Computational Neuroscience Project 2

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LIF MODEL

IN THIS PROJECT WE WILL BE USING THE LIF MODEL FROM THE PREVIOUS PROJECT WITH A FEW ALTERATIONS (ADDING U_RESET AND U_SPIKE) ALSO WE WILL ADJUST THE CODE SO THAT THE TIME LOOP WILL STOP AT EVERY STEP SO WE CAN CALCULATE HOW NEURONS EFFECT EACH OTHER.

NEURONS GROUP

IN THIS CLASS WE HAVE A LIST OF NEURONS AND A LIST OF CONNECTIONS WHICH SHOWS US WHICH PAIR OF NEURONS ARE CONNECTED TO EACH OTHER.

FIRST TEST:

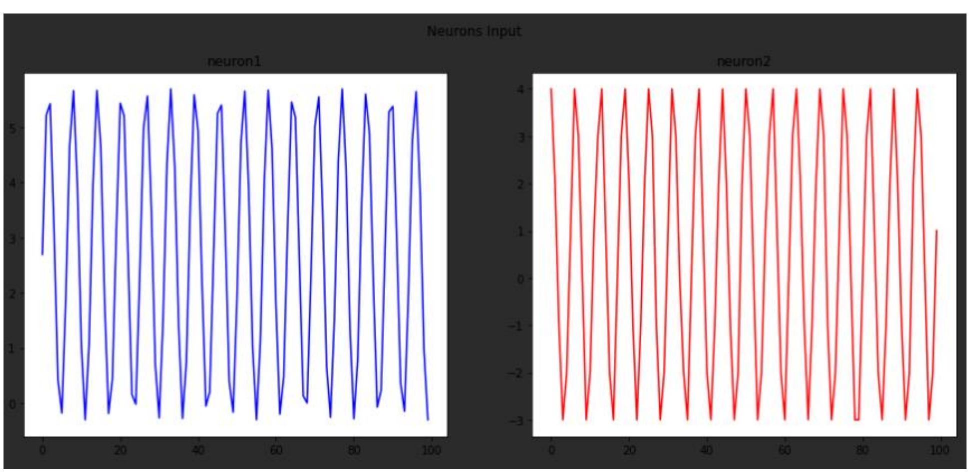
Here our neurons group consists of two neurons with the default values of:

```
u_rest=-70, resistance=10, capacitance=0.8, time=100, dt=0.1, threshold=-45,
u_spike=5, u_reset=-65, u_start=-80
```

where our first and second neuron are affected by the input currents of:

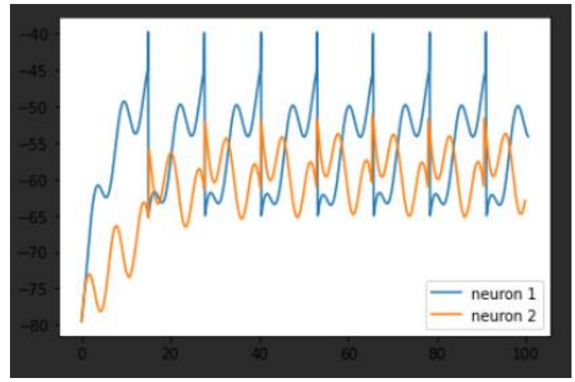
```
I1 = lambda x: 3 * (math.sin(x) + 0.9)
I2 = lambda x: math.ceil(3.5 * math.cos(x))
```

*Note that both our neurons are excitatory.



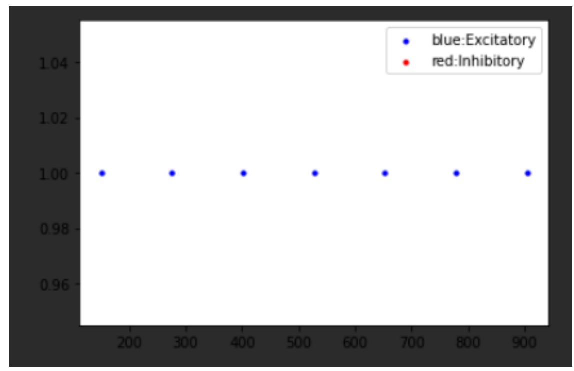
THE ABOVE FIGURE SHOWS THE INPUT CURRENT OF OUR NEURON MODELS.

