

Practical 3: Interaction of inputs on a dendrite

Neural Computation 2003-2004
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1 Introduction & Implementation

In this exercise we study synaptic inputs in a simple passive neuron model with a soma and two dendrites.

Create a cell with a realistic sized soma and two dendrites of 500μ length and 1μ diameter. You can do this as follows: `create dend[2], dend[0] L=500, dend[1] L=500`, etc.; use a value for `nseg` of about 50. All compartments should be passive. Careful with this bug:

```
connect dend[0](0),soma(0)
connect dend[1](0),soma(0)
// next gives error
//connect soma(0),dend[0](0)
//connect soma(1),dend[1](0)
```

After creating the cell, supply synaptic input. This goes with three steps in Neuron:

1. Create a source of input spikes. In general, this can be another neuron, but here we take an artificial spike generator, called a NetStim

```
objref Espikesource // our label for excitatory source
dend[0] Espikesource = new NetStim(0.5) // arbitrary location
Espikesource.interval = 10 // inter-spike interval of the input (in ms)
Espikesource.number = 100
Espikesource.start = 10
Espikesource.noise = 0.0 // =0 periodic input, =1 Poisson
```

2. Next, we have to create a synapse on the neuron.

```
objref Esynapse
dend[0] Esynapse = new ExpSyn(0.5) // the location of synapse on the dendrite

Esynapse.tau = 3 // synaptic time constant (ms)
Esynapse.e = 0 // synaptic reversal potential (mV)
The location parameter, which is 0.5 here, is important and determines the location of the synapse. Its value should be between 0 and 1.
```

3. Finally, the NetStim input should be connected to the synapse. This connection is yet another object. It contains the strength or weight of the connection. Here we model the synaptic conductance as single exponential function of time.

```
objref Econn
thresh = 10 // not important when connection is from NetStim
```

```

delay = 0.0
Eweight = 0.1 // connection strength in  $\mu$ S
Econn = new NetCon(Espikesource, Esynapse, thresh, delay, Eweight)

```

The properties of the input can be changed by command line statements such as:

```
Esynapse.tau = 100, Econn.weight = 1.
```

In this way create a model of the cell in a .hoc file with one excitatory and one inhibitory input. Make the two synapses identical, except for the reversal potential, which should be -70mV for the inhibitory synapse. Place the excitatory synapse in the middle of dendrite 'dend[0]'.

2 Single input

First, we study the effect one single excitatory synapse. First, set the inhibitory weight to zero, so that we can study the excitatory input in isolation. Make plot windows of the voltage at different locations in the cell. A space plot will also be helpful to see what is going on.

- Plot the voltage change in soma as a function of the synaptic weight. Why does it saturate? The voltage change due to the excitatory input is also known as an EPSP (excitatory post-synaptic potential).
- Inspect the amplitude of the EPSP at both ends of the dendrite which contains the synapse. Explain the difference and check your explanations by changing the model.
- How fast does the voltage at both ends of the dendrite reach its maximum? Measure the times to reach maximal voltage. In order to compare your results with the expression given in the lecture notes, we need a very brief pulse, this can be achieved by setting a very short synaptic time constant. Measure the latency again and compare to the expression in the lecture notes. Why is there a difference? Make sure to set the synaptic time constant back to 3ms.

3 Interaction with inhibitory input

Next, we study the interaction between inhibition and excitation, and research how effective the inhibition is in reducing the EPSP. The excitatory synapse remains fixed, but move the inhibitory one around. The command to use is 'loc', syntax:

```
dend[0] Isynapse.loc(x)
```

This moves the synapse to location x of the dendrite 'dend[0]'. Alternatively, you can use Tools-> PointProcesses-> Manager-> PointGroup. And then, ShowAll-> ExpSyn to view and move the synapse.

- Measure the EPSP amplitude while inhibition is active as a function of the location of the inhibitory synapse. Also move the inhibitory input to the soma and various locations on the other dendrite. Plot the EPSP amplitude as a function of the location of the inhibitory synapse. What is the most effective location of the inhibitory synapse. Explain your result.
- Change the inhibitory reversal potential to -140mV and repeat the same analysis as above. Change the inhibitory weight if necessary.
- Indicate how your findings can be used to do computations.