NEURON
for empirically-based simulations of neurons and networks of neurons

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- What is NEURON
- How to use NEURON
- 99 bottles of beer
- Comparison of NEURON to conventional programming languages

What is NEURON?

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NEURON is not a programming language.

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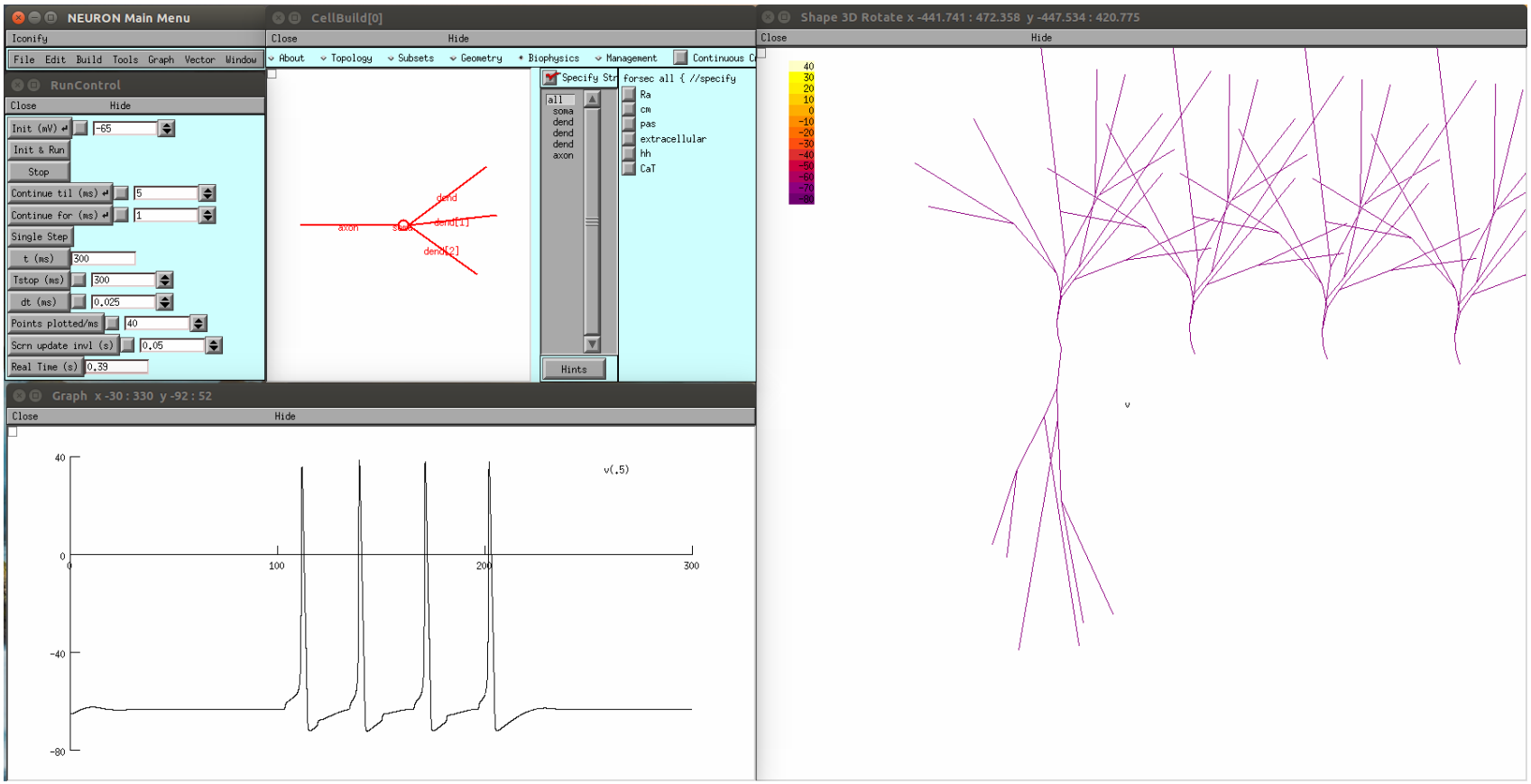
NEURON is an environment for modeling and simulating neurons, networks of neurons and their behaviour under specified circumstances.
Primarly developed by Michael Hines, John W. Moore and Ted Carnevale at Yale and Duke in the 1990s.

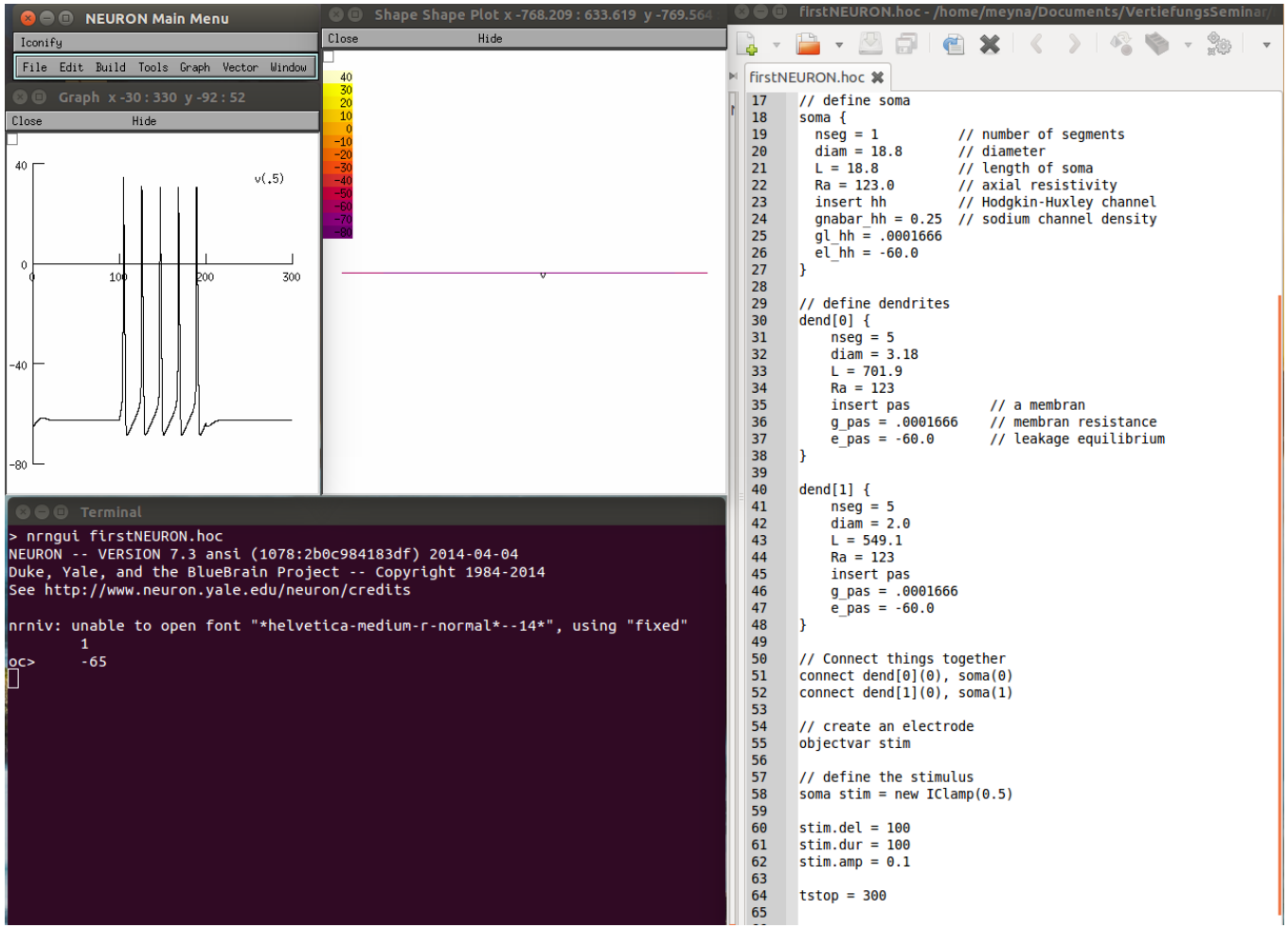
What is NEURON?

