In the name of Allah

Computational Neuroscience
Second project: implementation of neuronal population
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In this series of exercises, the model we used to implement a neuronal population is the LIF model, which was implemented in the previous project. The link of the first project in the gate hub where you can examine the LIF neuronal model.

Link:

https://github.com/HasanRoknabady/ComputationalNeuroscienceProjects/tree/main/Projects/HasanRoknabady-99222042/Project1

As we know, to design and implement a neuronal population, we have two types of models and neuron typing: excitatory typing and inhibitory typing.

Here, as in the past, the parameters we had in the past are the same for all neuronal populations, but the threshold parameter will be different so that it has a minimum and will be added with a random number so that it is not the same as the spike model observed in a rotation.

First, we implemented two functions in our neuronal class, in the first function, which you can see in the image below:

```
69
70      def bring_up_to_date(self, j, charge):
71          self.U[j] += self.U[j - 1] \
72                       + (self.R * charge - (self.U[j - 1] - self.u_rest)) \
73                       / self.tha * self.dt
74          result = 0
75          if self.U[j] >= self.thre:
76              result = self.thre - self.u_rest
77              self.U[j] = self.u_rest
78          return result
```

At j moment, the input charge and input current are given to the neuron and the instantaneous potential is calculated and returned, and it should be noted that the external input will be input.

In the second function we have :

```
59      def update_potential(self, val, j, pre_t):
60          if pre_t == "excitatory" or pre_t == "inhibitory" and self.t == "inhibitory":
61              self.U[j] += val
62          else:
63              self.U[j] -= val
```

This function can be excitatory or inhibitory to combine the potential of pre neurons with its own potential and to consider the type of neurons.

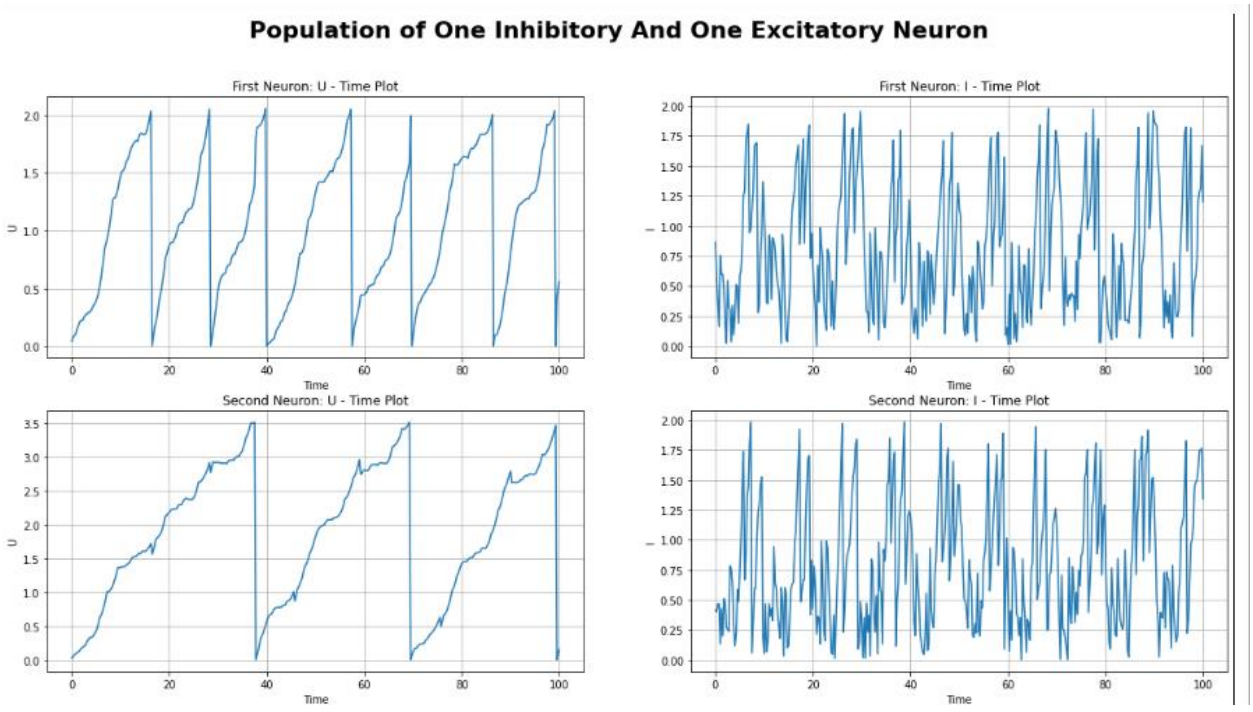
It should be noted that the input flow pattern is selected quite randomly but designed with the pattern.

The first part of the project:

Here, using the join function, we designed a pattern by which two neurons can be connected to each other, and with the weight we know, the weight variable shows the weight value of that connection. Now, we can use this current-potential diagram for two different neurons. Draw as we see in the diagrams below.

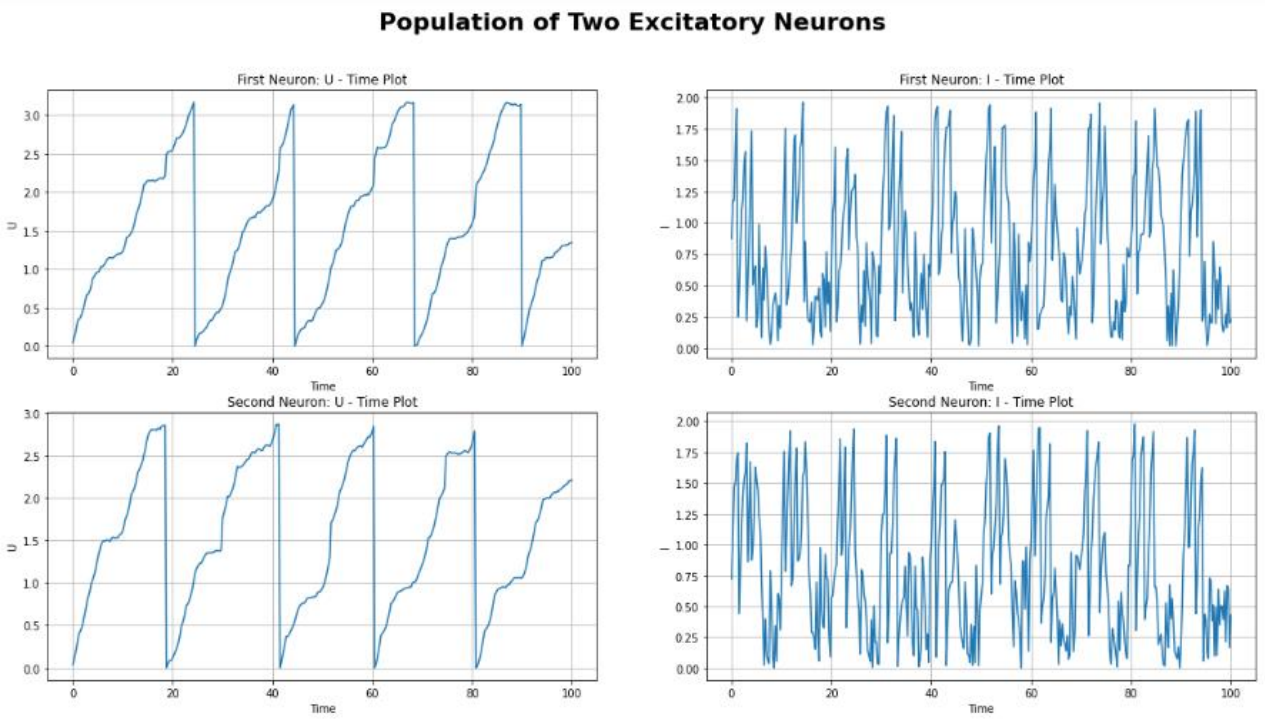
Excitatory and Inhibitory :

