EE746 Assignment 3 Report

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Contents

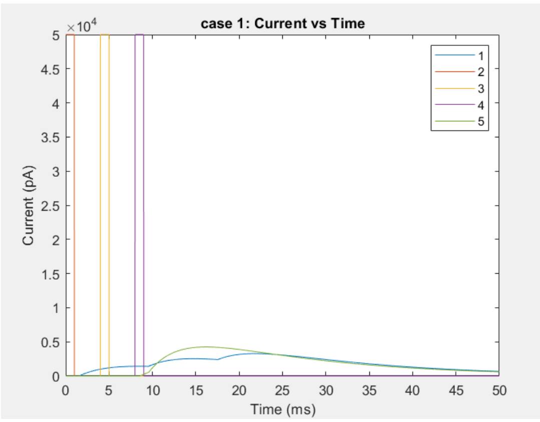
1 Problem 1: Representing synaptic connectivity and axonal delays

1.1 Create three cell arrays named Fanout, Weight and Delay to store the connectivity information and axonal delays of all the neurons for the network shown

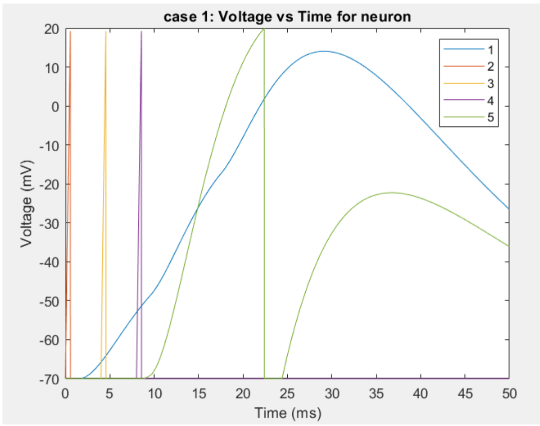
This can be done in following lines of MATLAB code

```
Fanout = {[],["a","e"],["a","e"],["a","e"],[]};
Weight = {[],[3000,3000],[3000,3000],[3000,3000],[]};
Delay = {[],[1,8],[5,5],[9,1],[]};
```

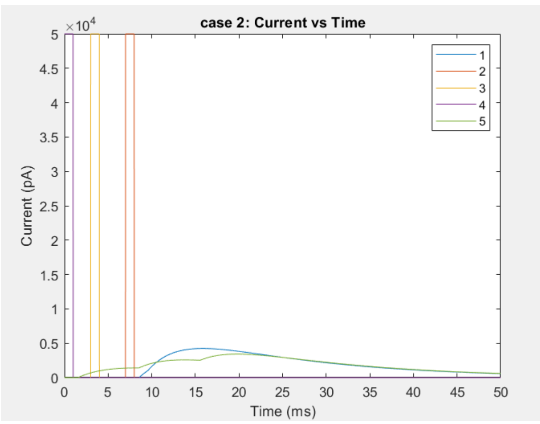
1.2 Assume that the neurons can be modeled by the simple Leaky Integrate and Fire model discussed in Homework 1, with a minor modification to incorporate an artificial re-fractory period, R_p Write a MATLAB code to simulate the behavior of the network in the figure for the two situations described below:
Case 1: Neurons b, c, d received a square pulse input of duration 1 ms, starting at t=0, 4 and 8 ms respectively.
Case 2: Neurons d, c, b received a square pulse input of duration 1 ms, starting at t=0, 3 and 7 ms respectively.
Plot the synaptic currents and the response of the neurons.



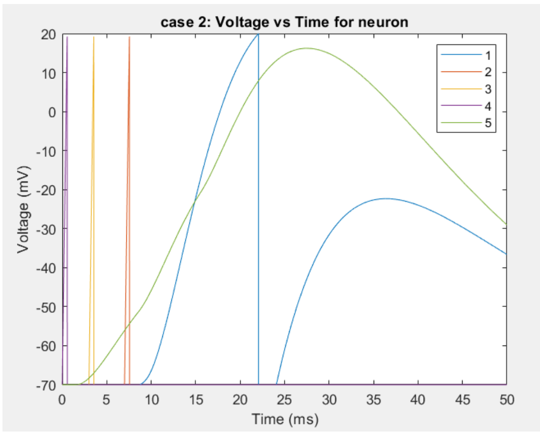
(a) Current in Case 1: input pulses at 0, 4, 8 ms



