Week 1:Cells, synapses and connections

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Abstract

In the first report I created cells from templates, performed current clamp and connected cells with synapses.

1 Creating cells

The code for the original model("A 1000 cell network model of Lateral Amygdala" (Kim et al, 2013), acquired from ModelDb) contains a template for three types of principal cells(A,B,C) and one type of interneuron. We first create two type A principal cells and an inhibitory cell.

```
load_file("nrngui.hoc")
load_file("LAcells_template.hoc")
load_file("interneuron_template.hoc")

number_of_cells=2
objectvar cell_exc[number_of_cells], cell_inh

for i = 0, number_of_cells-1 {
    cell_exc[i] = new Cell_A()
}

cell_inh = new InterneuronCell()
```

2 Current injection

We next inject current into a principal cell and inhibitory neuron, plot the voltage response and compare it with Figure 1 in the paper associated with the model, "Mechanisms contributing to the induction and storage of Pavlovian fear memories in the lateral amygdala", Kim et al, 2013, Learning and Memory.

```
objectvar stim
cell_exc[0].soma stim = new IClamp(0.5)
cell_inh.soma stim = new IClamp(0.5)

stim.del = 100
stim.dur = 200
stim.amp = 0.4 //0.3 //-0.1
```

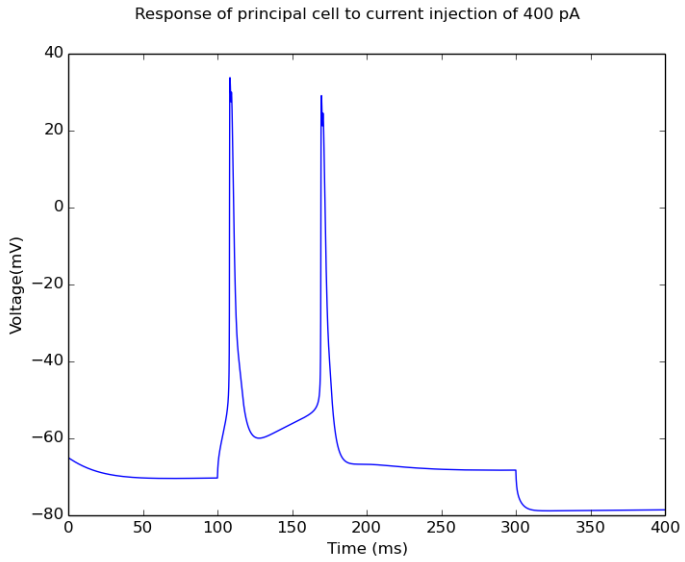

Figure 1: Principal cell, 400 pA

```
tstop = 400
```

stim.amp is in nanoamperes. We give the voltage plots in the soma for the current injections of 400 picoamperes, 300 picoamperes and -100 picoamperes as was done in the paper. The plots are identical to the figure in the paper.

3 Connecting the cells

Connecting two cells is done via the NetCon class. In this example we create a pyramidal-to-pyramidal synapse onto the first cell and use the synapse in a NetCon object to use spikes from the second cell. The thrid argument of NetCon class is the threshold, the fourth is the delay and the fifth is the weight of the synapse.

```
objref syn, nc
cell_exc[0].dend syn = new pyrD2pyrD_STFD(0.9)

cell_exc[1].soma nc = new NetCon(&v(1), syn, 0, 2, 1)
```

We stimulate the second cell with 400 pA. The results are plotted in Figure 7, showing a slight depolarization of the membrane of the post-synaptic cell.

4 Bringing the cell to threshold through identical synaptic inputs

We next ask how many simultaneous synaptic events are needed to bring the post-synaptic pyramidal cell to threshold. We create 5, 10 and 100 pre-synaptic