In this model, we see that wherever the second neuron of the excitatory neuron has a reduced potential, the first neuron of the inhibitory neuron strikes a spike, and wherever we see an increase in the potential of the inhibitory neuron, we see a spike of the excitatory neuron.



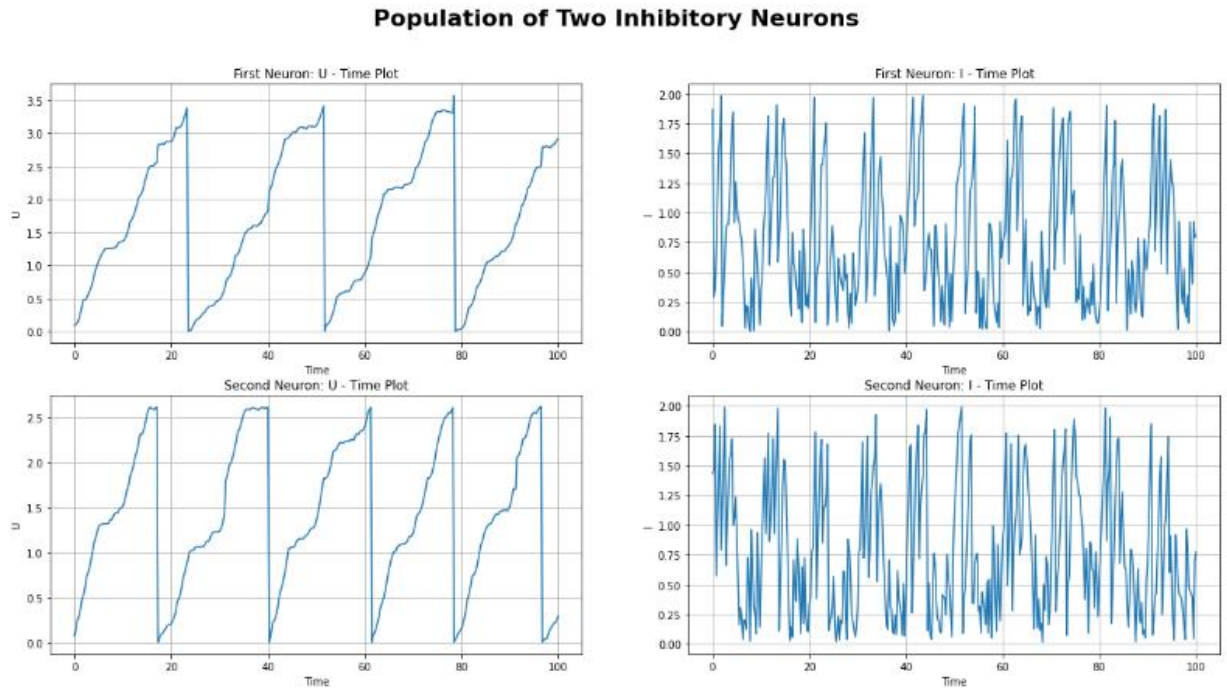
Two Excitatorys :

We know that in this type of model, both neurons are of the stimulus type, so they will have a positive effect on each other's potential and increase each other's activity during spikes.



Two Inhibitorys :

We know that in this type of model, both neurons are inhibitory of type, so as above, they will have a positive effect on each other's potential and stimulate each other and increase each other's potential during spikes.



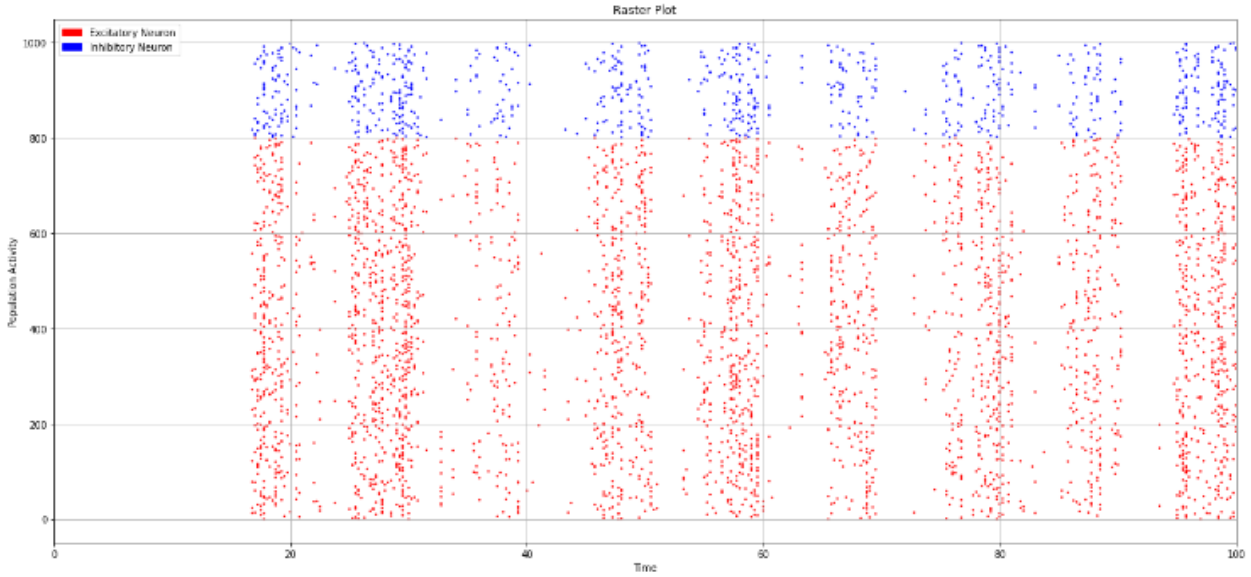
The second part of the project:

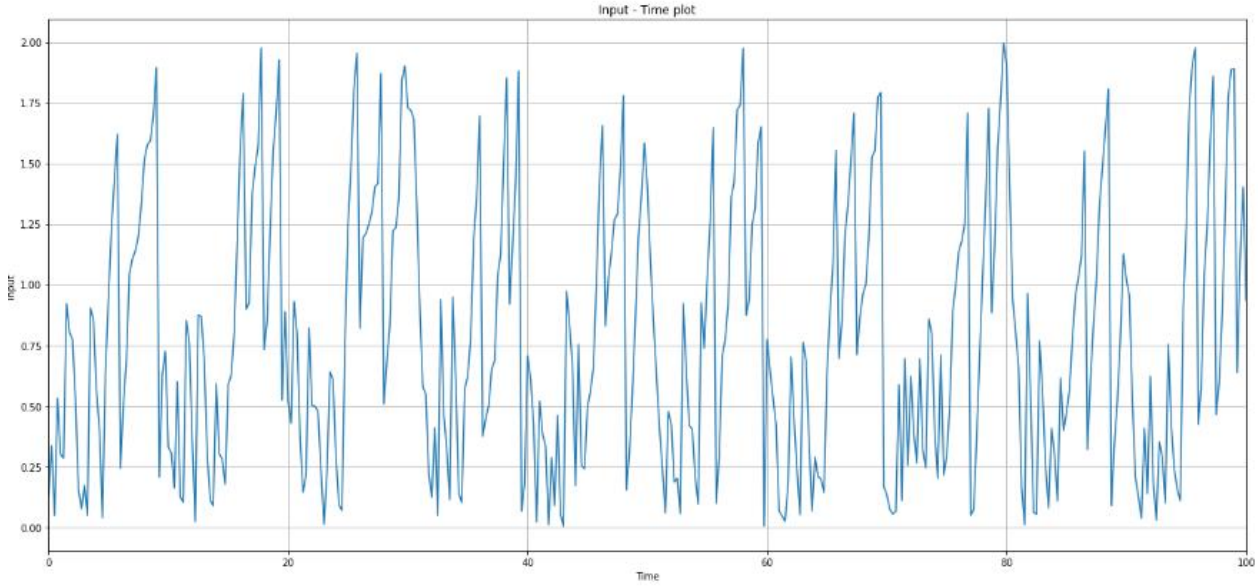
In the second part of the project, we know that the synaptic weights we have must be constant in the whole population we have, according to the formula that divided a fixed constant value by the number of neurons in a population (w = J / N). Inhibitory and excitatory states of neurons with these two types are typed. Here we will see the implementation of a neuronal population homogeneously and the current that enters from the outside will enter all the neurons that output the following figures and diagrams. We will see that:

The moment we see spikes of neurons, we usually expect an increase in the activity of neurons, which is true, and we also see that after a while two populations of neurons neutralize each other's effect. Equality of neurons with different types We see that the ratio of density or firing neurons has decreased.

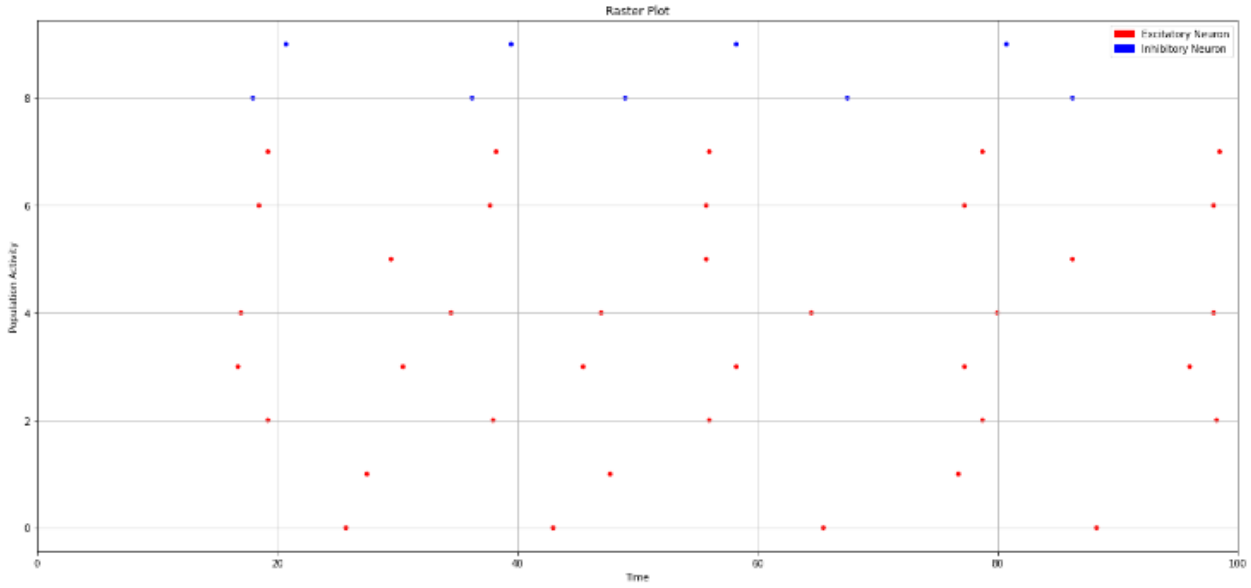
We also see that by increasing the excitation neurons in a sample compared to the inhibitory model, by lowering the electric current, the chance of firing the neurons increases.

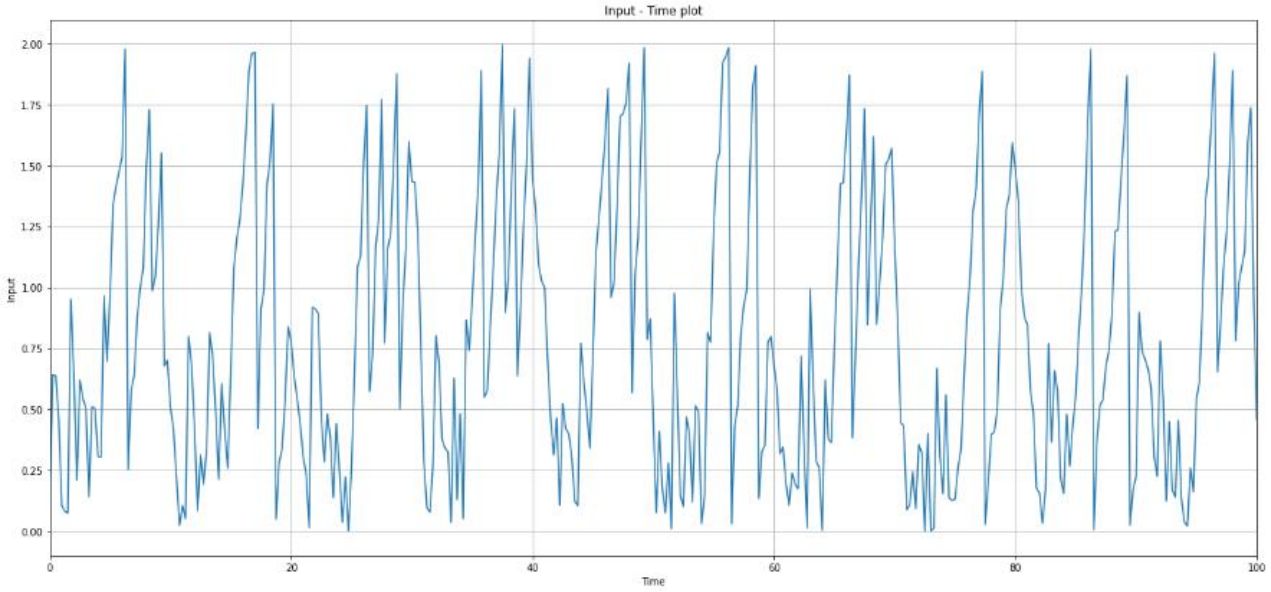
Population of 800 Excitatory Neurons with 200 Inhibitory Neurons