We run the model and see the u_t plot of both our neurons:



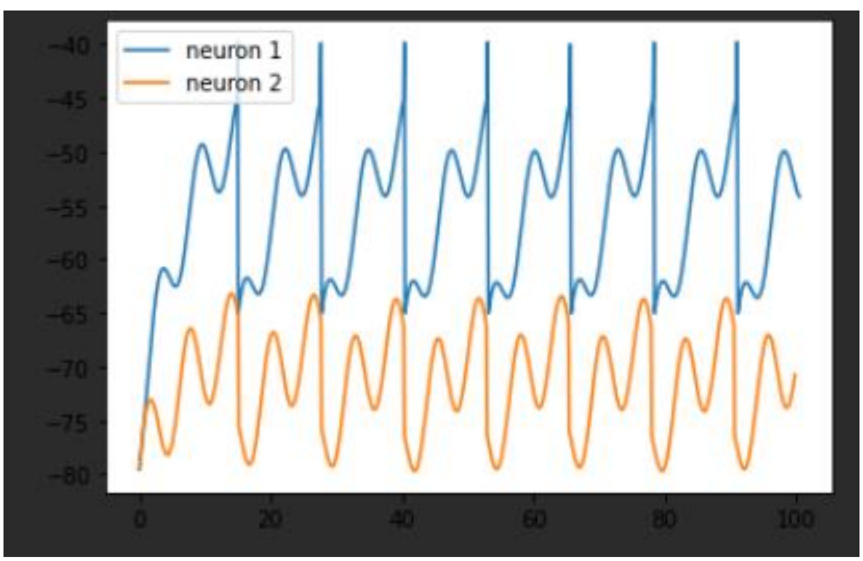
We can easily see how when the first neuron spikes the second neuron is affected by it and has a jump in potential.

since both our neurons are excitatory the scatter plot will only show blue dots since it represents the number of spikes made by excitatory neurons.



By making the first neuron inhibitory we re run the program again to see how it turns out this time.

- Note that the input current hasn't been change



we can easily see whenever the first neuron spikes (the inhibitory neuron) there is a sudden drop in the potential of the second neuron.

SECOND TEST:

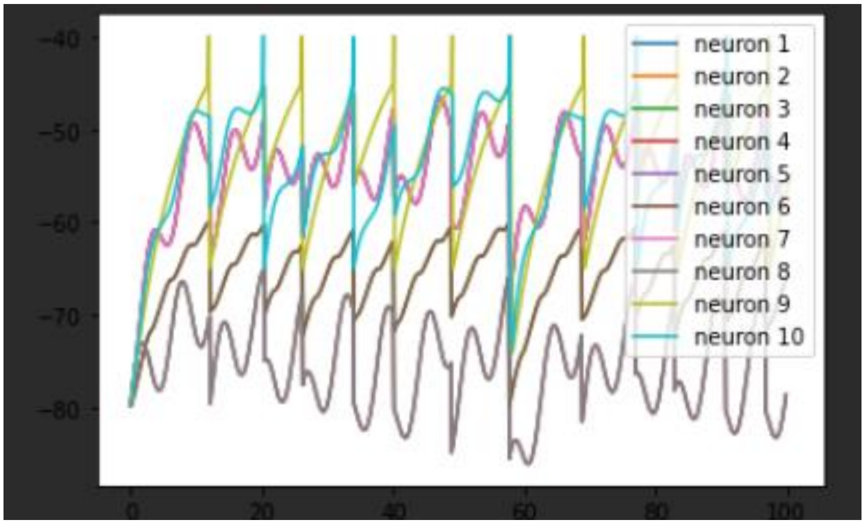
Now we will make a neuron population consist of 10 neurons (8 excitatory, 2 inhibitory) all of which will affect each other.

