Computational Neuroscience: Integrate and Fire

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Question One

The rate of change in voltage for the "integrate and fire" neuron modelled in Figure 1 is given by the following equation:

$$\frac{dV}{dt} = \frac{Leak\ Potential - Voltage + Membrane\ Resistance \cdot Current_e}{\tau_m} \tag{1}$$

Where $\tau_m = \frac{Membrane\ Capacitance}{Membrane\ Conductance}$, and $Current_e$ refers to the injected current from an electrode.

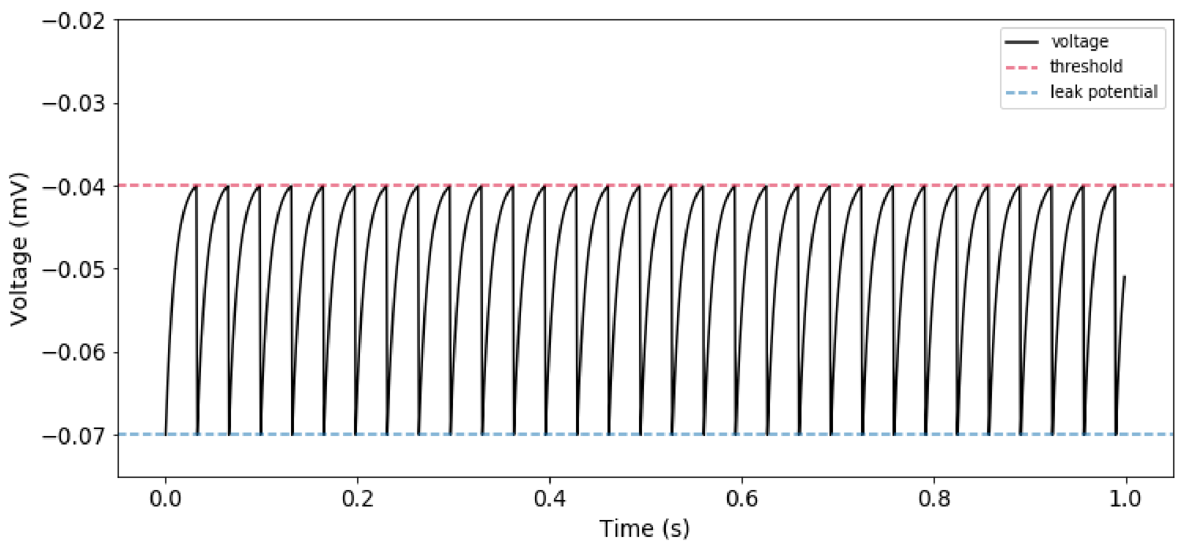

Figure 1: Integrate and fire neuron voltage.

Question Two

The figures below show the relationship between two neurons with identical parameters. The neuron voltages for excitatory synapses are shown in Figure 2 and inhibitory synapses in Figure 3.