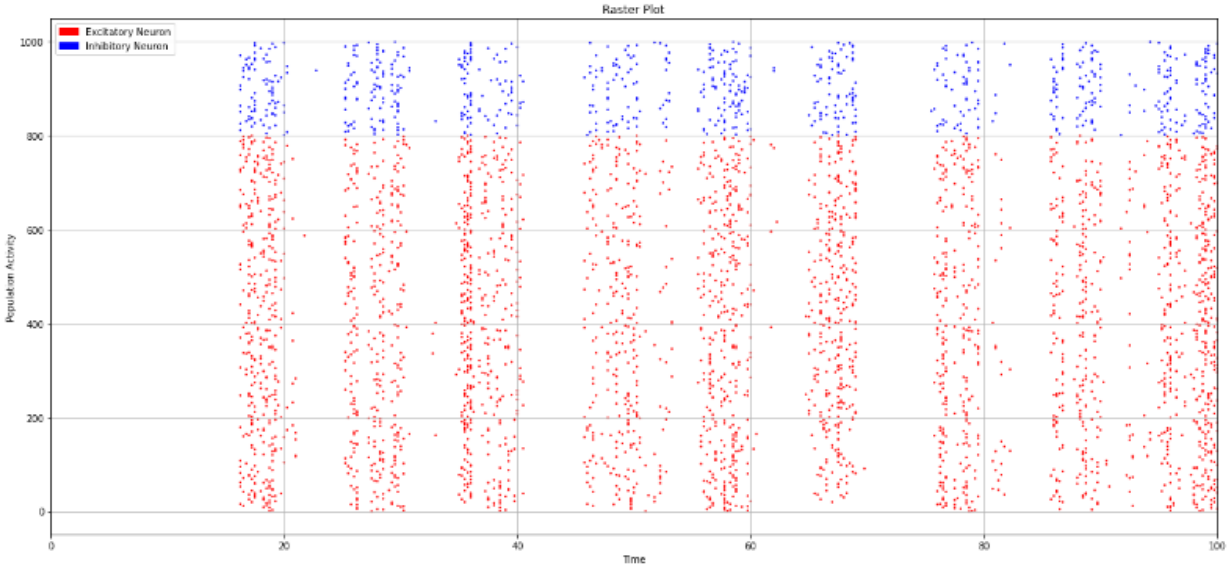


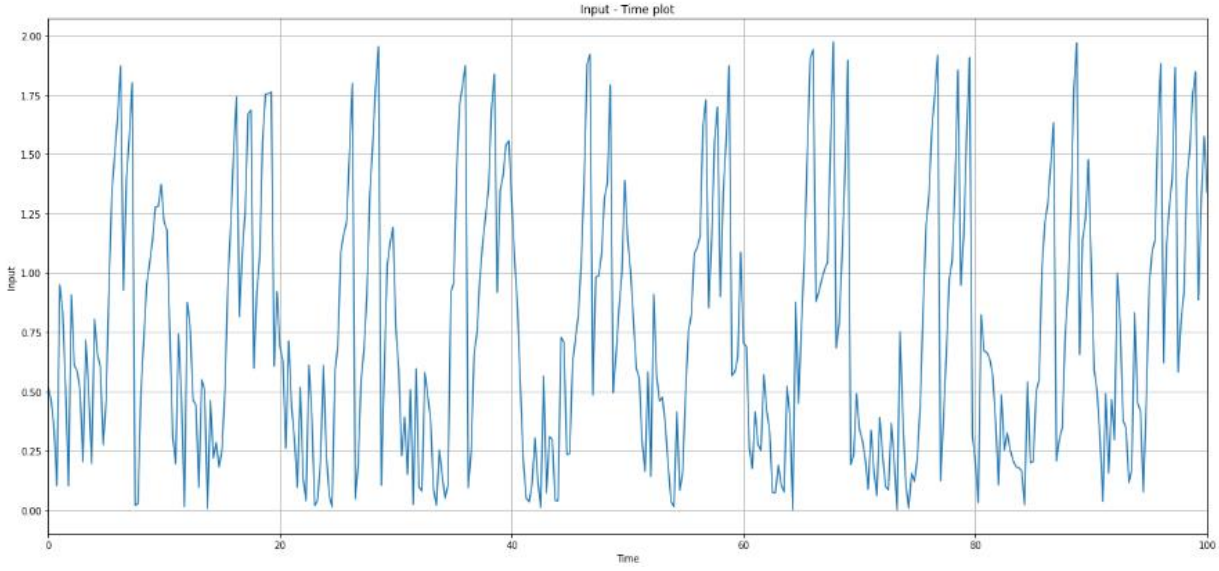
Population of 8 Excitatory Neurons with 2 Inhibitory Neurons