The input currents for our excitatory neurons are:

```
I0 = lambda x: 2 * (math.sqrt(math.fabs(math.sin(x))))
I1 = lambda x: 3 * (math.sin(x) + 0.9)
I2 = lambda x: math.ceil(3.5 * math.cos(x))
```

And the input currents for the inhibitory neurons will be:

```
I3 = lambda x: 3.5
I4 = lambda x: 3 * math.sqrt(math.pow(math.e, math.sin(x)))
```



as seen in the figure the inhibitory neurons have stronger input currents thus, they will spike more and as we will see in the raster plot, they will stop the excitatory neurons from being effective.

THIRD TEST:

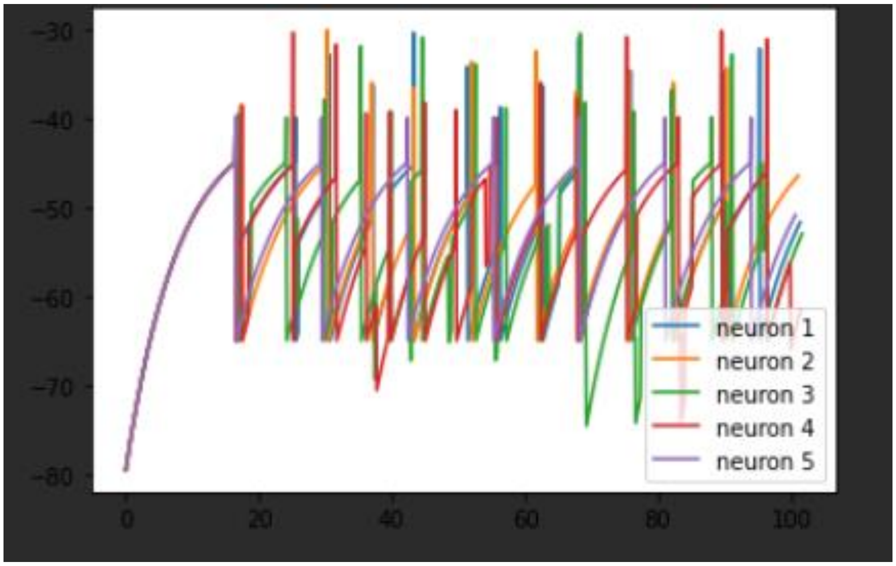
Now we will use a method called:

```
create_neuron_group()
```

to make a random neuron group. The input parameters of the function determine how many neurons will be in our group and how many of them will be excitatory and how many will be inhibitory neurons.

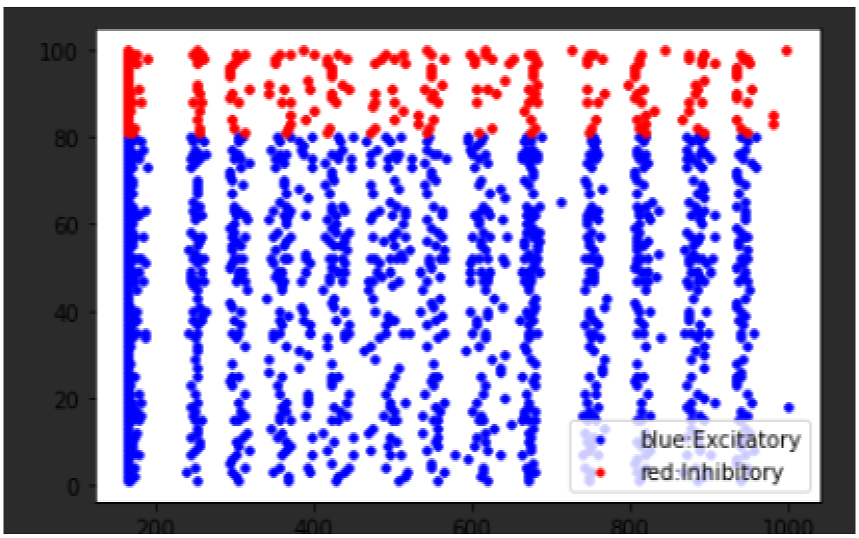
We also will get two parameters for the chance of connection between inhibitory and excitatory neurons and the rest.

