BCS304 Theoretical Neuroscience Fall 2023

Homework set #2: Due 10/8(Sun), 6:00 PM

Prepare your report as below and send it to: bcs304ta@gmail.com

- **Summarize your results including discussion and comments for each question, as a pdf file. Name it as "HW#_answer.pdf".**
- **Zip all the Matlab® codes and texts in one file**, named as: "HW#_YourSID_YourName.zip".
- For each problem, clearly indicate which file to run, by naming them as "Prob1a.m", "Prob1b.m", etc. You can use as many other sub-function files as you want.
- If you don't follow this direction you might get a penalty.

Comments In this problem set, detailed information is not given as it is in your research, often you need to decide what to do and what not to do based on your own reasoning and hypothesis. Thus, please provide explanations as specific as possible. You may get some extra points from demonstrating this successfully, regardless of whether it is true or not.

Problem 1

Implement a code for a leaky integrate-and-fire model neuron using Euler method.

a. Model a mild background noise by adding random currents so that you can achieve the average firing rate of 5Hz with no input current or spike. Describe and explain your choice of noise design.

b. This neuron receives spike inputs from another excitatory neuron. Implement an excitatory synapse and set parameters such that an isolated (without noise) single spike input generates an EPSP that is not enough to induce a spike response of this model neuron. Plot the membrane potential for a single spike input without noise.

c. Plot the membrane potential for a single spike input with noise in **a** to compare with that in **b**. Show sample membrane potential plots for two different cases – (i) the target neuron induces a spike output due to an input spike (ii) it does not. Calculate the probability of output spike for a single input spike under this condition.

d. Now the input is modeled as a spike train of regular, constant inter-spike-interval (ISI). Find the condition of ISI that generates output firing rate of 10Hz with noise. Plot your input and output spike trains for three sample trials.

e. Now generate a random Poisson input spike train of the average ISI that induces the same output firing rate of the target neuron in **d** under the same noise condition. Compare your estimated ISI with that in **d** and discuss any differences.

f. Find the response functions of the neuron for two conditions of input spike trains in **d** and **e**. Compare them both qualitatively and quantitatively.

g. Assume that this neuron is under "sustained constant inhibition" from other neurons You can implement this condition by simply adding a constant negative input current. Vary your inhibition level and discuss the changes of the response functions in **f**.