UNV Assignment 2

Deadline: Submit report by week 7.
Topics: Hodgkin-Huxley (H-H) model.

General guidelines for the assignment:

Assignment has to be submitted in the form of a report (referát) following the guidelines listed below:

- **Format of the heading:** Include a header having an assignment title, student's name who worked on it (like in case of a project, you should work in max. 4 student's group), study year, group etc…
- **Format of the answers:** Firstly, the answer needs to be written in text format. Further, insert the MATLAB code/script relevant to the answer. Try to supplement with proper comments explaining your code. Sometimes the questions are freely given in the input text. So read it carefully, and make sure you answer all the questions.
- **Format of the figures:** The figures should be self-explanatory by adding a legend (Example: What each colored line represents?), labelled axes with proper units. Further, add a figure number, title and text description explaining the results shown in the figure. This could also include your evaluation/discussion whether the results in the figure are matching with your expected results.
- **Format of the document:** The report should ideally be in a PDF format (use PDFCreator for instance). Send the report via email to **kogneuro@gmail.com** (note that this email id is different from the one on which I read standard emails). The subject of the email should have the following structure: UNV Zx author_names. (x- assignment number).

Assignment description:

Download the MATLAB file http://ics.upjs.sk/~kopco/UPJSONLY/unv/z2/cc.m (matlab .m files are called "scripts"), in which there is a simulation of the Hodgkin-Huxley model in the current clamp setting. The equations used in this simulation are described in the 5th chapter of the Dayan-Abbott book. Note: If any of the questions are unclear to you, try reading the lecture on Hodgkin-Huxley model in detail.

Tasks:

1.) To study the impulse frequency dependency on the input current. Modify the cc.m script so that you can simulate the H-H model's response to a step change of the current (Iapp) from zero to a positive value.

a) Simulate the behavior of H-H model for the input currents 0.01; 0.05; 0.1 and 5 $\mu A/cm^2$. Do not change the initial conditions (i.e. initial values of V, m, h, n). Plot the behavior for each current value in voltage vs time graph and describe it in words.

b) Find the threshold values of the current, for which the qualitative behavior of the system changes. In other words, in the previous paragraph, you might have seen 4 different types of behavior. How does the value of the neuron flow change from one type of behavior to another?
c) One of the 4 types of the behavior is repeated generation (production) of action potentials. What is the minimum and maximum frequency of impulses? Can you explain, why the neuron cannot generate action potentials when it exceeds the maximum?

2.) The cc.m script has the initial values of V, m, h, n set to approximately resting values when no current is supplied. In this problem, we look at how varying the initialization conditions affect the behavior of the neuron.

a) Increase the initial V voltage by 5 mV and simulate the behavior of the neuron for the next 100 ms. Generate a graph of the voltage as a function of time. The model should return directly to the quiescent value.
b) Now increase the initial V value by 10 mV compared to the original value, and start a 100-millisecond simulation. Generate a graph of the voltage as a function time. This time the model should generate one action potential and then return to a quiescent value.
c) Find the voltage threshold required to generate an action potential.

3.) "Post-inhibitor rebound." Create a simulation with following conditions: Start with a zero current, then change it abruptly to a negative value (using a step function), and then change it back to zero. At certain amplitude and duration, the neuron generates an action potential when returning to zero. This phenomenon is called "post-inhibitory rebound". Display V, m, h, and n as a function of time. Describe in words what causes the production of an impulse.

4.) Plot graphs showing that the Hodgkin-Huxley's neuron has an "absolute and relative refractory period." Also describe in words. Hint: Consider short input current (eg 2 ms) of 0.05 μA for the neuron.

5.) Generate plots explaining the term latency. That is, show that smaller the current, the more the action potential is delayed.