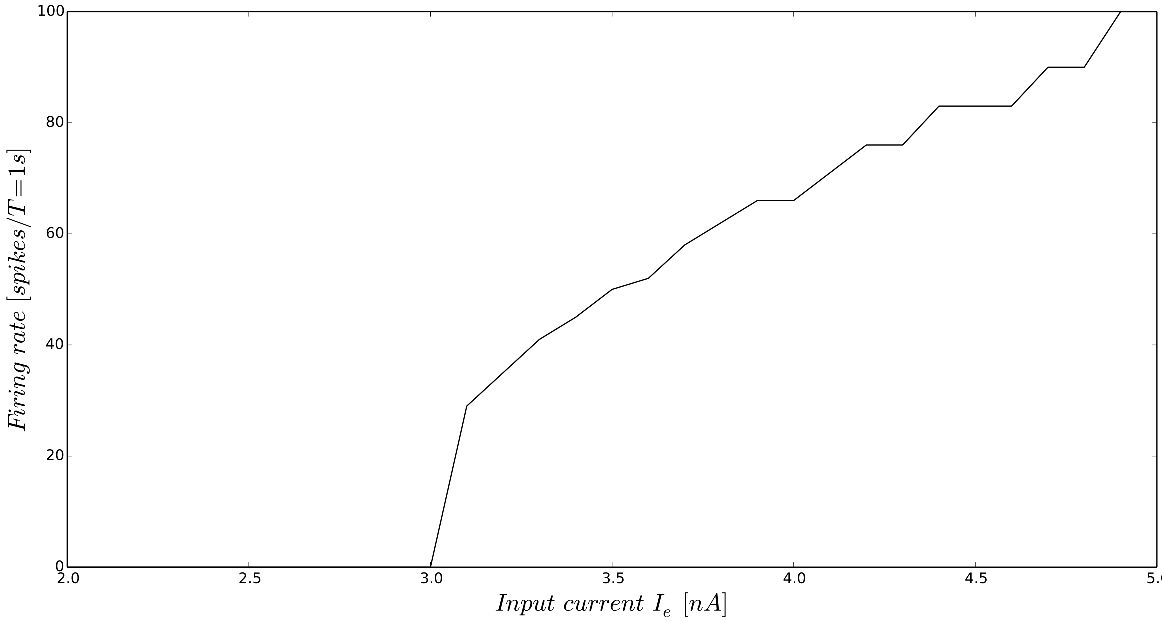

Figure 3: An integrate-and-fire neuron is simulated with input currents ranging in $[2.0, 5.0]$ at step 0.1 $[nA]$, recording the number of spikes fired over the simulation period $T = 1$ $[s]$ at each trial. The firing rate is plotted as a function of the current.