The model which we built has 100 neurons 80 of which are excitatory.



this here I five of the 100 neurons if you want to see the rest you could go to the jupyter notebook file in the same repo.

Now let us look at the raster plot of the model.



as it can be seen just like the 80 to 20 ratio of excitatory neurons to inhibitory ones the ratio between the spikes of the excitatory and inhibitory neurons here is roughly 80 to 20.

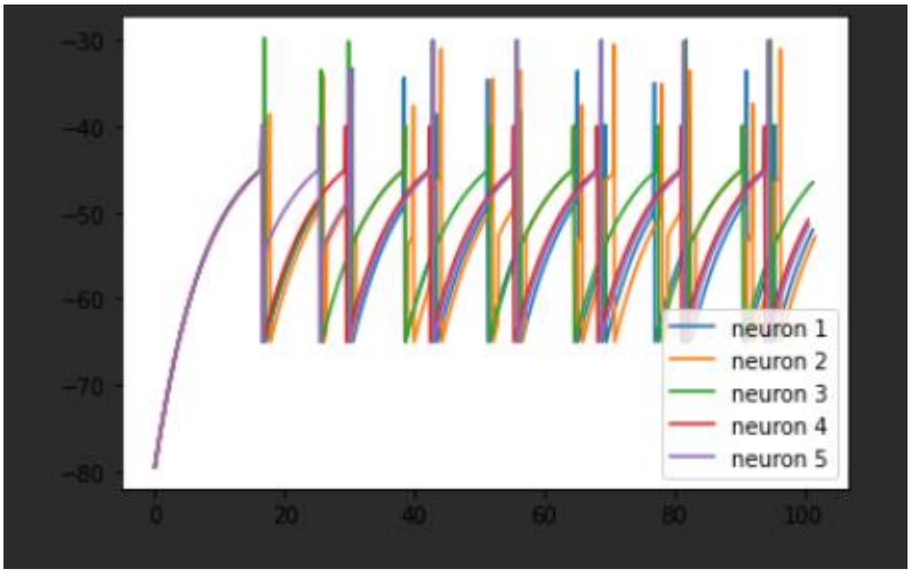
Neurons Groups effect on each other

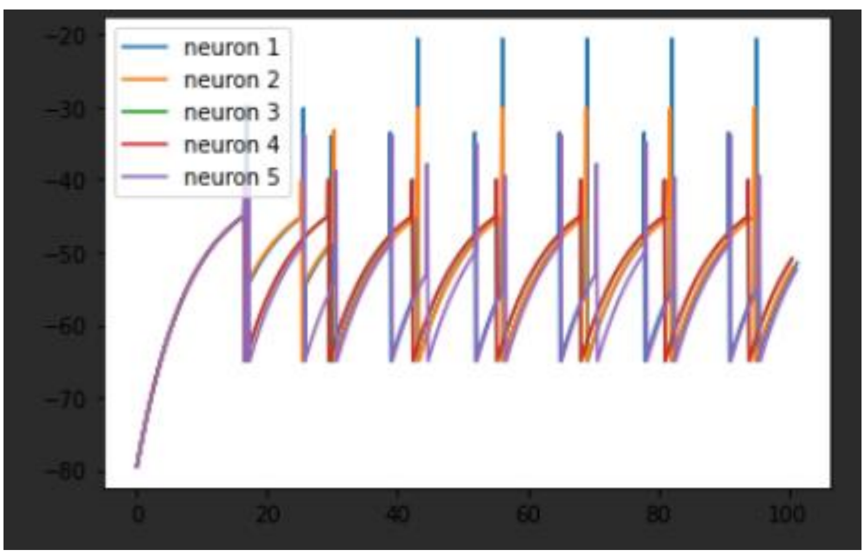
By tweaking the neuron groups a little bit we make it so it can be connected to other neuron groups. And by using python generators we make it so each level is done separately so we can count the change groups will have on each other. Each neuron group will have a spike threshold and if the number of spikes made in each run of the model surpasses the said threshold, we will add to the potential of all neurons in groups which are connected to our neuron group.