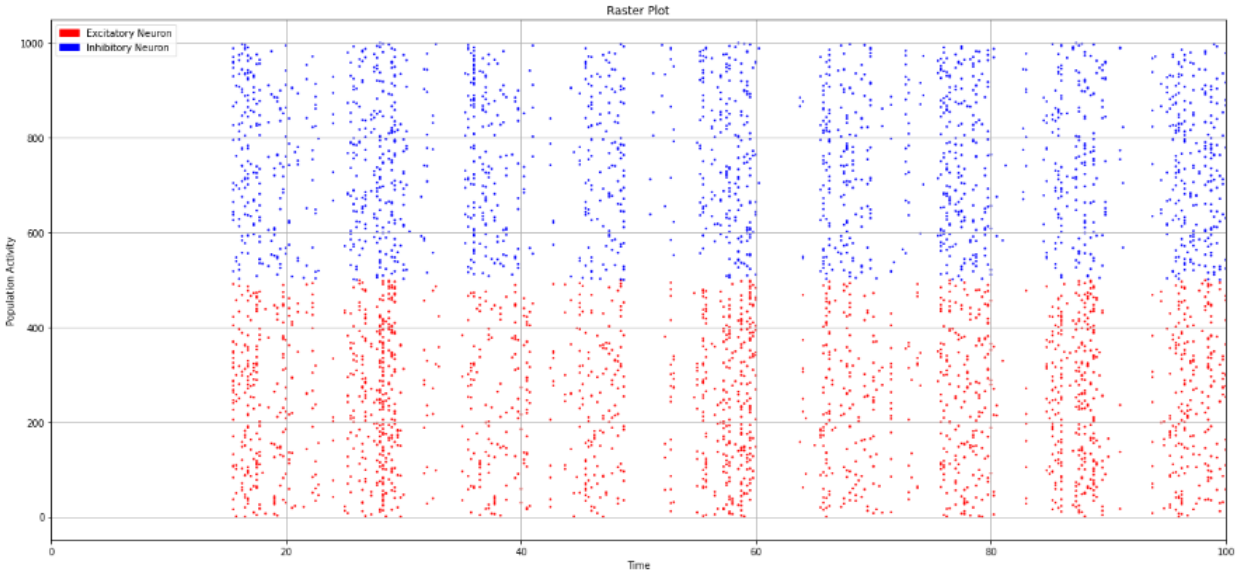


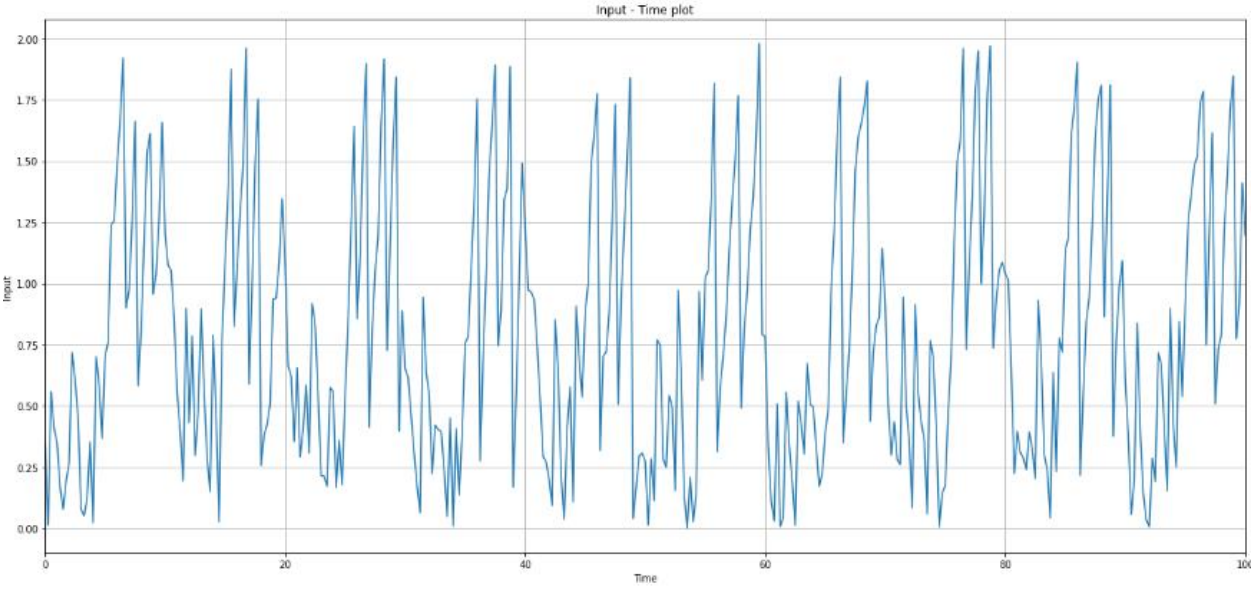
Population of 800 Excitatory Neurons with 200 Inhibitory Neurons



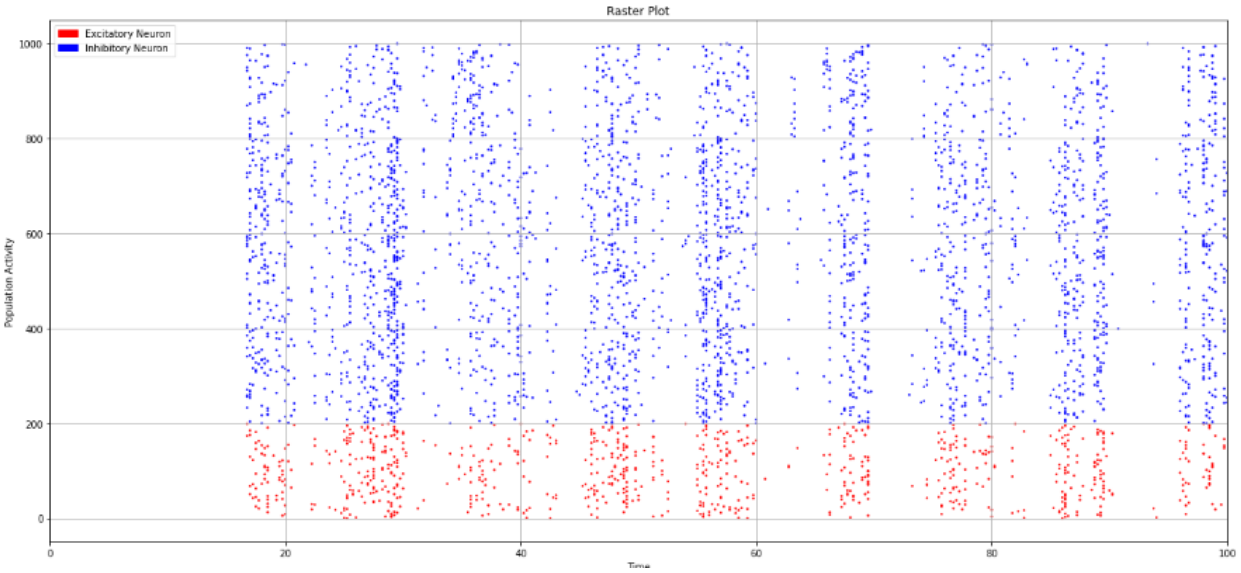


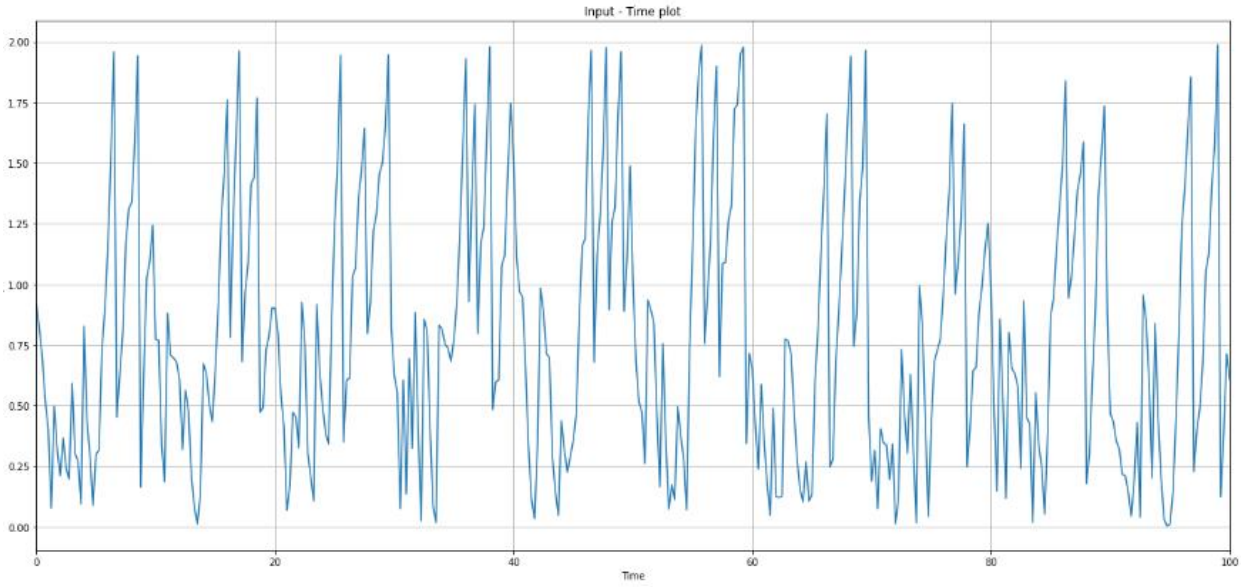
Population of 500 Excitatory Neurons with 500 Inhibitory Neurons