Q5. Simulation of two coupled integrate-and-fire neurons

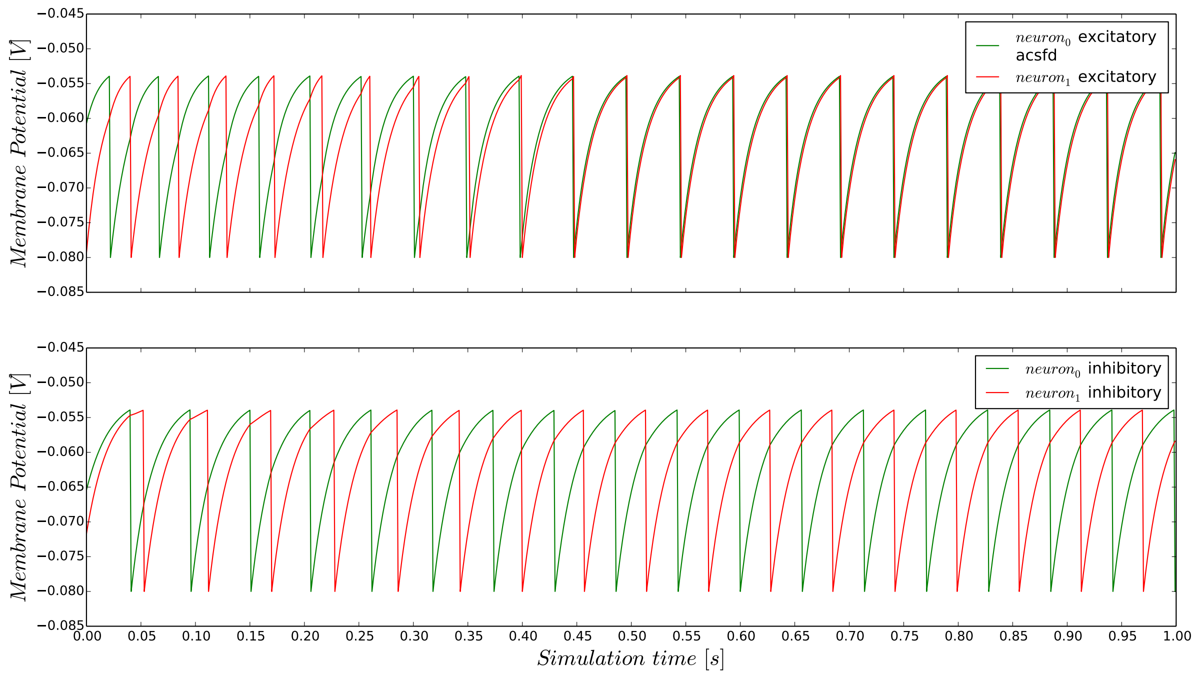

Figure 4: (Top) Two excitatory ($E_s = 0$ $[mV]$) integrate-and-fire neurons synapting onto each other simulated over time. The two neurons' spiking synchronises; (Bottom) The neurons are inhibitory ($E_s = -80$ $[mV]$). The spiking times diverge.

Q6. An integrate-and-fire neuron simulation with a slow potassium channel

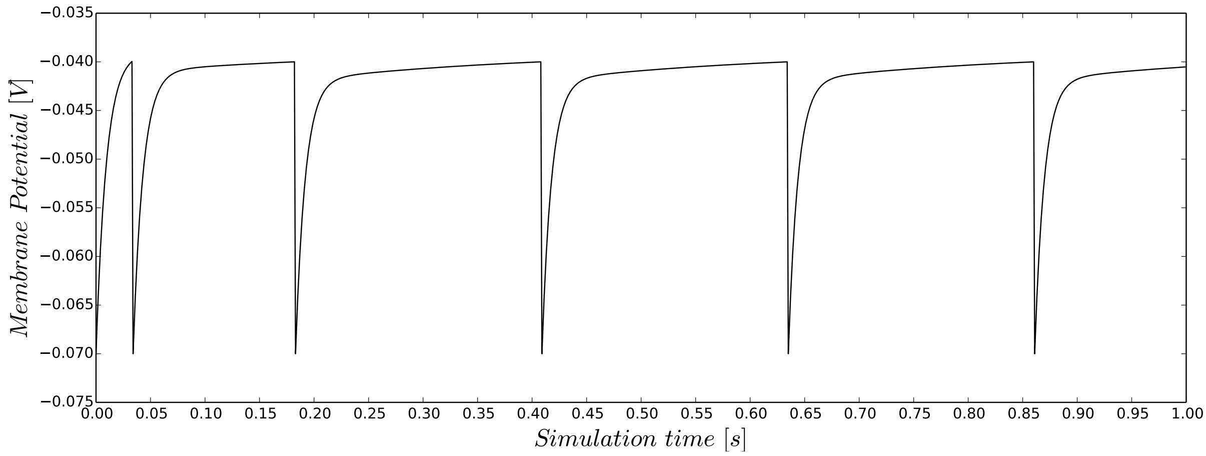

Figure 5: The neuron from question 1 simulated with a slow K+ channel over a period $T = 1s$. The leak current due to potassium is added to the equation: $R_m G_k(E_k - V)$; $G_k \rightarrow G_k + 0.005$ $[M\Omega]^{-1}$ at every spike.