(b) Voltage in Case 1: input pulses at 0, 4, 8 ms



(c) Current in Case 2: input pulses at 7, 3, 0 ms



(d) Voltage in Case 1: input pulses at 7, 3, 0 ms

Figure 1: Analysing spiking in a neuronal network

2 Problem 2: Dynamical Random Network

2.1 Create a raster plot for the spikes of the N = 500 neurons for a total simulation time of T = 1000 ms

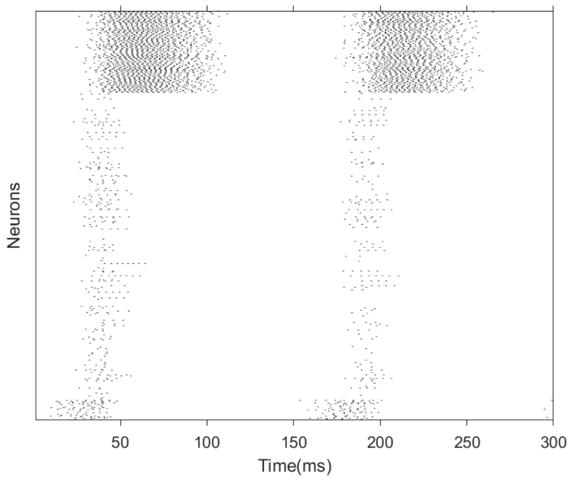


Figure 2: Rasterplot

2.2 Let $R_e(t)$ and $R_i(t)$ denote the total number of spikes issued by all the excitatory and inhibitory neurons in the interval [t, t + 10ms]. Plot how $R_e(t)$ and $R_i(t)$ vary during your simulation.

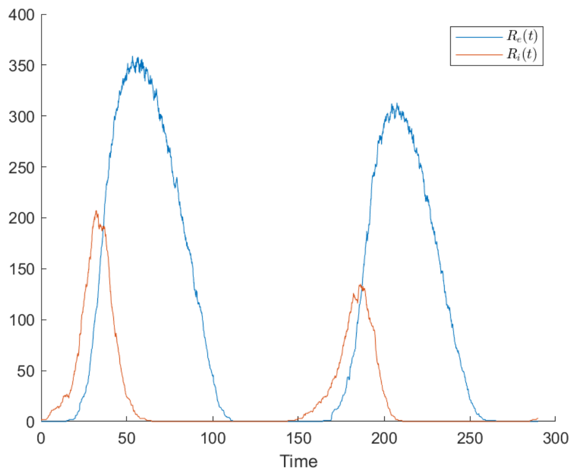


Figure 3: Variation of $R_e(t)$ and $R_i(t)$

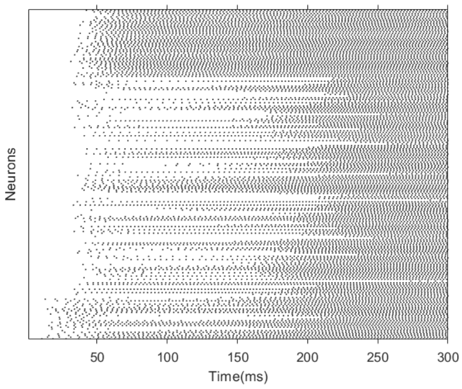
2.3 Qualitatively explain the mechanisms underlying the dynamical behavior.

In the raster plot and plots of $R_e(t)$ as well as $R_i(t)$ we can observe that the excitatory neurons show much lesser spiking than the inhibitory neurons. This is because the excitatory neurons receive both excitatory as well as inhibitory synaptic signals, while the inhibitory neurons are only connected to excitatory preneurons and thus, spike much more.