Graphical user interface to build cells, neurons, networks, or generate simulations of interacting neurons



What is NEURON?

Also programmable with different languages like C++, Java, Python or Hoc



What is NEURON?

The community behind NEURON is quite well organized, they have:

- good tutorials for beginners and advanced users
- forum with numerous topics and still active users
- database with over 1000 models and simulations
- a book called "The NEURON Book", by Nicholas T. Carnevale and Michael L. Hines
- online documentation

How to use NEURON

How to use NEURON

Before we start using NEURON, we need to know what a neuron is, what components a neuron has and how they are working.

What is a neuron and how does NEURON represent a neuron?

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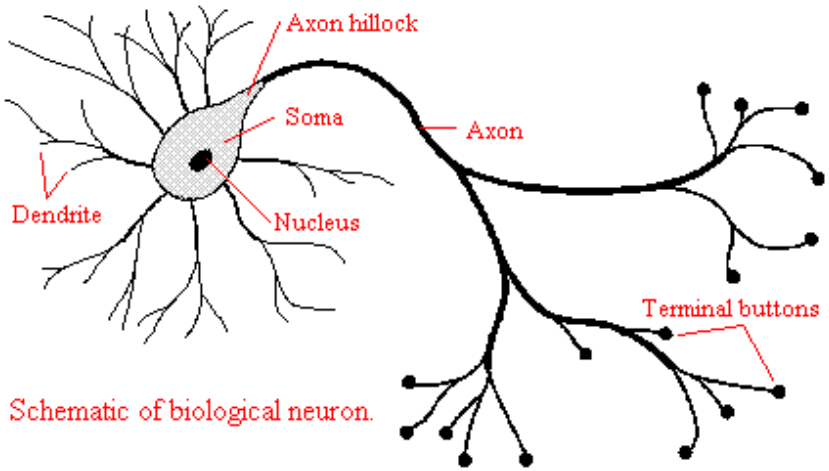
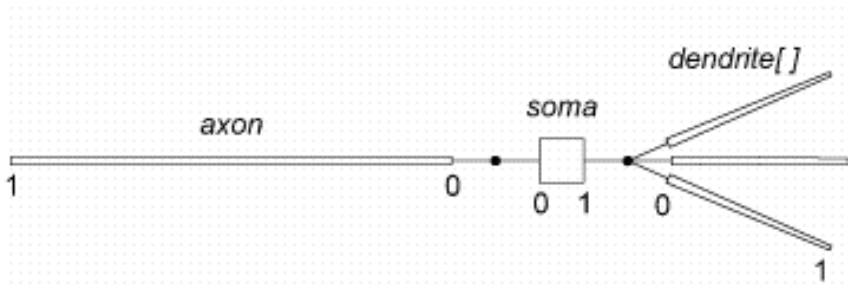
Neuron biological representation



NEURON representation



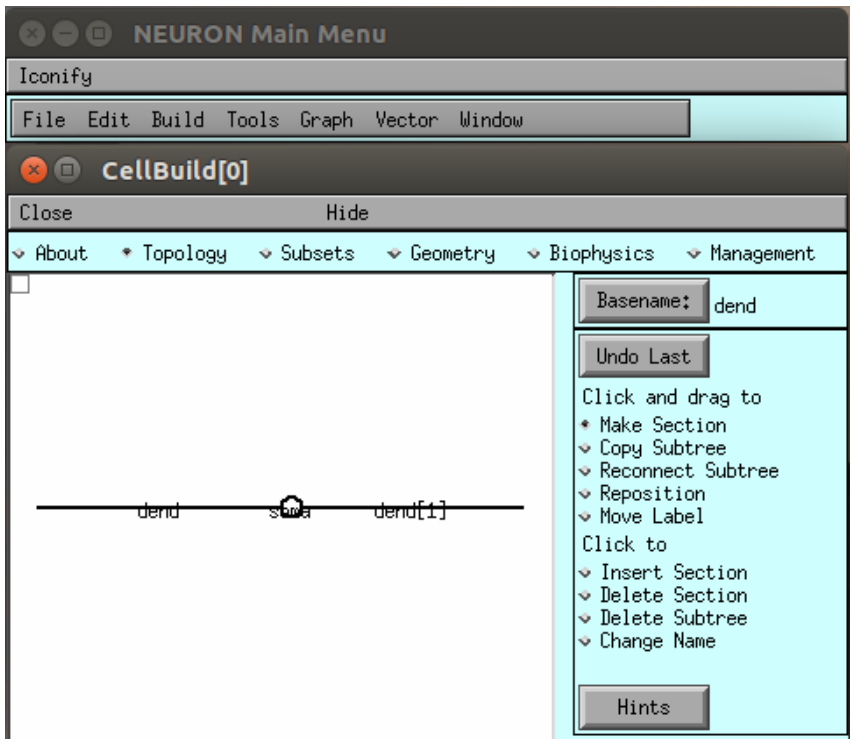
soma . . . the cell body without its extensions

dendrite . . . the cell extensions which are responsible for absorption of a stimulus

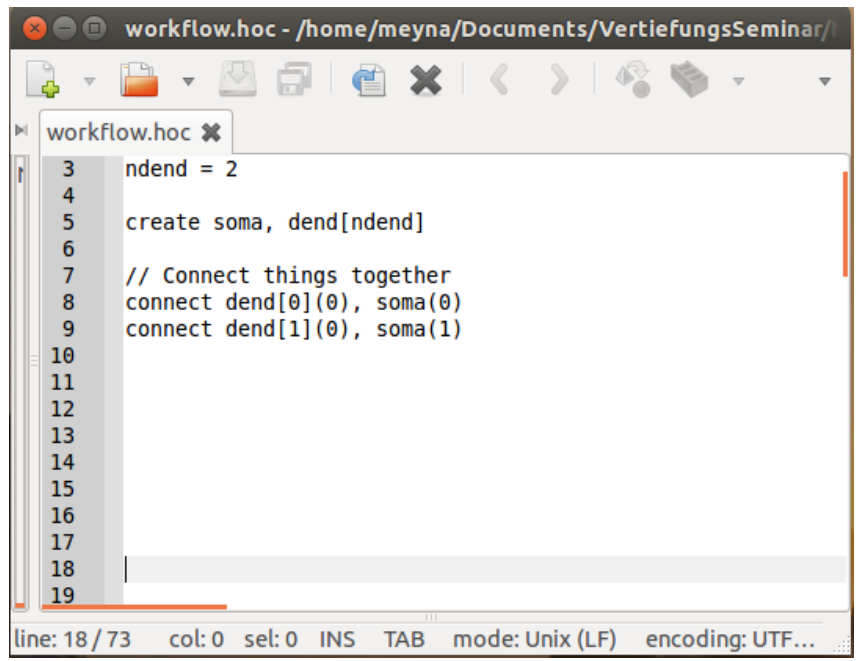
axon . . . a single neuron extension which is responsible for forwarding a nerve impulse away from its soma (optional)