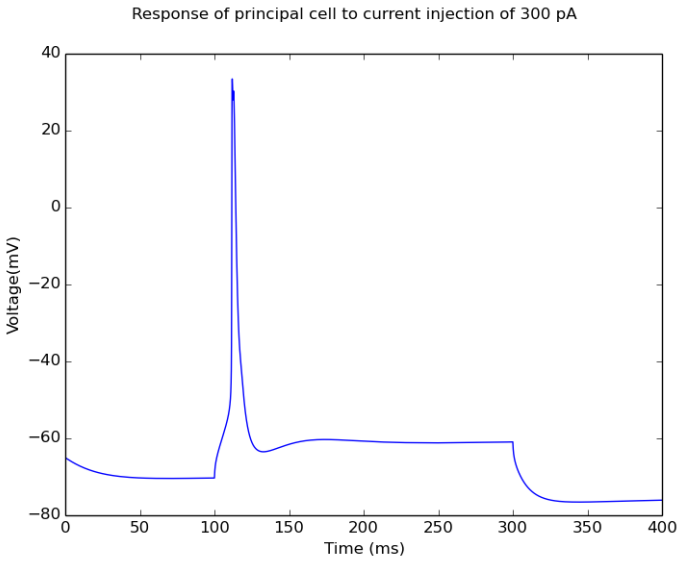

Figure 2: Principal cell, 300 pA

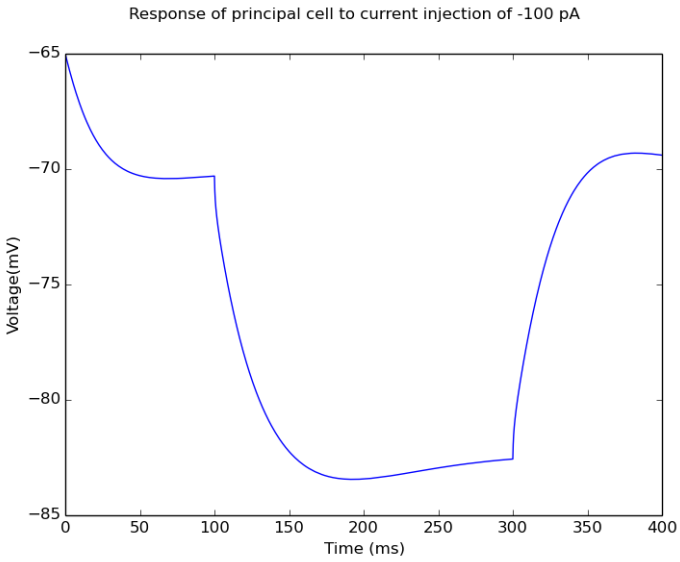

Figure 3: Principal cell, -100 pA

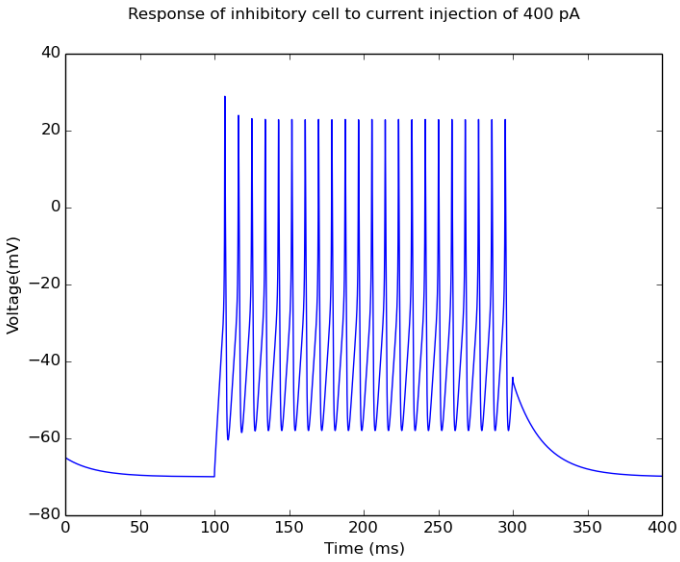

Figure 4: Inhibitory cell, 400 pA

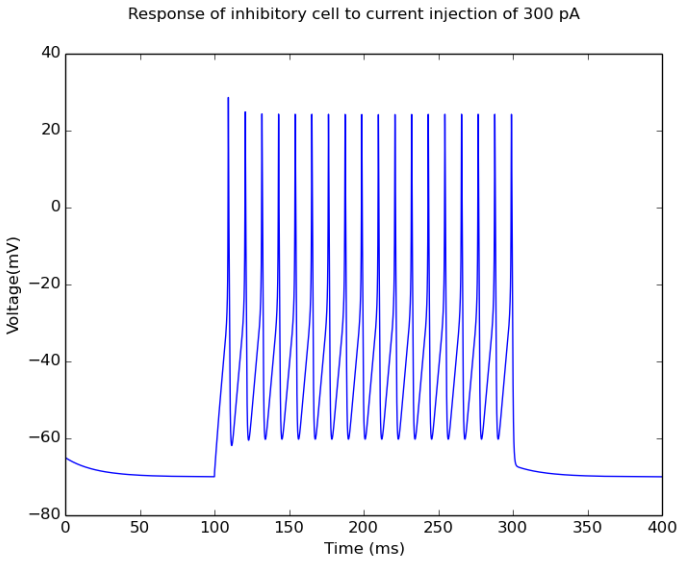

Figure 5: Inhibitory cell, 300 pA

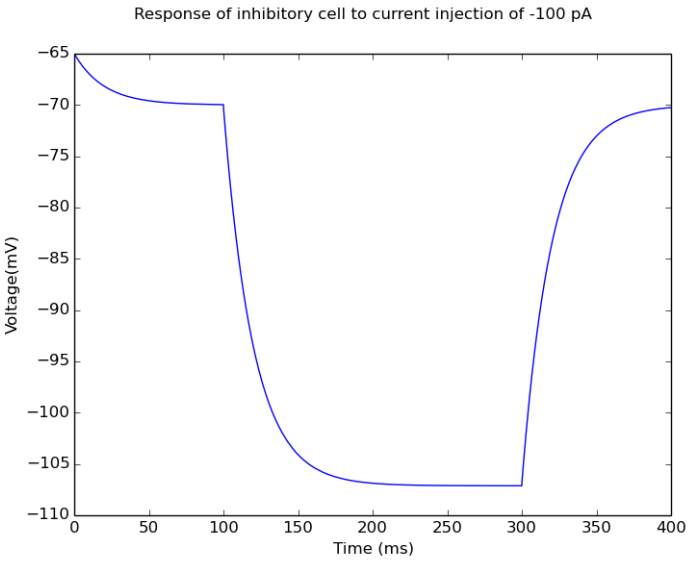

Figure 6: Inhibitory cell, -100 pA

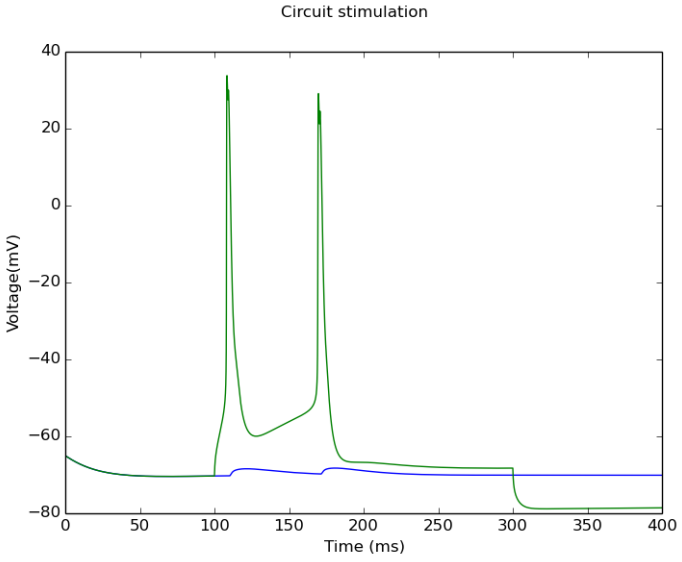

Figure 7: Circuit simulation, green cell stimulated with 400 pA

cells and stimulate them with 400 pA and observe the post-synaptic effects (Figures 8,9 and 10).

```
number_of_cells=6 //11 //101
objectvar cell_exc[number_of_cells], cell_inh

for i = 0, number_of_cells-1 {
    cell_exc[i] = new Cell_A()
}

objref syn[number_of_cells-1], nc[number_of_cells-1]

for i=0, number_of_cells-2{
cell_exc[0].dend syn[i] = new pyrD2pyrD_STFD(0.9)
}

for i=1, number_of_cells-1 {
cell_exc[i].soma nc[i-1]=new NetCon(&cell_exc[i].soma.v(1), syn[i-1], 0, 2, 1)
}

objectvar stim[number_of_cells-1]
for i=1, number_of_cells-1{
cell_exc[i].soma stim[i-1] = new IClamp(0.5)

stim[i-1].del = 100
stim[i-1].dur = 200
stim[i-1].amp = 0.4
}
tstop = 400
```

5 Summary

In this week's report I learned how to create cells from templates, inject current and connect the cells together with synapses.

