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Course: BT6270 - Computational Neuroscience
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ASSIGNMENT #1
Roll No.: ME18B183
Semester: JUL - NOV 2021
Due Date: 15^{th} September, 2021

Assignment Description:
Run and modify the MATLAB® code which simulates the **Hodgkin Huxley model** so as to find and/or plot the following:

1. Threshold values for the external applied currents I_1, I_2, and I_3 in which shift of dynamical behavior from one to another is seen, such as *no AP, finite number of APs, Continuous firing and then followed by distortion resulting in no more APs.*
2. A graph which depicts the firing rate (frequency) as you change the applied external current (i.e. I_{ext} vs. Firing rate (f), as explained by professor in the class). You can make this plot either in MATLAB® or Python.

Solution:

- **Assumption(s):**
  1. Threshold value of voltage, for a voltage ping to be considered as an Action Potential is assumed to be equal to 5 mV.
- **Plot:**

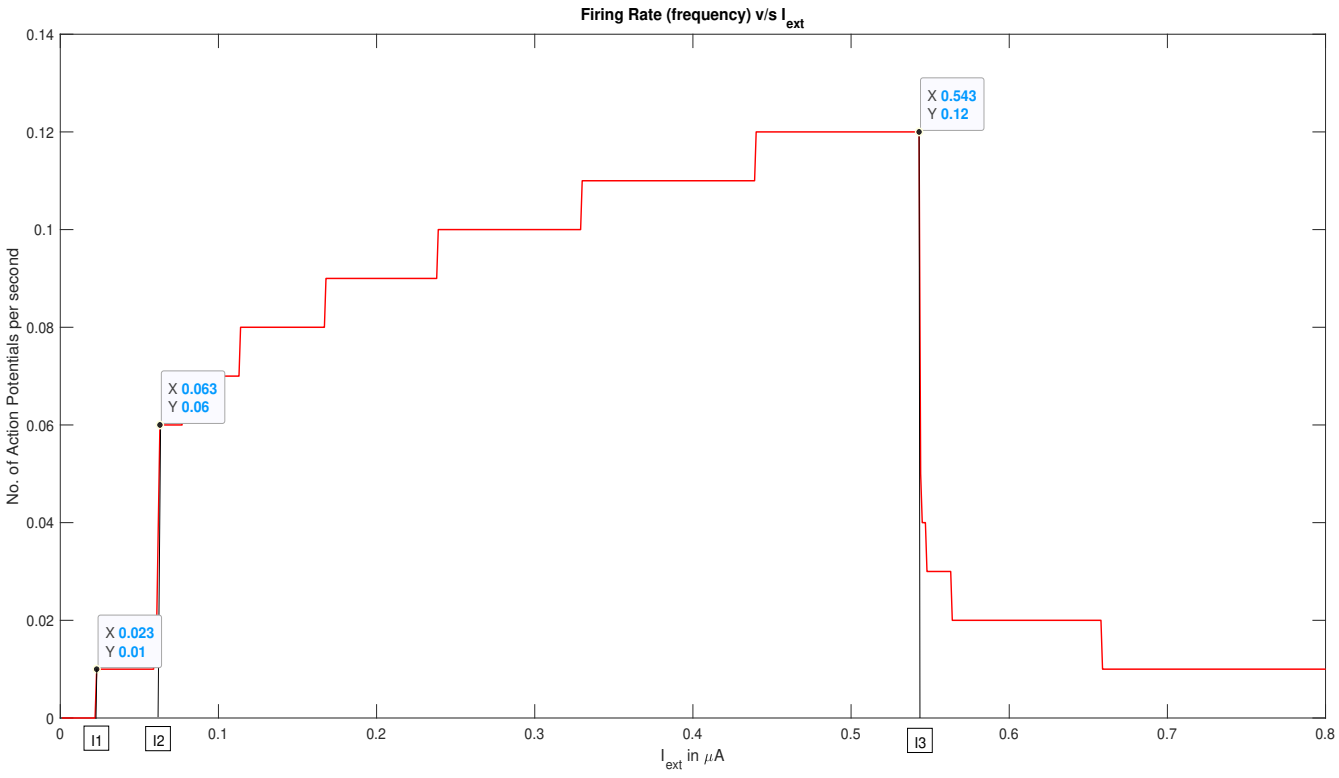

Figure 1: Action Potential frequency v/s I_{ext} plot for the Hodgkin Huxely model.

- **Observation(s):**
  1. The threshold values for the external applied currents I_1, I_2 and I_3 in which shift of dynamical behavior from one to another is seen are: I_1=0.023 μA, I_2=0.063 μA and I_3=0.543 μA.

Current Range	Observation
0 to I_1	No APs are observed
I_1 to I_2	Finite no. of APs are observed
I_2 to I_3	Continuous firing is observed
$\geq I_2$	No more APs are observed

Table 1: Shift of dynamical behaviour for various current inputs.

For 0 to I_1, no action potentials are observed because I_{ext} fails to meet the threshold value of 0.023 μA (for which the first action potential is observed). As we further increase I_{ext} in the range [I_1 , I_2], we observe finite no. of action potentials, which once peaked, die down to the base value of membrane potential, i.e. V_m = -64.9964 mV. After crossing the mark of I_2, we start observing continuous firing of the neuron, i.e. we observe more action potentials. The no. of action potentials increases with increase in I_{ext}, however the amplitude of these action potentials keeps decreasing with the increase in I_{ext}. This happens till I_{ext} reaches I_3. Once I_{ext} exceeds I_3, we do not observe any action potentials, solely because of the reason that the peak values of voltage pings fail to overcome the threshold value (for classifying voltage pings as action potential) of 5 mV (assumption). Hence, with the help of Figure 1 and Table 1, we can understand the relationship between firing rate (f) and I_{ext}.

$**$ End of Assignment $**$