Workflow of NEURON

Create a neuron with a soma and two dendrites:



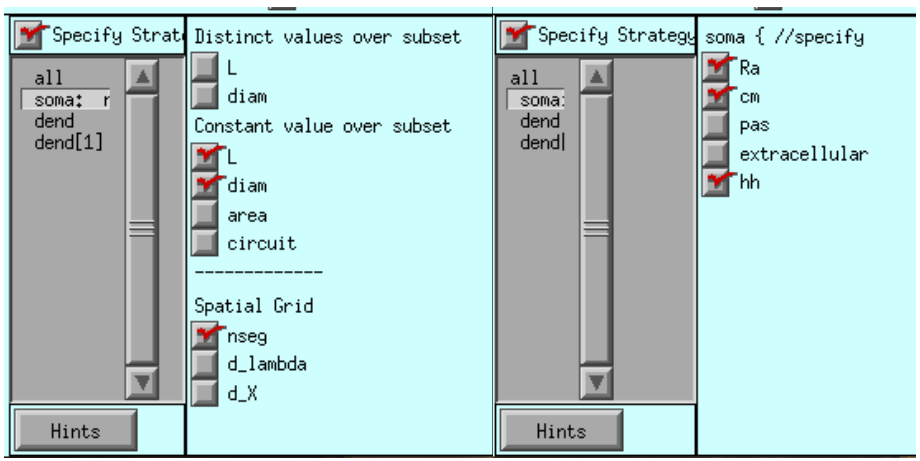
Click and drag.



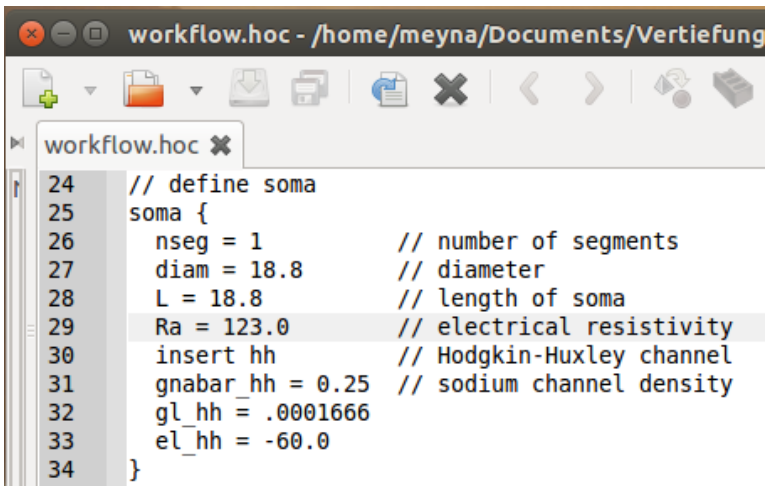
The programming way.

Workflow of NEURON

Define geometry and biophysics of the soma:



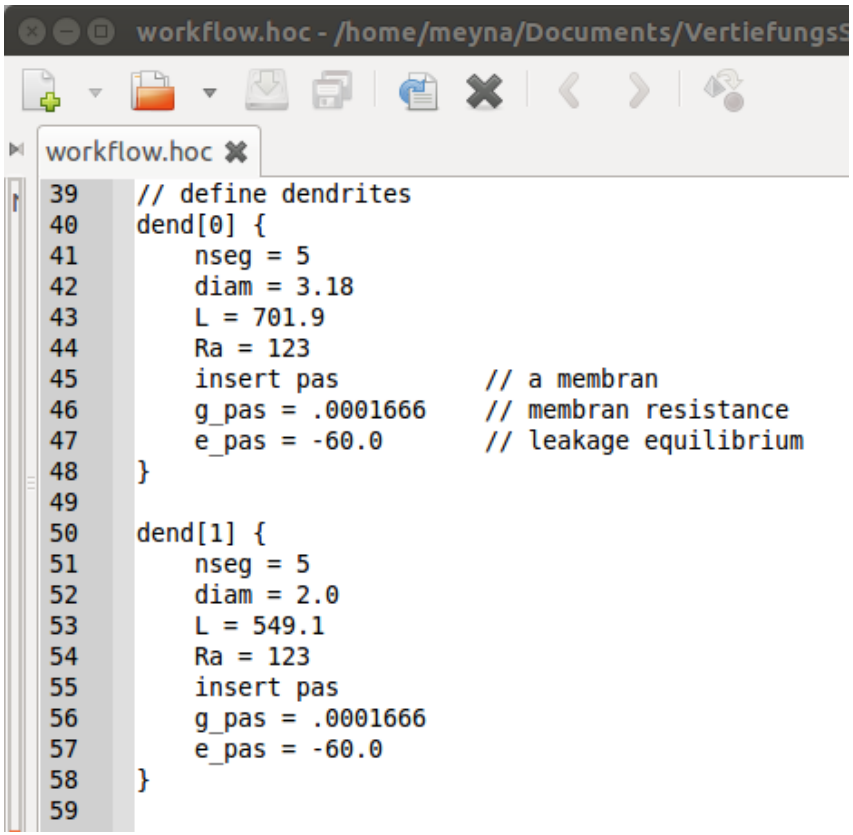
Click parameters.