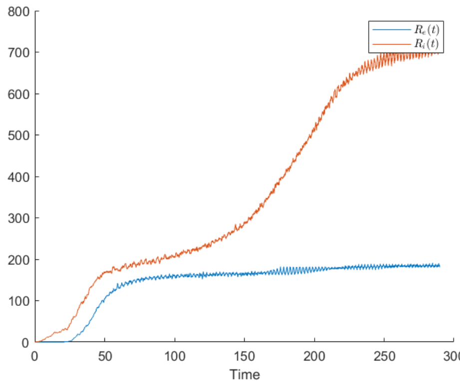
3 Problem 3: Dynamics of smaller networks

3.1 Repeat the exercise in Problem 2, but now with N = 200 neurons. Assume similar statistical connectivity characteristics as in Problem 2. (i.e., the excitatory-inhibitory populations are in the 80 - 20 ratio, and the fanout of each neuron is N/10 = 20). Assume $w_e = -w_i = 3000 =$ wi = 3000, and the first 25 neurons are receiving Poisson stimulus.

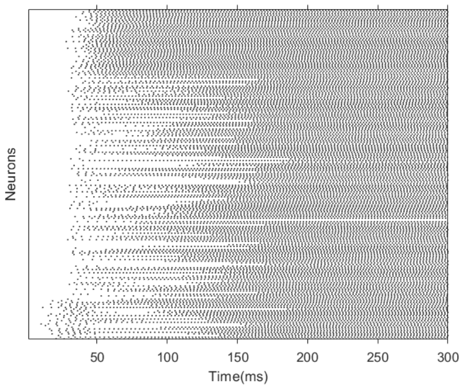
3.2 Study the behavior of the network for other values of synaptic strengths, while maintaining $w_e = w_i$. Are you able to obtain the behavior you saw earlier for some aptly chosen value for the synaptic magnitude. Explain on the basis of $R_e(t)$ and $R_i(t)$



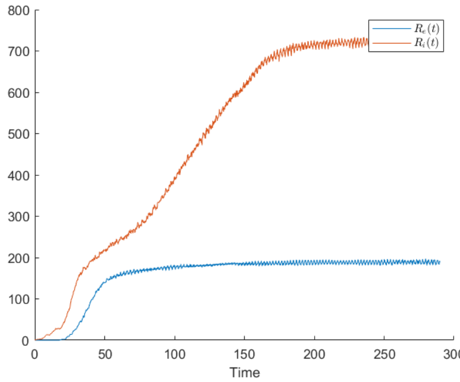
(a) Rasterplot with $|w_i| = |w_e| = 3000$



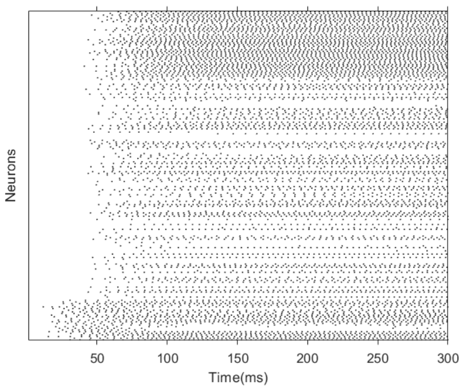
(b) $R_e(t)$ and $R_i(t)$ with $|w_i| = |w_e| = 3000$



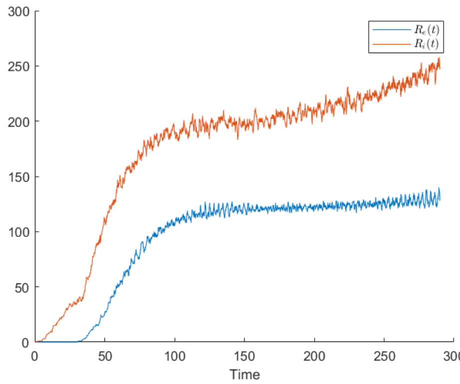
(c) Rasterplot with $|w_i| = |w_e| = 4000$



(d) $R_e(t)$ and $R_i(t)$ with $|w_i| = |w_e| = 4000$



(e) Rasterplot with $|w_i| = |w_e| = 1000$



(f) $R_e(t)$ and $R_i(t)$ with $|w_i| = |w_e| = 1000$

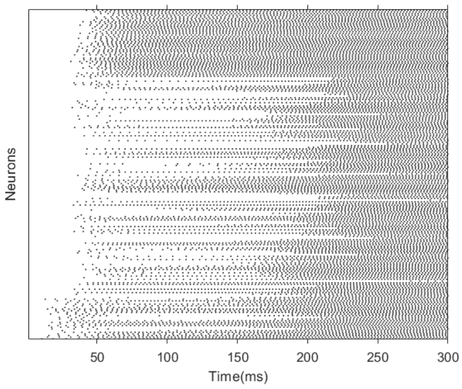
Figure 4: Effect of weight changes on a network of 200 neurons