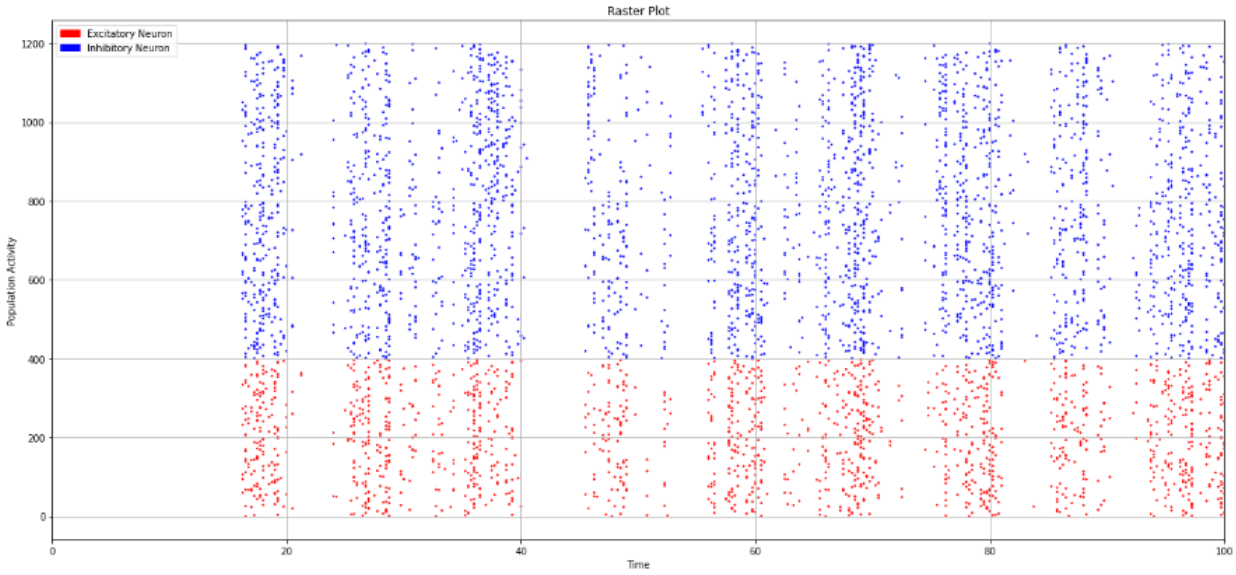


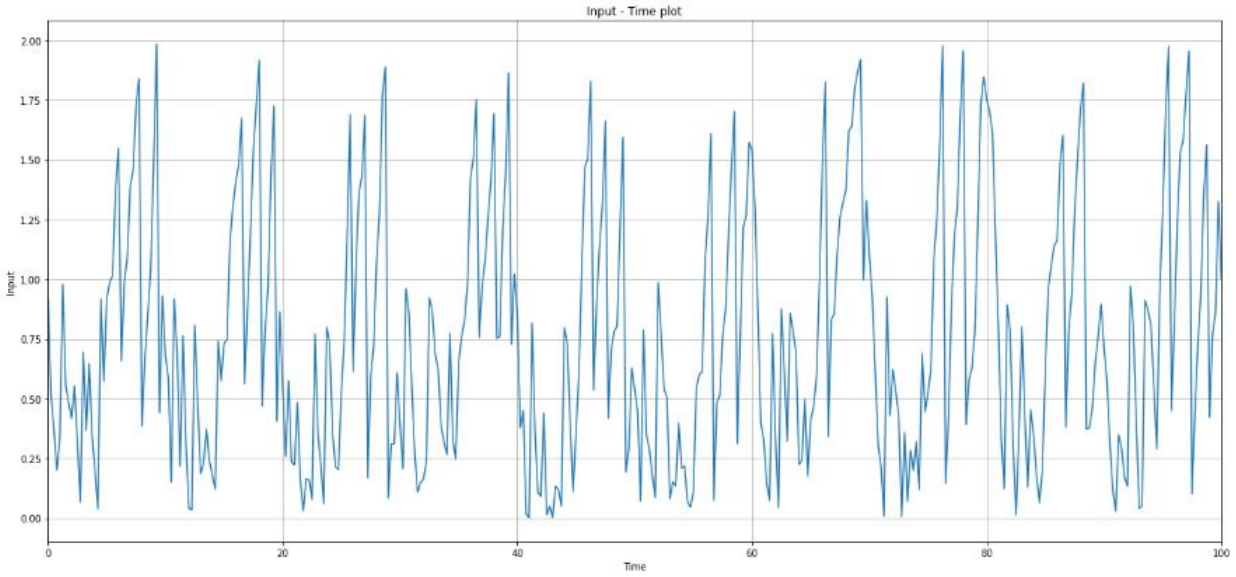
Population of 200 Excitatory Neurons with 800 Inhibitory Neurons