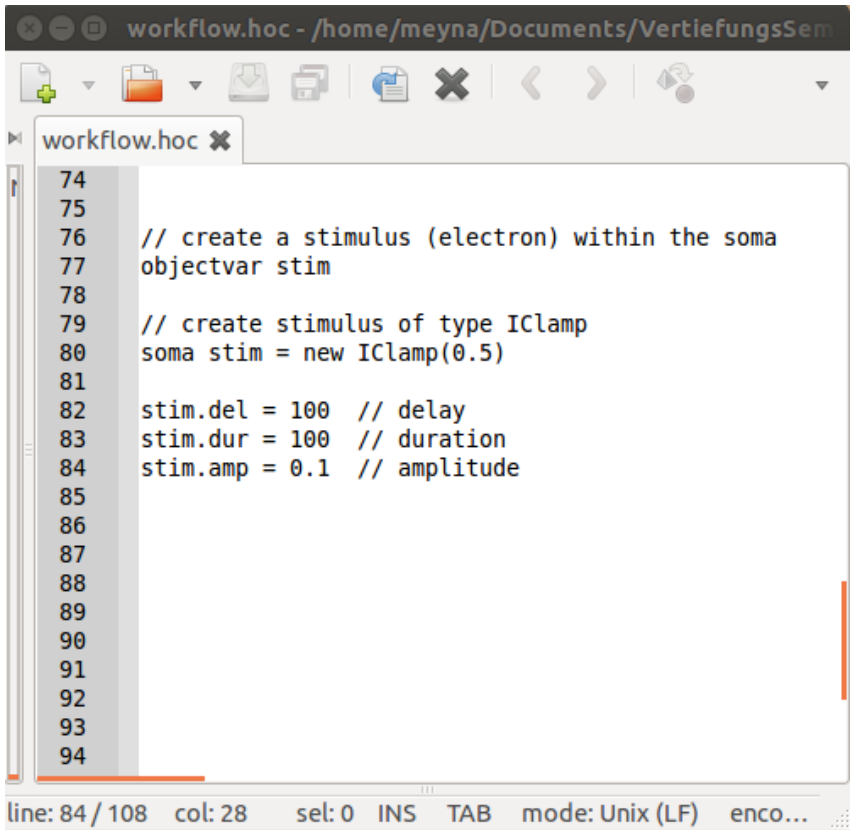


The programming way.

Workflow of NEURON

Define dendrites and create a stimulus (electron):

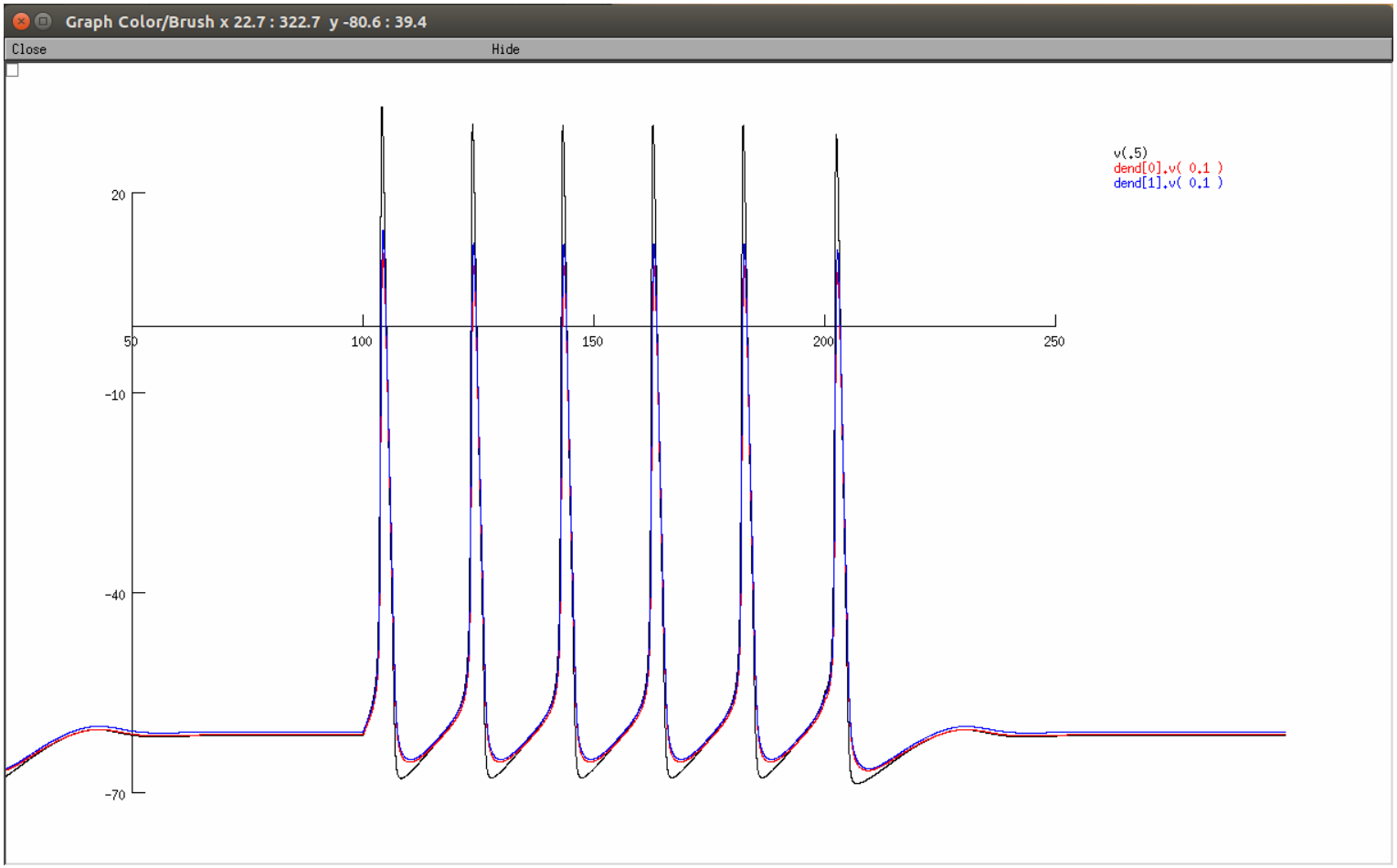




The stimulus of the type IClamp is emitting some electric impulse, which the dendrites will detect and forward it to the soma.
In general a stimulus comes from another neuron.
(Here in a simulation of a single neuron, it is just present)

Workflow of NEURON

The result of the simulation:



Workflow of NEURON

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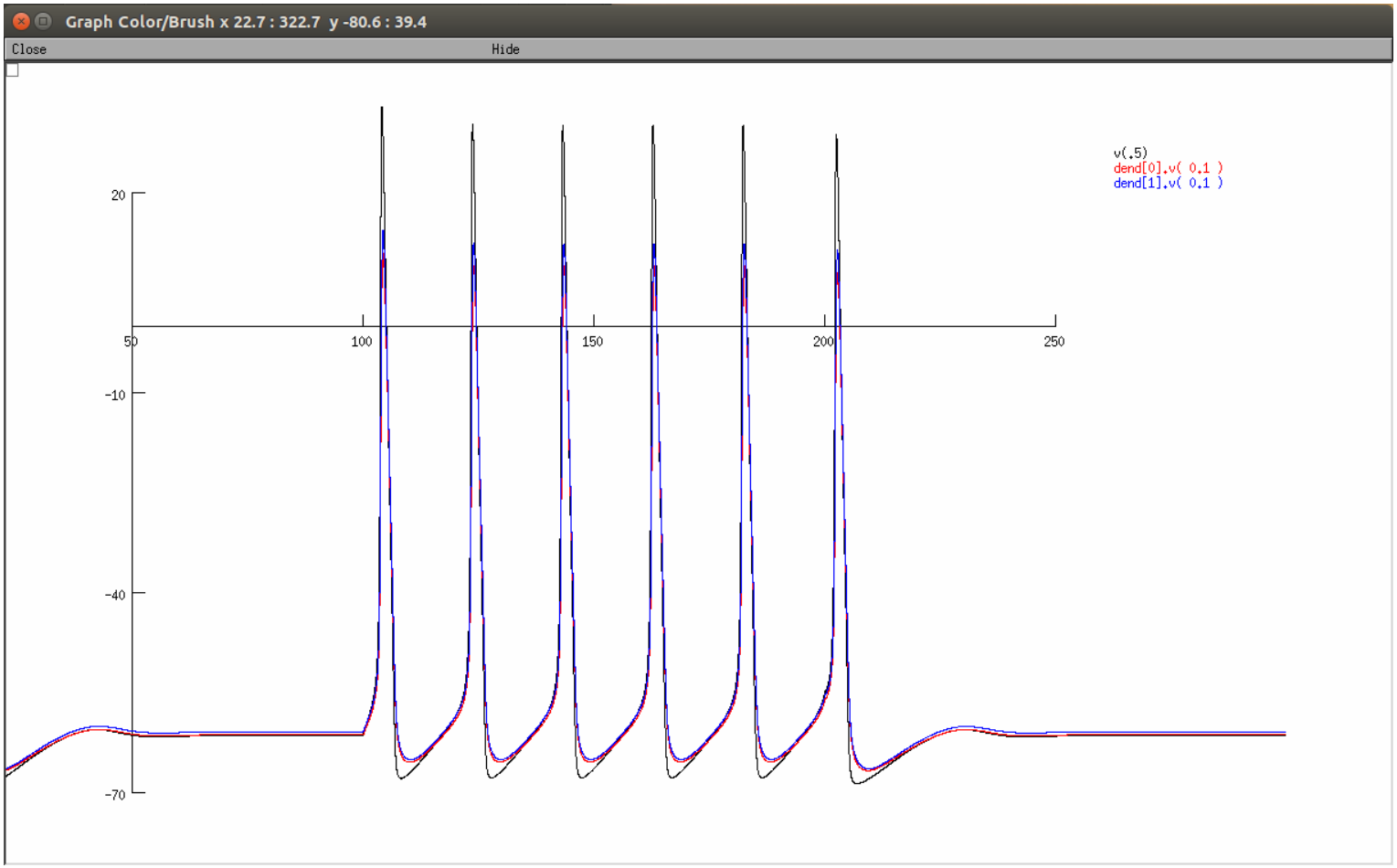

What is happening here?

Simulation explanation

We have modeled and simulated a subthalamic nucleus neuron.

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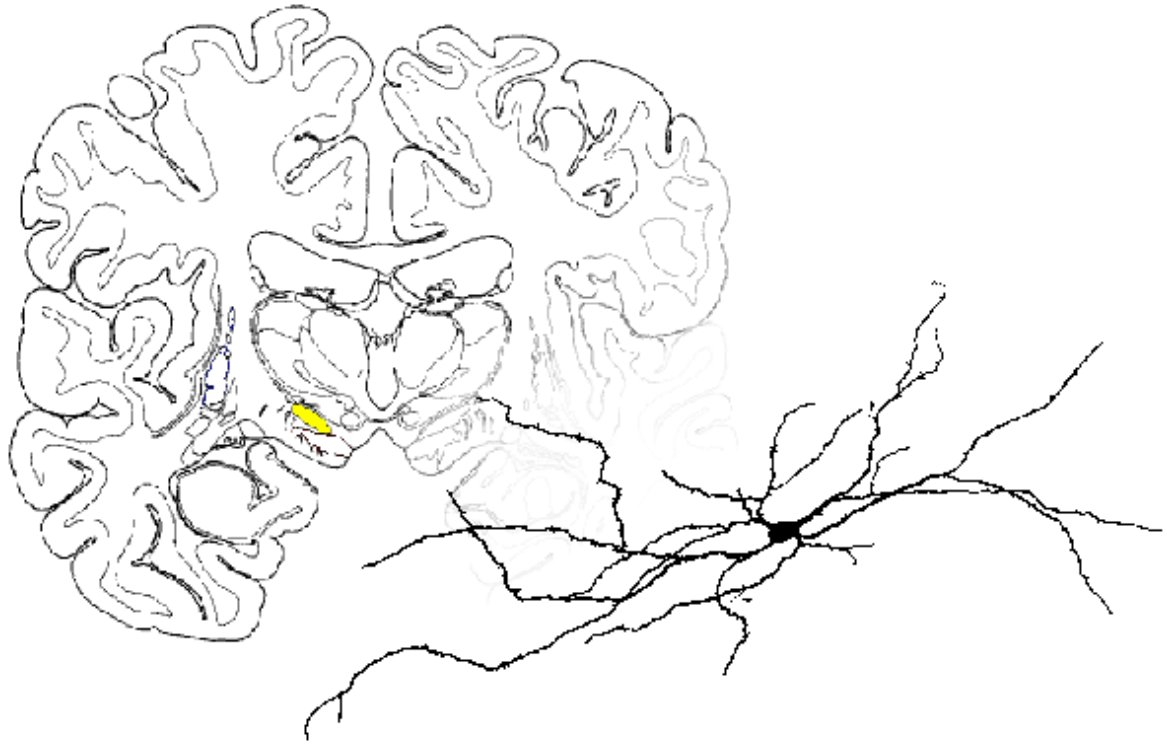
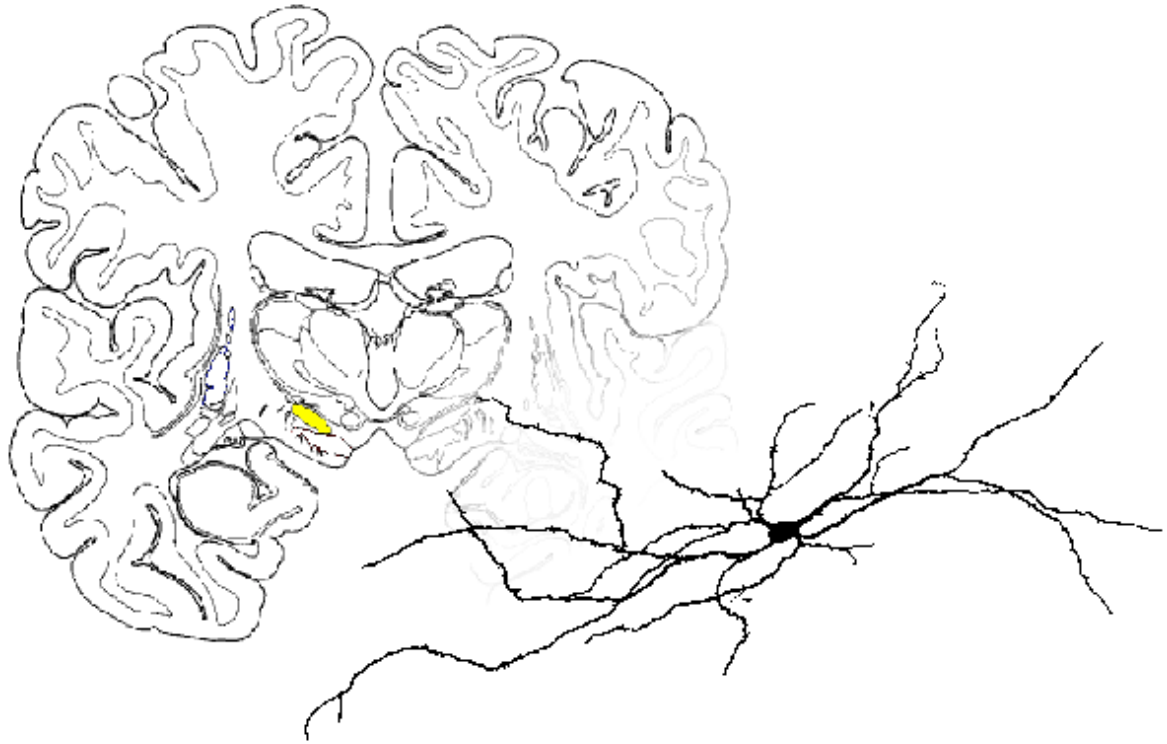


Simulation explanation

We have modeled and simulated a subthalamic nucleus neuron.