3.3 Relationship between $\|w_i\|$ and $\|w_e\|$ for a smaller network

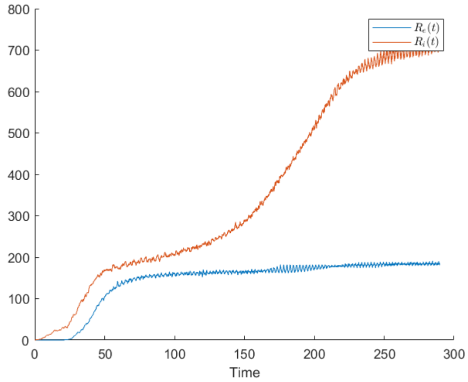
The net inhibition in the network should be increased in order to observe the network behavior observed in problem 2. Thus we need $\|w_i\| > \|w_e\|$.

3.4 Propose a modification of the synaptic configuration, $w_e = -\gamma w_i$

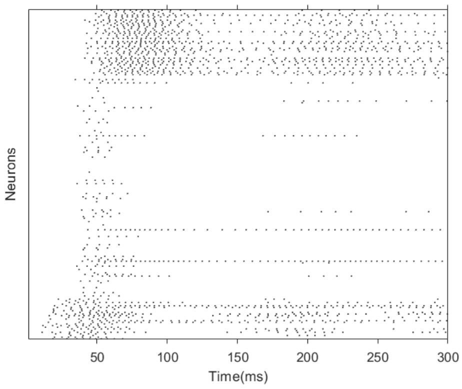
Since we need inhibition to be greater, we will try $\gamma < 1$.



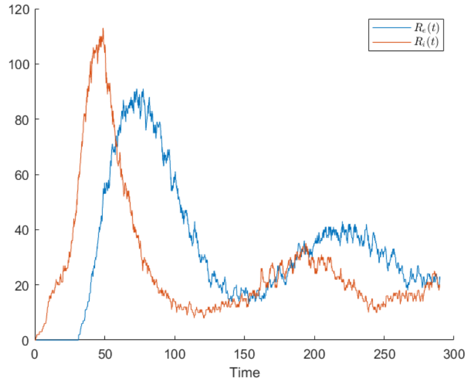
(a) Rasterplot with $\gamma = 1$



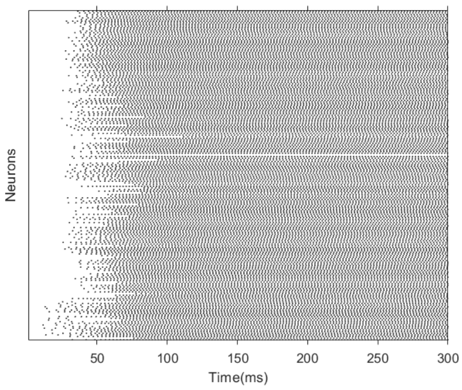
(b) $R_e(t)$ and $R_i(t)$ with $\gamma = 1$



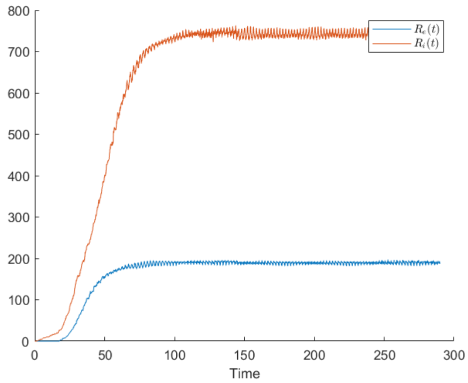
(c) Rasterplot with $\gamma = 0.5$



(d) $R_e(t)$ and $R_i(t)$ with $\gamma = 0.5$



(e) Rasterplot with $\gamma = 1.5$



(f) $R_e(t)$ and $R_i(t)$ with $\gamma = 1.5$

Figure 5: Effect of weight changes on a network of 200 neurons

For $\gamma = 0.5$ we can see a similar pattern in the rasterplot and $R(t)$ curves as we saw in Q2.