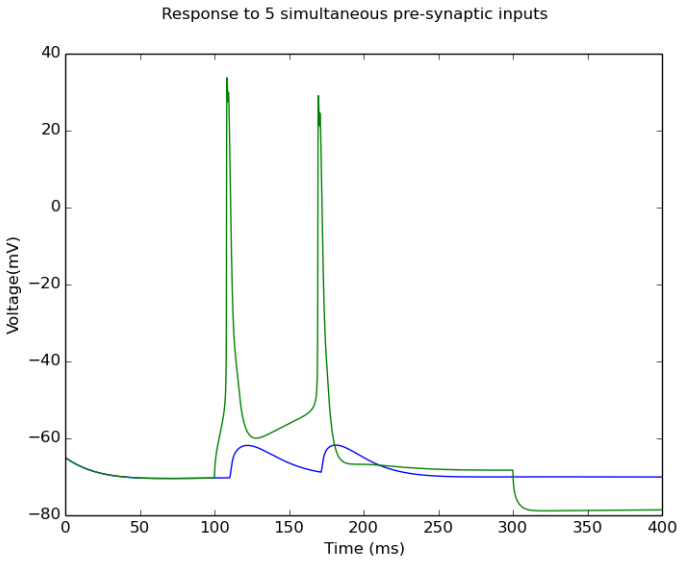

Figure 8: Response to 5 identical pre-synaptic inputs

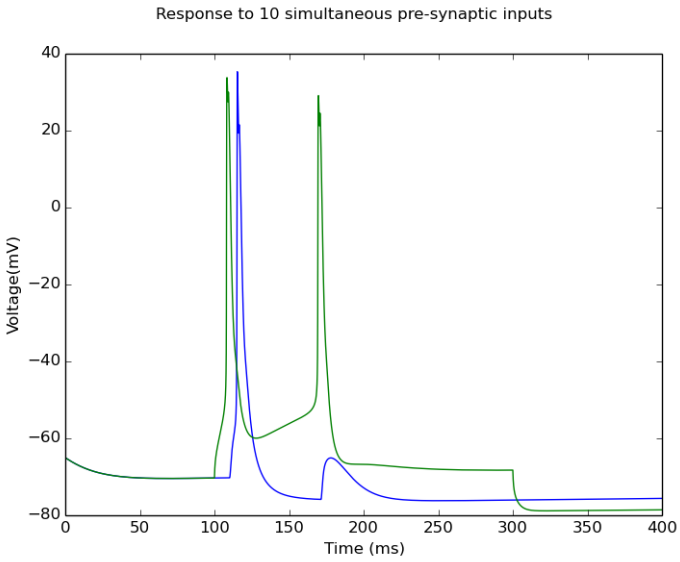

Figure 9: Response to 10 identical pre-synaptic inputs

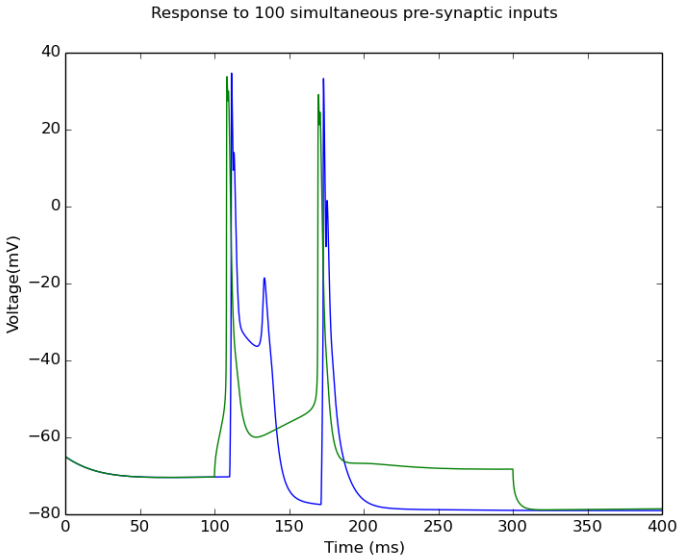

Figure 10: Response to 100 identical pre-synaptic inputs