COSC422: Assignment 1 (worth 20 marks) Due: Fri 17 Aug 2012

Exercises with NEURON

The goal of this assignment is to investigate the behaviour of the models of a single neuron. You will use the programme codes called **`sthA.hoc`** and **`sthB.hoc`**, available at http://www.anc.ed.ac.uk/school/neuron/ where you click Download the Zipfile of Tutorial Code. The program **`sthA.hoc`** simulates a single neuron from the rat subthalamic nucleus represented by soma only and is described in the NEURON tutorial part A. The program **`sthB.hoc`** simulates a single neuron from the rat subthalamic nucleus represented by soma plus two dendrites and is described in the NEURON tutorial part B.

Your investigation will consist of the following 4 tasks each worth 5 marks:

(1) Simulate **`sthA.hoc`** with the default parameters of current injection.

(A) Report and include the graphs of the voltage (**`v`**), sodium current (**`ina`**) and potassium current (**`ik`**). Answer the question: What is the membrane of soma doing when we inject an electric current into it and the voltage exceeds the firing threshold?

(B) Keep decreasing **`stim.amp`** and run the simulation again to see how the output of soma changes. What is the membrane of soma doing when we inject an electric current into it and the voltage **does not** exceed the firing threshold? Show the voltage graph and provide an explanation.

(C) Return to the default values of **`sthA.hoc`** and change the soma parameters. Observe the effect of increasing and decreasing the values of **`diam, L`** and **`Ra`** upon the soma voltage and describe results of your investigation.

(2) Simulate **`sthB.hoc`** with the default parameters of current injection. Report and include the graphs of the voltage (**`v`**), sodium current (**`ina`**) and potassium current (**`ik`**) for

(A) soma

(B) proximal part of one of the dendrites

(C) distal part of one of the dendrites.

Answer these questions: Soma without dendrites generates 7 spikes whereas soma with the dendrites generates only 5 spikes. Why?

Why the voltage attenuates towards the distal end of the dendrite? What would have to be done in order to prevent this voltage decay?

Repeat the task (2A, 2B, 2C) when you double the number of segments in the observed dendrite (i.e. **`nseg = 10`**). Has anything changed and why?

(3) In the program **`sthB.hoc`** increase the stimulation amplitude (**`stim.amp`**) until you find out what is the maximum number of spikes the soma can fire. You may find it usefull to observe what is happening with the currents **`ina`** and **`ik`**, too. Each spike has to have a peak voltage > 0. If the peak voltage < 0, we do not consider it to be a spike. Can you explain why there is a limit on number of spikes a neuron can fire? Can you explain why the amplitude of spikes decreases when there is more of them in close succession? When experimenting with stimulation amplitude you will find out that above certain value the neuron malfunctions. Try to explain why.

(4) Now block all the sodium channels by calling the procedure **`block_sodium().`**

(A) Visualise the voltage on soma and both currents too, i.e. **`ina`** and **`ik`**. You should observe that all variables stay at their initial values. Why is the potassium current also equal to zero, when we blocked just the sodium channels?

(B) Try to find the value of proportion of the blocked sodium channels **`X`**, i.e. **`block_sodium(X)`** to simulate the "zombie" effect, that is the neuron fires just one spike**.**

IMPORTANT:

E-mail your reports with answers to the questions and corresponding graphs to:
lubica@cs.otago.ac.nz by Friday 17 August 2012.

If you need an extension please email or speak to me about it.
I will subtract 10% of total marks for each working day late without prior arrangement with me.