This kind of neurons are components of a control system inside the subthalamus and are responsible for holding muscular response in check.

If these neurons are damaged, the result would be movement disorder.

Who uses NEURON and its possibilities

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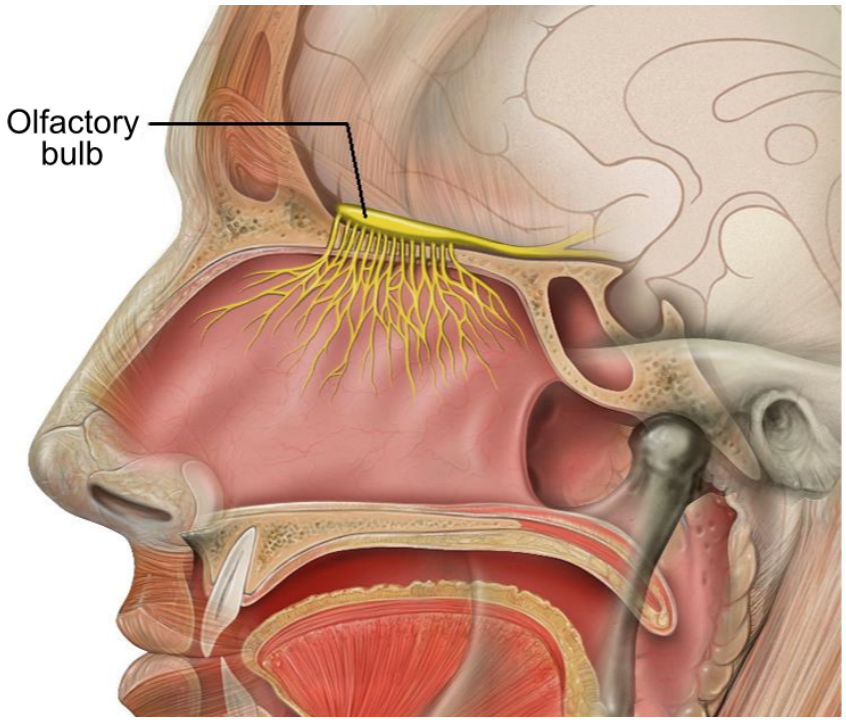
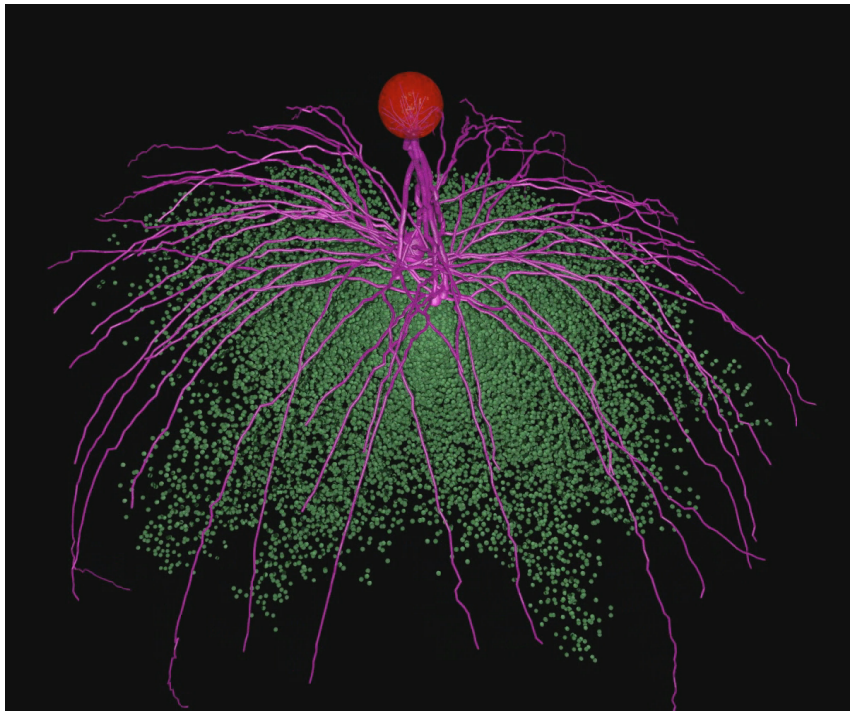
M Migliore, F Cavarretta, ML Hines, and GM Shepherd
from the Department of Neurobiology, School of Medicine, Yale University USA and Institute of Biophysics, National Research Council, Palermo, Italy.

"Distributed organization of a brain microcircuit analysed by three-dimensional modeling: the olfactory bulb"
Published online in 2014 on Apr 29th at Frontiers in Computational Neuroscience 2014; 8: 50.

Who uses NEURON and its possibilities



neural structur with
extensions to the nasal cavity



model representation of it

99 bottles of beer

How to generate the lyrics of the song 99 bottles of beer?

99 bottles of beer

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With Hoc to console?

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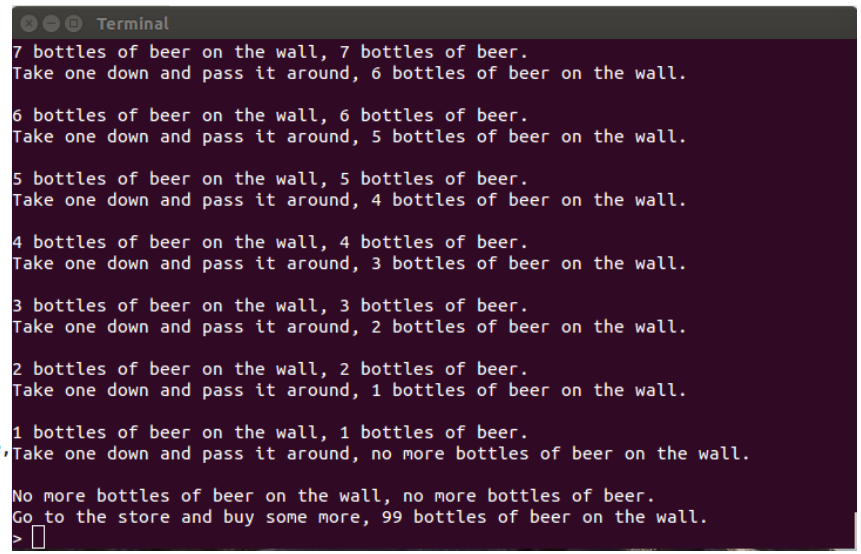
With Hoc to console?

```
1   nrOfBottles = 99
2
3   for (i=nrOfBottles; i>=0; i=i-1) {
4       if ( i > 1) {
5           printf("%d bottles of beer on the wall, %d bottles of beer.\n
6               Take one down and pass it around,
7                   %d bottles of beer on the wall.\n\n", i, i, i-1)
8       } else if (i == 1 ){
9           printf("%d bottles of beer on the wall, %d bottles of beer.\n
10              Take one down and pass it around,
11                  no more bottles of beer on the wall.\n\n", i, i)
12      } else {
13          printf("No more bottles of beer on the wall,
14              no more bottles of beer.\nGo to the store and buy some more,
15                  %d bottles of beer on the wall.\n",nrOfBottles)
16      }
17  }
18
```



99 bottles of beer

With a network of neurons, where the neurons are organized such that they will graphically represent the lyrics?

