

Computational Neuroscience

Coursework 1 Report

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Q1

According to the equation of Integrate and Fire Model, V satisfies:

$$\tau_m \frac{dV}{dt} = E_L - V + R_m I_e$$

If $V \geq V_T$ a spike will happen and the voltage is set to a reset value V_R , the solution to this equation is:

$$V(t) = E_L + R_m I_e + (V(t_0) - E_L - R_m I_e) \exp\left(-\frac{t - t_0}{\tau_m}\right)$$

$$V(t + \Delta t) = E_L + R_m I_e(i) + (V(t) - E_L - R_m I_e(t)) \exp\left(-\frac{\Delta t}{\tau_m}\right)$$

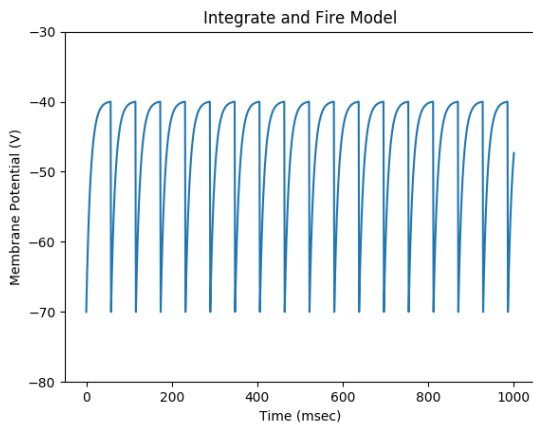


Figure 1 Integrate and Fire Model for Q1

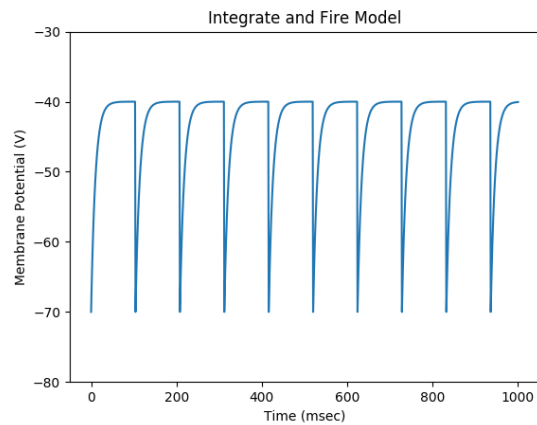


Figure 2 Integrate and Fire Model for Q2 when $I_e = 3.0001$

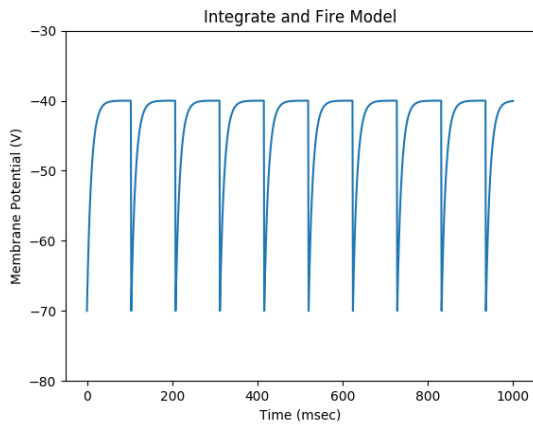


Figure 3 Integrate and Fire Model for Q2 when $I_e = 3$

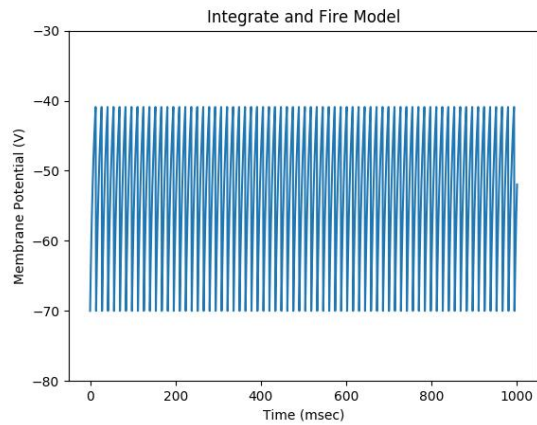


Figure 4 Integrate and Fire Model for Q2 when $I_e = 4$

Q2

According to the model in Q1, we can generate:

$$I_e = \frac{V_{th} - E_L}{R_m} = 3$$

The result shows that any value of I_e larger than 3 will make spike happen in the neuron, and any value of I_e smaller or equal to 3 will result to no spikes. As Figure 2, Figure 3 , Figure 4 show above.