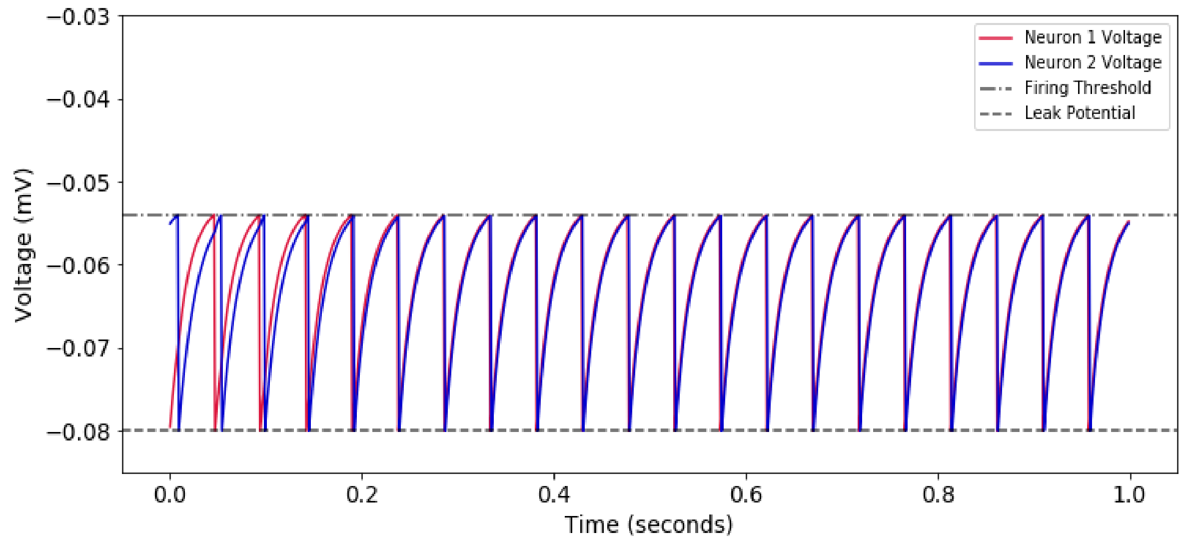

Figure 2: Neuron voltages with an excitatory synapse.

Looking closely at the figure above, it can be seen with the excitatory synapse that a spike in one neuron causes an increase in the rate of change of voltage in the other neuron. Also the spike timings become synchronous over time.

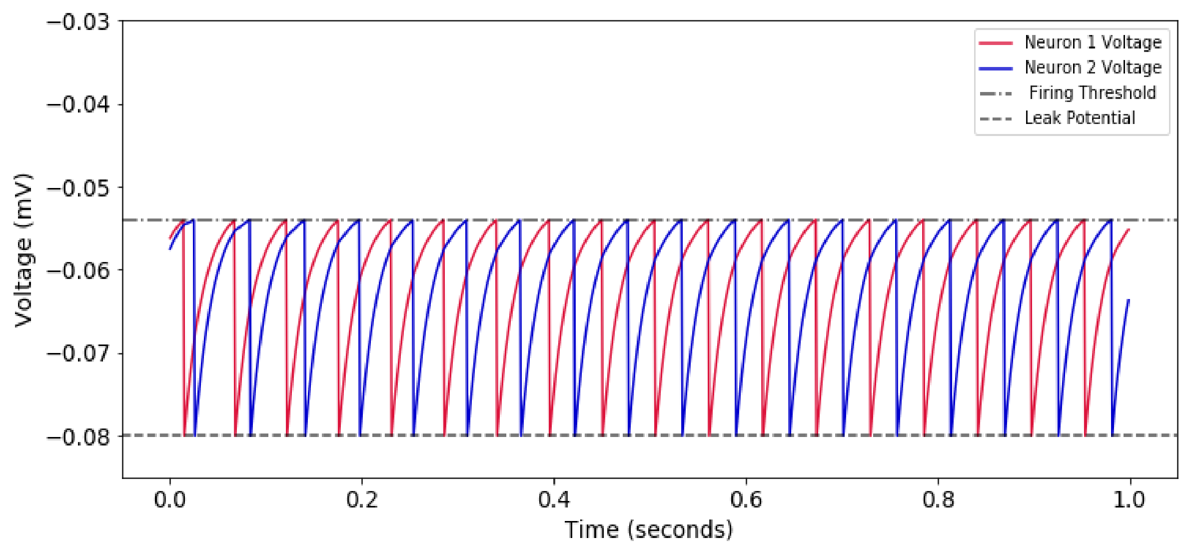

Figure 3: Neuron voltages with an inhibitory synapse.

Looking closely at the figure above, it can be seen with the inhibitory synapse that a spike in one neuron causes an decrease in the rate of change of voltage in the other neuron. Also the spike timings become fully asynchronous over time, with uniform timings between alternate spikes.