Exercise 3 (15 pts in total)

HH_multi.py/m implements a multi-compartment Hodgkin-Huxley model. It simulates the behavior of a cylindrical nerve fiber during an intracellular current injection (*iClamp*) or under the influence of an extracellular current source (*extracellular*). For stepwise integration, the forward and backward Euler methods are implemented (*solver*).

1. Apply an extracellular cathodic (i.e., negative) subthreshold pulse (Hint: a pulse not strong enough to cause an action potential) and analyze the membrane voltage directly below the current source in the center of the fiber, but also to the left and right. For this, plot the membrane voltage of all compartment over location for a certain timestamp while the stimulus is still active (Hint: choose a time point immediately after the stimulus has started, the matrix *vMat*(compartment,time) contains all the membrane voltages) (**2 pts**). Why can you see opposite polarizations along the fiber at the same time although all compartments experience a negative V_e? (**2 pts**)

2. Compute and plot the activating function over the length of the fiber for a cathodic and an anodic pulse with the amplitude from task 1. Describe the differences of the activating function for the two stimulus polarities. (**2 pts**)

3. Find the cathodic threshold which initiates an action potential for both point source and a 50 µm disk electrode. Where is the action potential initiated and what happens afterwards? (**2 pts**)

4. Change the intracellular resistivity *rhoA*. How does it influence the conduction velocity of an action potential? (**1 pt**)

5. An anodic (i.e., positive) pulse will hyperpolarize the compartments below the stimulating electrode (in contrast to the cathodic pulse). Is it still possible to trigger an action potential (at higher amplitudes)? If so, what is the ratio between cathodic and anodic threshold? (**2 pts**) At which location within the fiber is the action potential initiated for the anodic case? (**1 pt**)

6. Use HH_multi.py/m as a template to determine spiking activity when the electrode is shifted along the fiber. *cellX* sets the location of the fiber center in x-direction and should be varied in a script from -3000 to 3000 µm in steps of 100 µm, the electrode is always located at x/y=0/0. HH_multi.py/m must be modified to have an input *cellX*. Stimulation should be applied via a point source in a y distance *cellY* of 25 µm and a stimulation amplitude *I* of -5 µA. For each cell location spiking activity should be detected and stored (binary 0/1 for no spiking/spiking). Plot the spiking activity versus the *cellX* coordinate. (**3 pts**)

Short meaningful answers underlined with screenshots of the results are appreciated. For programming tasks, also provide the source code.

After completion of all four exercises, send your reports including your name and student ID to paul.werginz@tuwien.ac.at.