Solution to Exercise 4: Ball-and-stick neuron: Rall versus Eccles

Example code will be available.

(i) As seen in Figure 1, the ball-and-stick neuron model gives the best fit for the normalized charging curve. Note that only the shape of the curve matters here as both the lone-soma and ball-and-stick neuron model are linear so that the amplitude is simply proportional to the input current.

Note also that this 'best fit' is obtained for a dendritic stick diameter of 2 μm. Other values for this parameter would give a poorer agreement. Test it out in the Python program yourself!

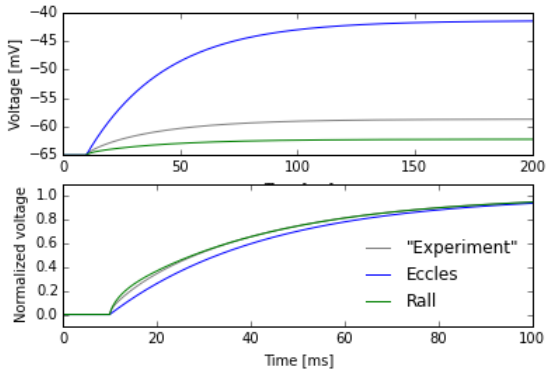

Figure 1: The charging curve of the soma, following the injection of a constant current starting at $t = 10$ ms for (virtual) experimental data (gray), a lone soma model (blue) and a ball-and-stick model (green).

(ii) As seen in Figure 2, the somatic voltage response to the current pulse becomes smaller and peaks later when the input is moved farther away from the soma along the dendrite. Thus the stick dendrite is acting as a lowpass filter, that is, the higher frequency components of the input signal is dampened the most.

(iii) An example spike is shown in Figure 3.

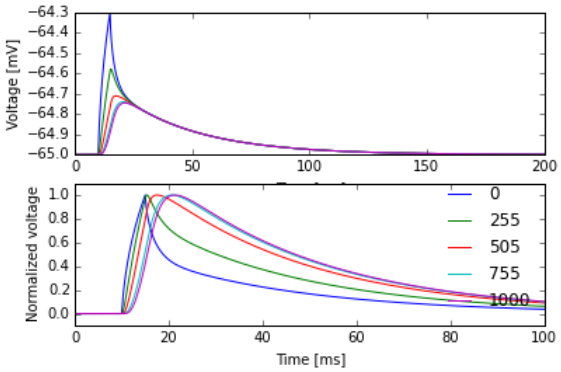

Figure 2: Potential response, both in absolute terms (top) and in relative terms (bottom), to a square current pulse lasting 5 ms injected at different dendrite height above the soma (labeled in micrometers).

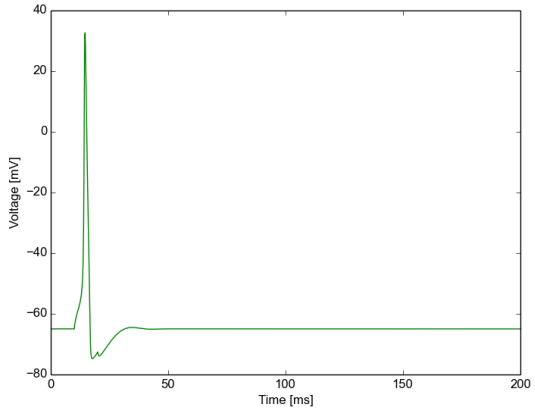

Figure 3: An example of a spike from a ball-and-stick model with Hodgkin-Huxley conductances inserted in the soma.