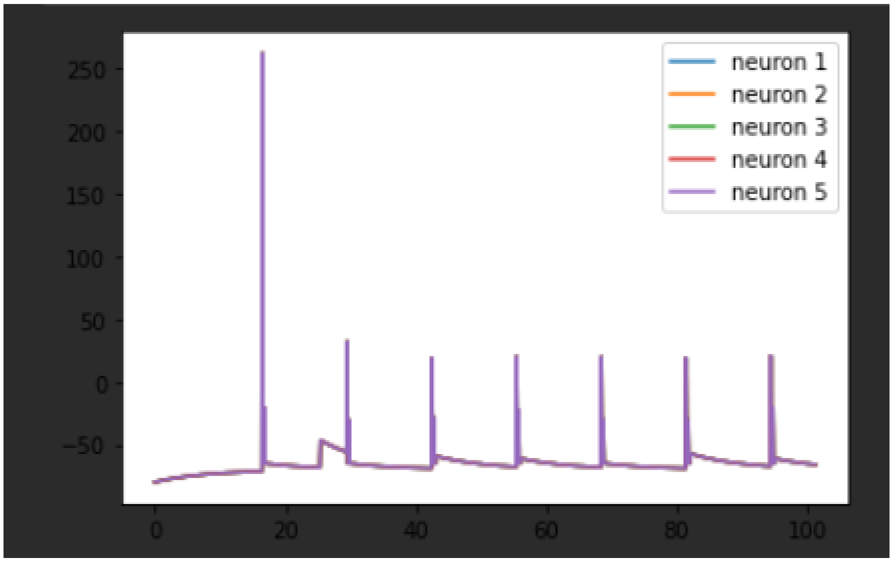
As said in the project doc we will make three neuron groups two entirely consist of excitatory and one consist of inhibitory neurons.

The two excitatory neuron groups will have a constant input current of 3 amperes and the inhibitory neurons will be connected to 0 amperes of input current.

The spike threshold for the groups will be set to 18 and the amount by which the connected neurons will be increased will be 2 amperes.

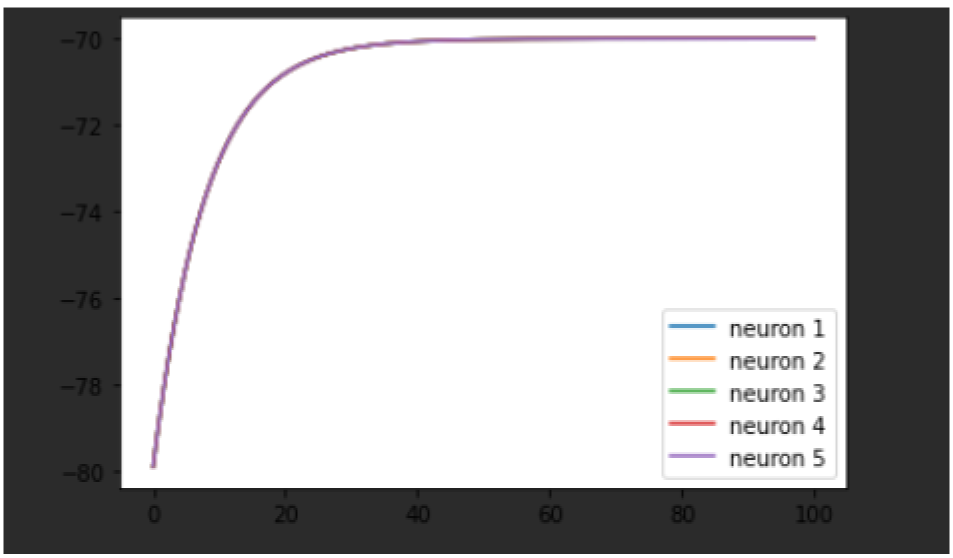






As it can be interpreted the first two figures belong to the excitatory neurons and the last belong to the inhibitory neurons group.

Now if the first and second neuron groups (the excitatory ones) weren't connected to our inhibitory neurons group the u_t plot of the population would be something like this:



So, it's obvious that the excitatory groups have affected on the inhibitory one and vice versa.