Q3

The result of Q3 shows below in Figure 5.

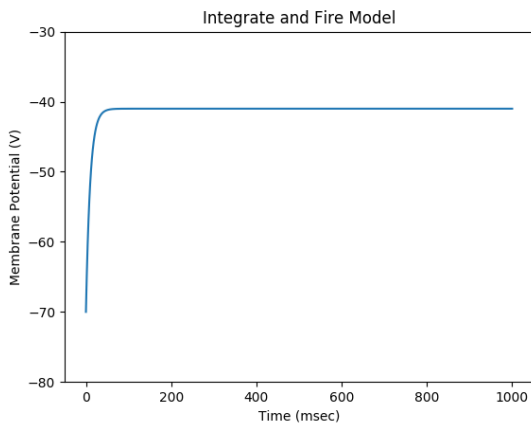


Figure 5 Integrate and Fire Model for Q3 when $I_e=2.9$

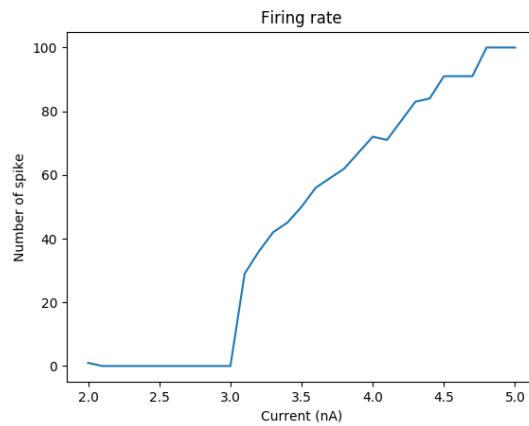


Figure 6 Integrate and Fire Model for Q4

Q4

The result of Q4 shows above in Figure 6. When the input current become larger, the Number of spike will increase, which indicates higher current will result to more frequent happening of spikes.

Q5

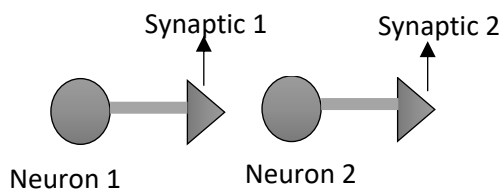


Figure 7 Two neurons with synaptic between each other

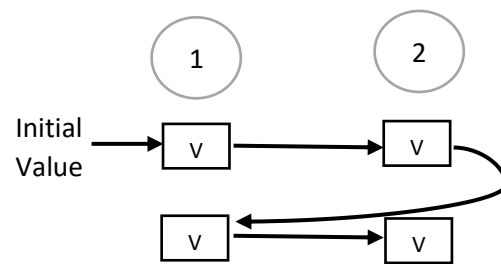


Figure 8 Voltage update demonstration

The two neurons model is shown in Figure 7. The program first generates a voltage value of neuron1 from the initial value set by person. The voltage of neuron2 then can be calculated from the voltage of neuron1. Then in the next time slot, the voltage of neuron 1 can be calculated using the voltage of neuron2 from the previous time slot.

According to the equation in Q1, We have:

$$V(t) = E_L + R_m I_e + R_m I_s + (V(t_0) - E_L - R_m I_e) \exp\left(-\frac{t - t_0}{\tau_m}\right)$$

$$I_s(t) = g_s s(t)(E_s - V) \quad , \quad s(t) = \exp(-\frac{t}{\tau_s})$$

$$V(t) = E_L + R_m I_e + R_m (g_s (E_s - V) \exp(-\frac{t}{\tau_s})) + (V(t_0) - E_L - R_m I_e) \exp(-\frac{t - t_0}{\tau_m})$$