Population of 400 Excitatory Neurons with 800 Inhibitory Neurons





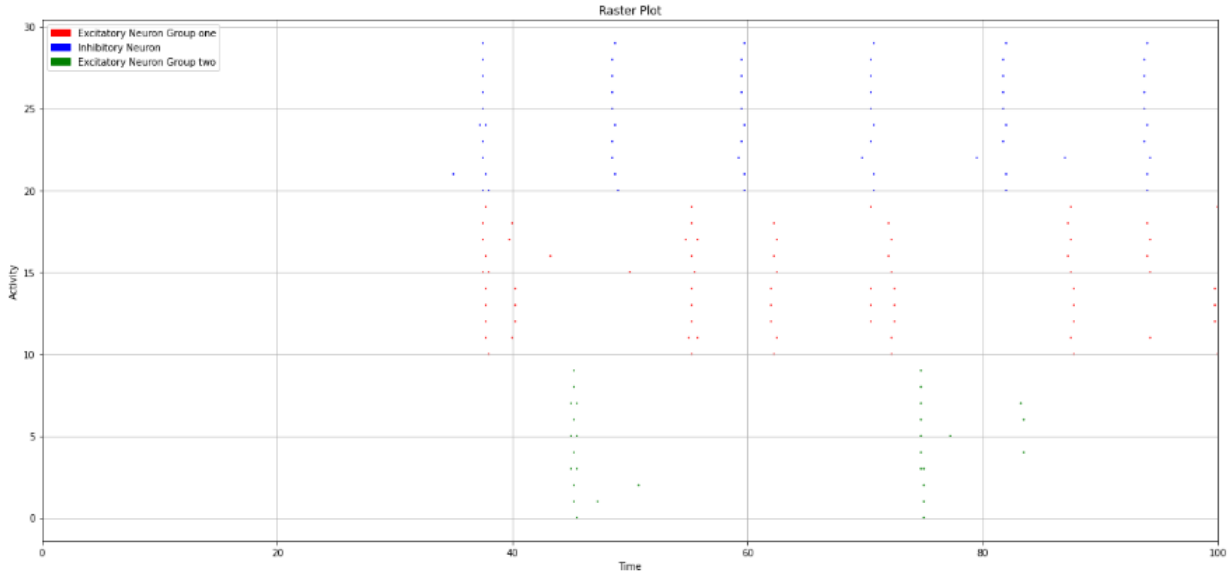
Part 3 of the project:

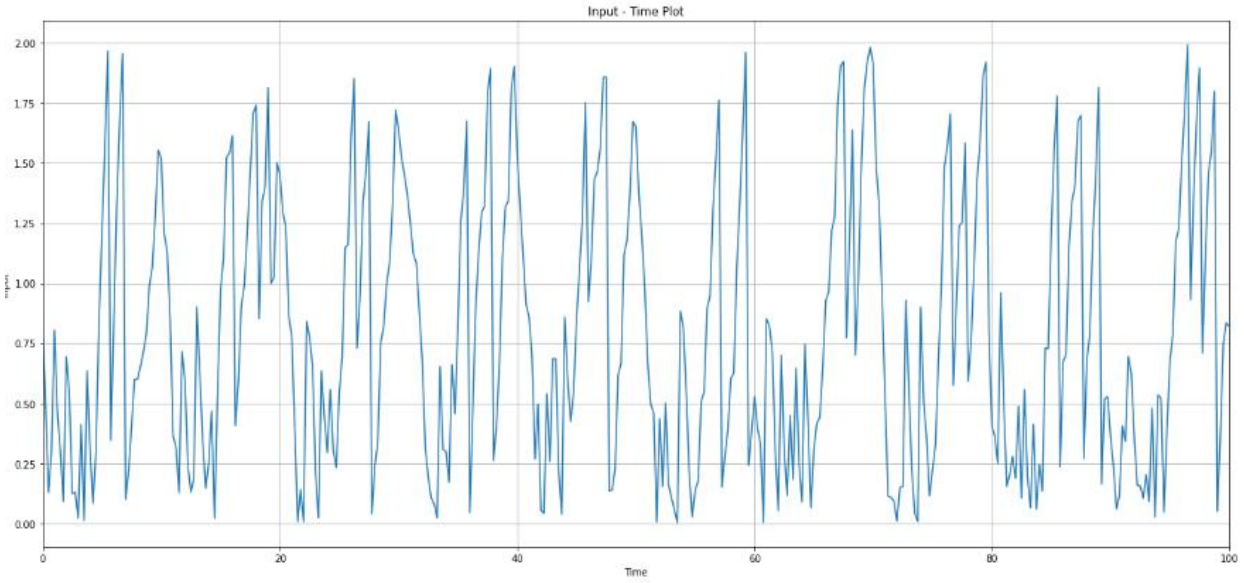
Here, synaptic weights are considered as vector matrices, so that three population types with three types of synaptic weights along with the population between these three types are included. In this section, to improve the output of two populations of typing We have a stimulus with a type of inhibitory population so that the inhibitory population is connected to two stimulatory populations to be as we saw in the neuroscience course and to examine this part more closely, the results of the third experiment are as follows. The following is:

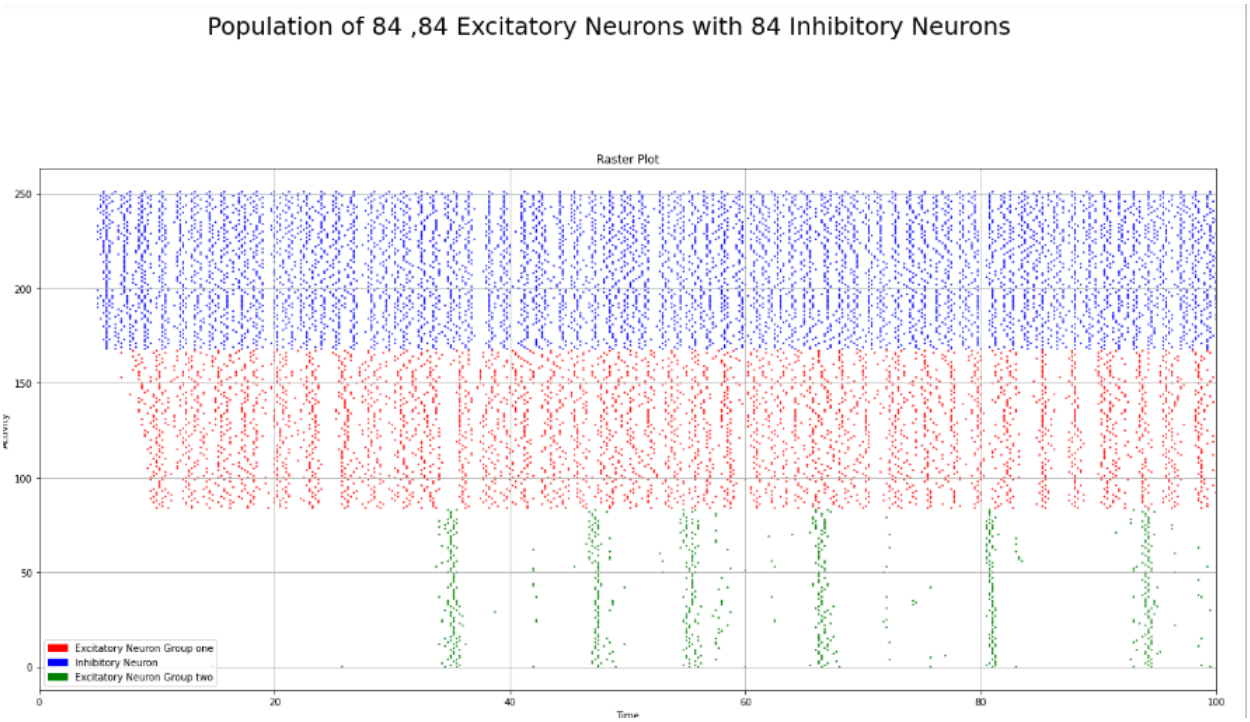
According to the diagrams you see below, we see that the presence of a type of inhibitory population over time will affect the two existing excitation populations and will reduce their firing frequency.

