Exercise 5: Multicompartmental neuron model with synaptic input

In this exercise you will work with a recently published 'state-of-the-art' multi-compartmental model form literature, namely the Hay model[1]. This model has an anatomically reconstructed dendritic morphology, and many active conductances that have been added and fitted to experimental data, see the journal paper on `doi:10.1371/journal.pcbi.1002107`.

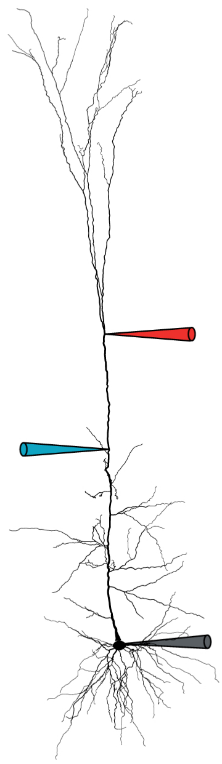

Figure 1: Reconstructed morphology of a rat neocortical pyramidal cell by Hay et al. (2011). Experimental recording sites are indicated by schematic electrodes at the soma (black), proximal apical dendrite (400 μm from the soma, blue) and distal apical site (620 μm from the soma, red). Taken from Figure 1 in Hay et al. (2011), `http://journals.plos.org/ploscompbiol/article?id=10.1371/journal.pcbi.1002107`

[1] Hay et al. (2011) *Models of neocortical layer 5b pyramidal cells capturing a wide range of dendritic and perisomatic active properties.* PLoS Comput Biol 7: e1002107, `doi:10.1371/journal.pcbi.1002107`

Many such cell models are now freely available from online data bases like `ModelDB (http://senselab.med.yale.edu/modeldb/)`, and if you want to make your own model, dendritic morphologies can be downloaded from `neuromorpho.org`. Scientific papers based solely on simulations with such cell models taken from literature and data bases are not uncommon.

In this exercise you will be given a simple example script, `exercise_5.py`, based on `LFPy` and `Neuron`, that you can adapt to solve this exercise.

(i) Make the cell spike by giving it one or more synaptic inputs. Experiment with different synapse numbers, locations and synaptic strengths. Have fun.

(ii) Plot the 'raw' and normalized subthreshold somatic voltage response from synaptic inputs for increasing distances between the synaptic input and the soma. What do you see?

(iii) Plot the somatic membrane potential response to a spike train input to a synapse in the distal apical dendrite when the neurons is passive, that is, have no active conductances. The incoming spike train should contain three spikes, with an even interspike interval of 40 ms. How do the synaptic input sum at the input site? How do they sum in the soma compartment? How does it change if the cell has all the original active conductances? (Note that the documentation in `exercise_5.py` explains how to turn active conductances on and off.)

(iv) [Optional] In the release of the `LFPy` program[2] several example applications were included. They are available through the `LFPy` website at `http://compneuro.umb.no/LFPy/`. Test out some of them (but note that the example scripts also produce plots of extracellular potentials which we will go through later in the course).

[2]Linden et al, *LFPy: a tool for biophysical simulation of extracellular potentials generated by detailed model neurons*, Frontiers in Neuroinformatics 7:41 (2014), `doi: 10.3389/fninf.2013.00041`