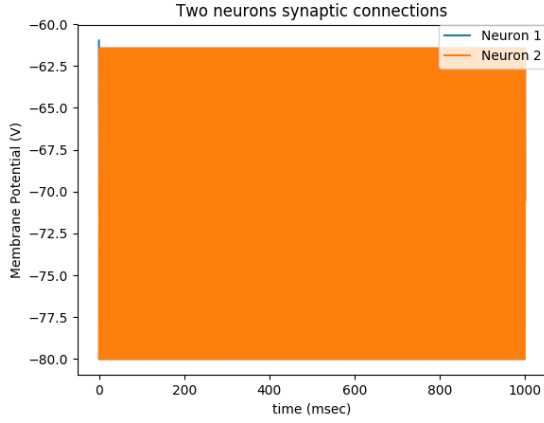


Figure 9 Two neurons model with initial value = -60 $E_s = 0$

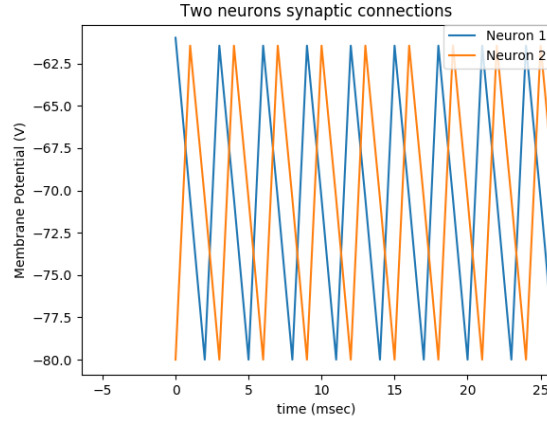


Figure 10 Zoom-in of Figure 9

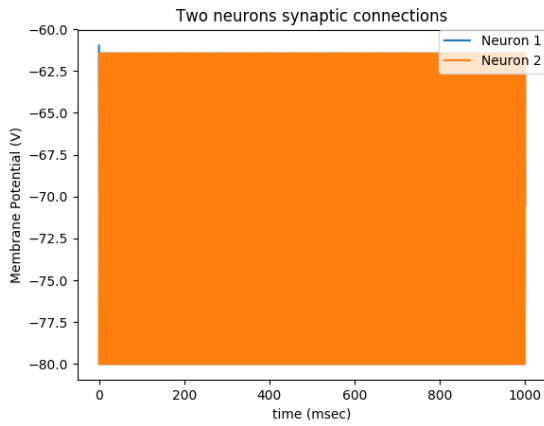


Figure 11 Two neurons model with initial value = -60 $E_s = -80$

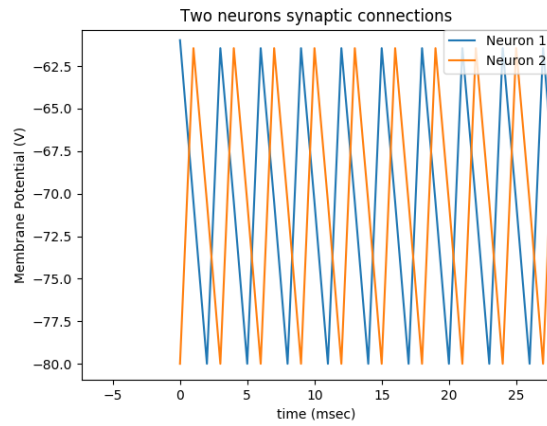


Figure 12 Zoom-in of Figure 11

Q7

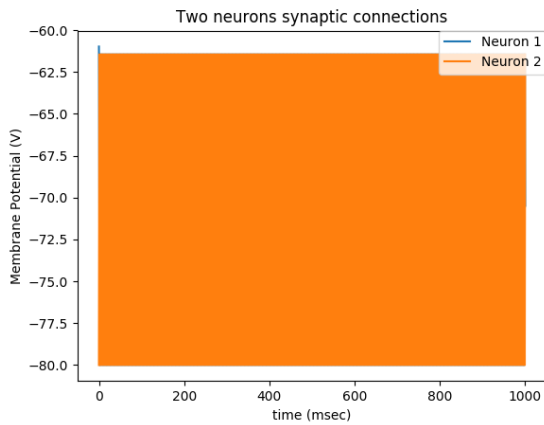


Figure 13 Two neurons model with alpha function

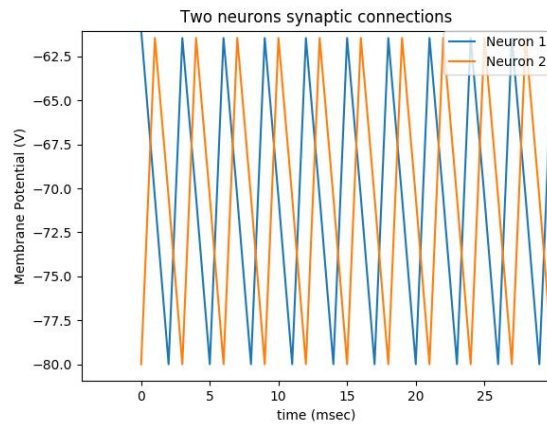


Figure 14 Zoom-in of Figure 13