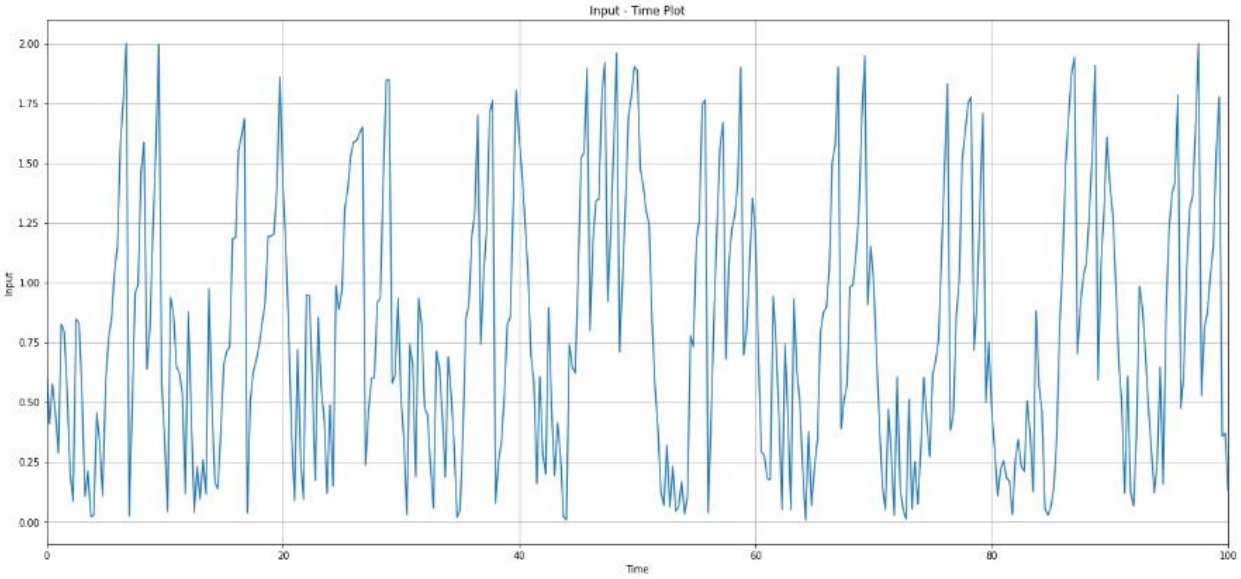
Finally, we see that the red population has won over the green, and we know that if a population wins, it means that its activity has increased and the decision is with that type of population.

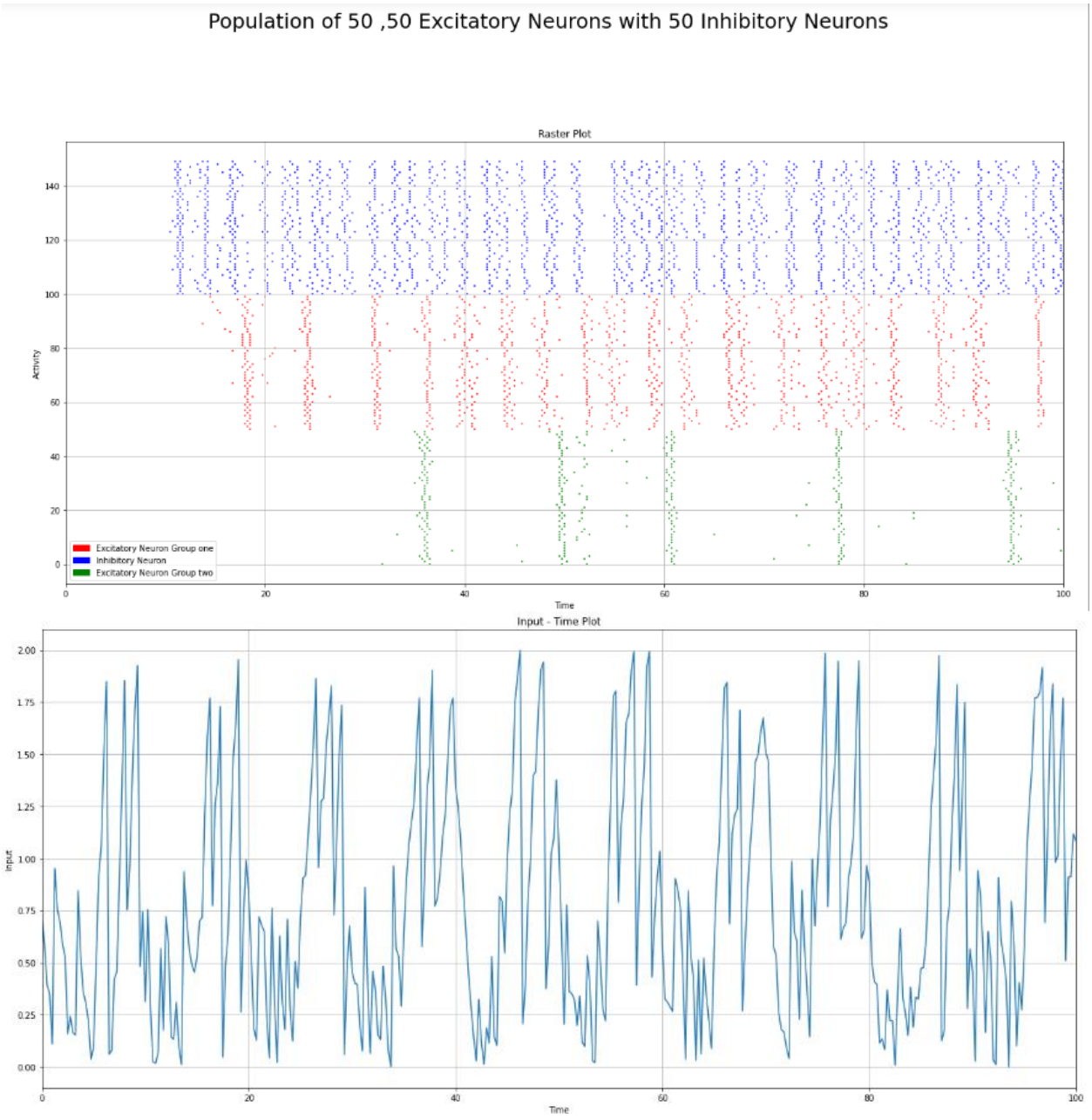
Population of 10 ,10 Excitatory Neurons with 10 Inhibitory Neurons






Population of 84 ,84 Excitatory Neurons with 84 Inhibitory Neurons
Raster Plot
Excitatory Neuron Group one
Inhibitory Neuron
Excitatory Neuron Group two
Time


Input - Time Plot
Input
Time


Population of 50 ,50 Excitatory Neurons with 50 Inhibitory Neurons
Raster Plot
Activity
Time
Excitatory Neuron Group one
Inhibitory Neuron
Excitatory Neuron Group two
Input - Time Plot
Input
Time