99 bottles of beer

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Possible solution and problems:

1. Use a neuron per letter / word / line / strophe
   - Tons of neurons to build
   - Shape neurons to letters by using dendrites
   - Connecting all these neurons e.g. from axons of neurons to dendrites of other neurons

99 bottles of beer

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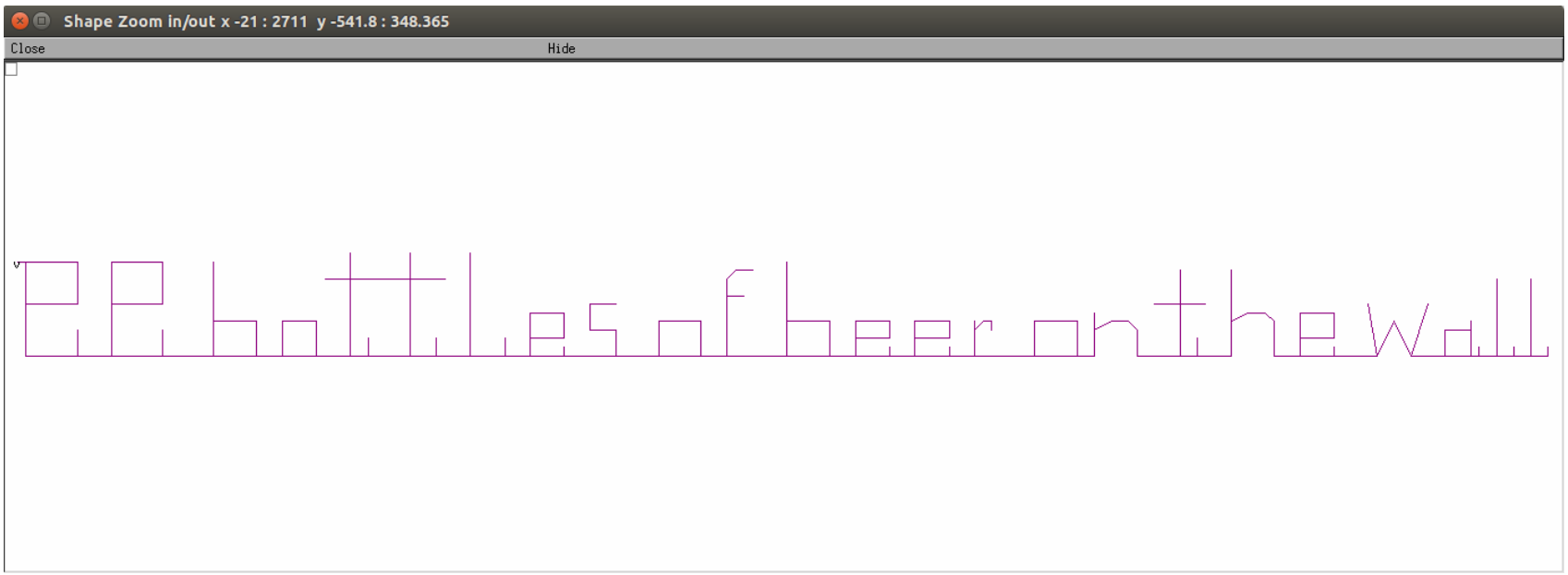
1. Use a neuron per letter / word / line / strophe
   - Tons of neurons to build
   - Shape neurons to letters by using dendrites
   - Connecting all these neurons e.g. from axons of neurons to dendrites of other neurons
2. How to simulate the flow of the song?
   - We can't eliminate neurons and create some new ones during a simulation (e.g. to count from 99 to 0).
   - Even if we would build all 100 strophes (have fun), how to simulate a stimulus spreading through the network?
   - 99 peaks inside a voltage graph, like we've seen before?

99 bottles of beer

Finally an example of one neuron with a soma and 143 dendrites shaping the first sentence of the song

99 bottles of beer

Finally an example of one neuron with a soma and 143 dendrites shaping the first sentence of the song



Comparison to other languages

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Better task would be to compare NEURON to something similar.

Compare NEURON to another code controlled simulation environment

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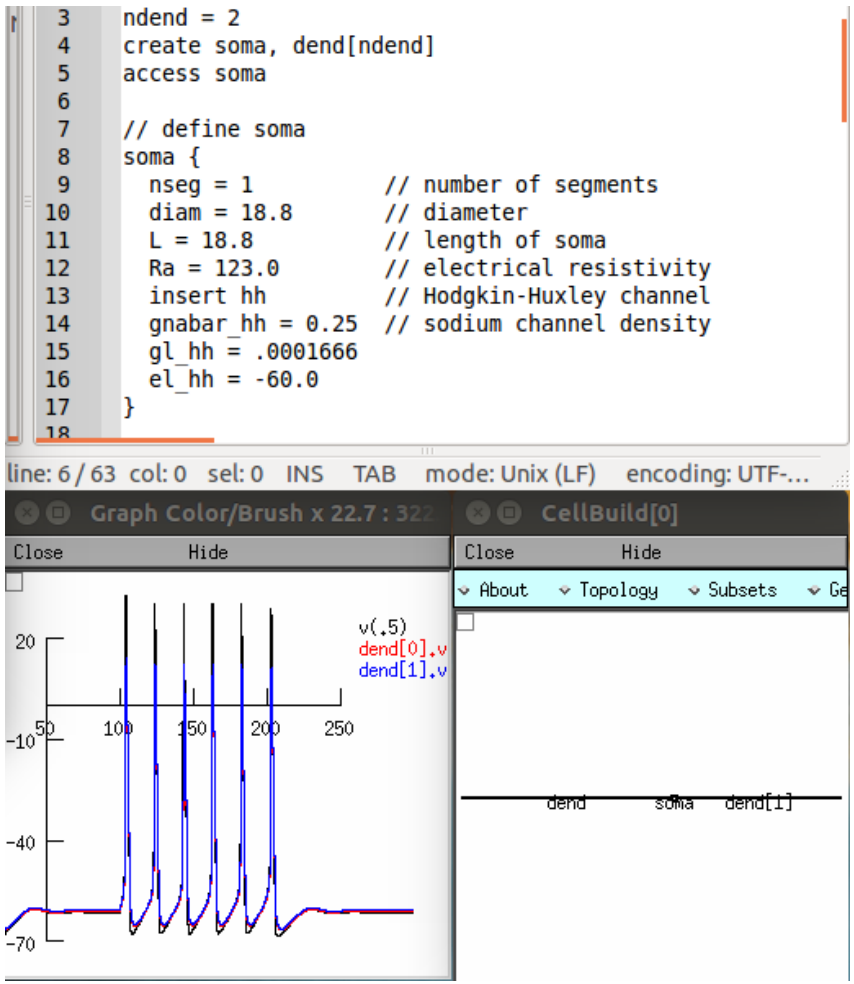
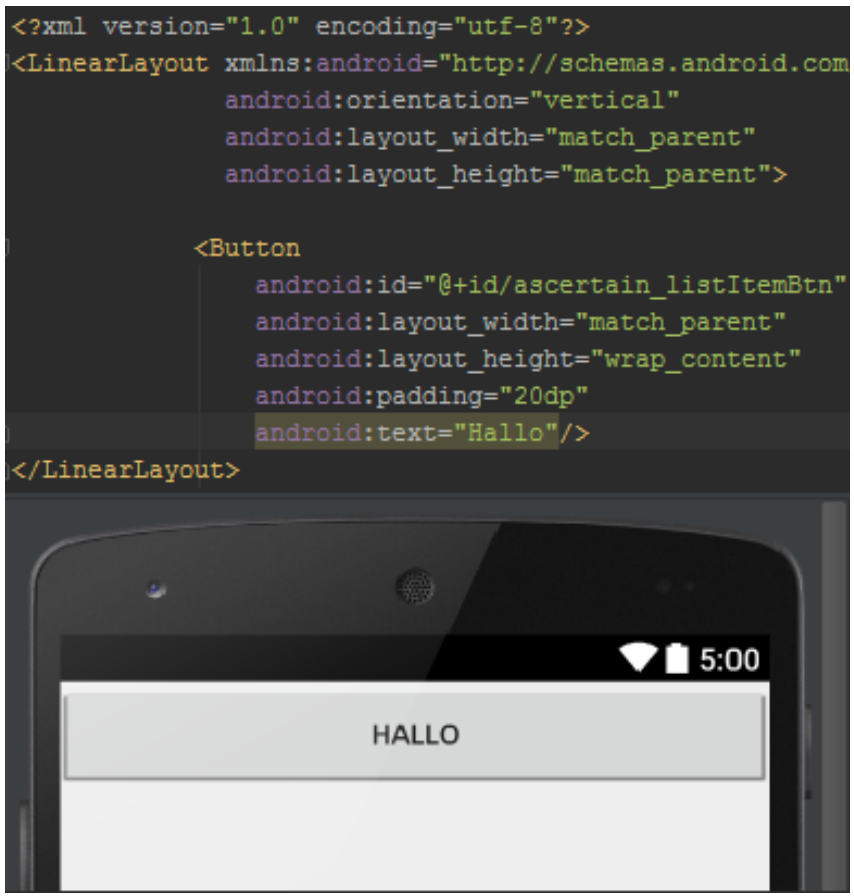
NEURON and Hoc



Android Studio and XML



Summary

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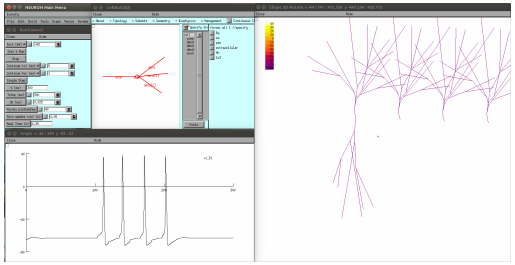

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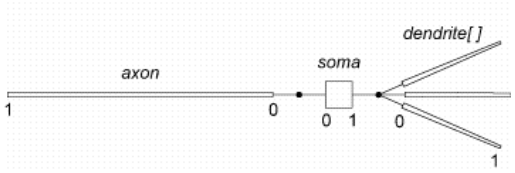
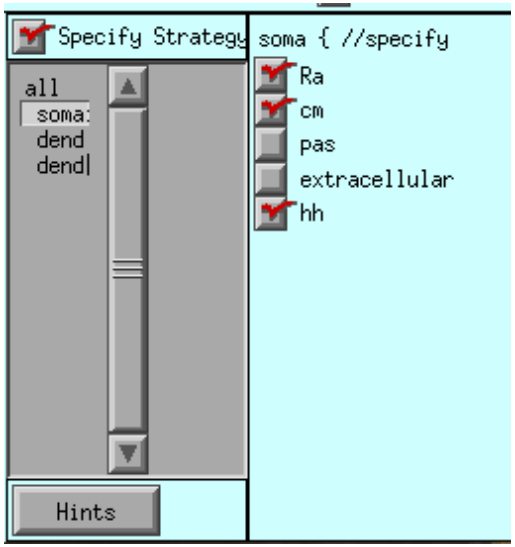
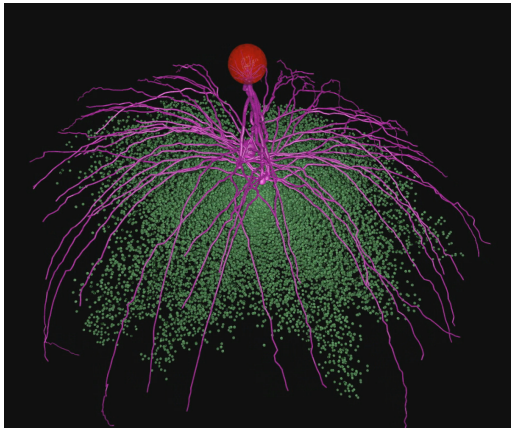


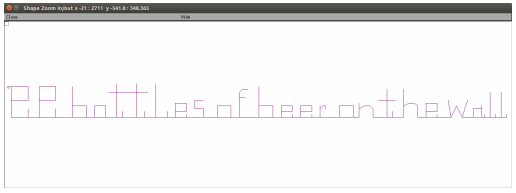
What is a neuron



Workflow



Possibilities



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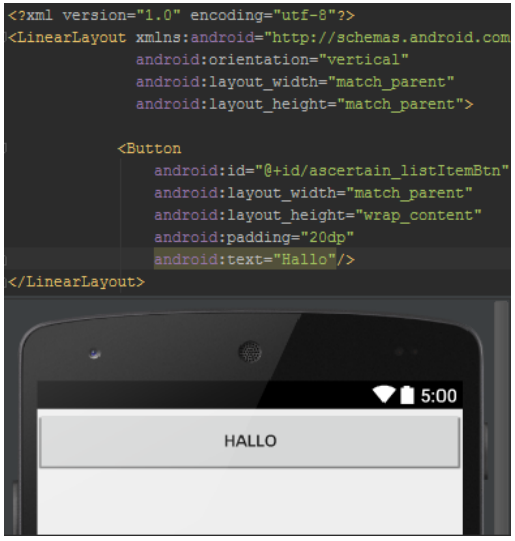

Comparison

Questions ?