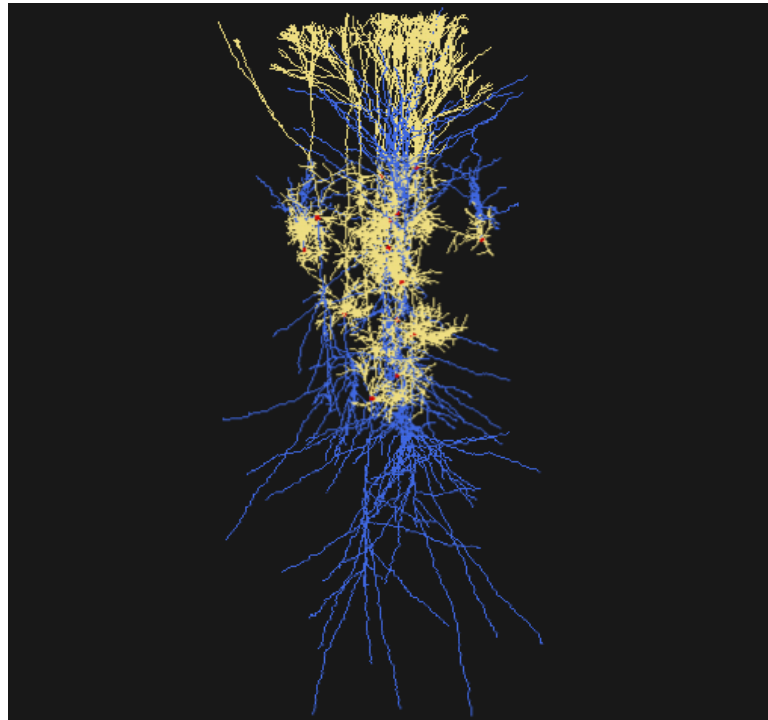


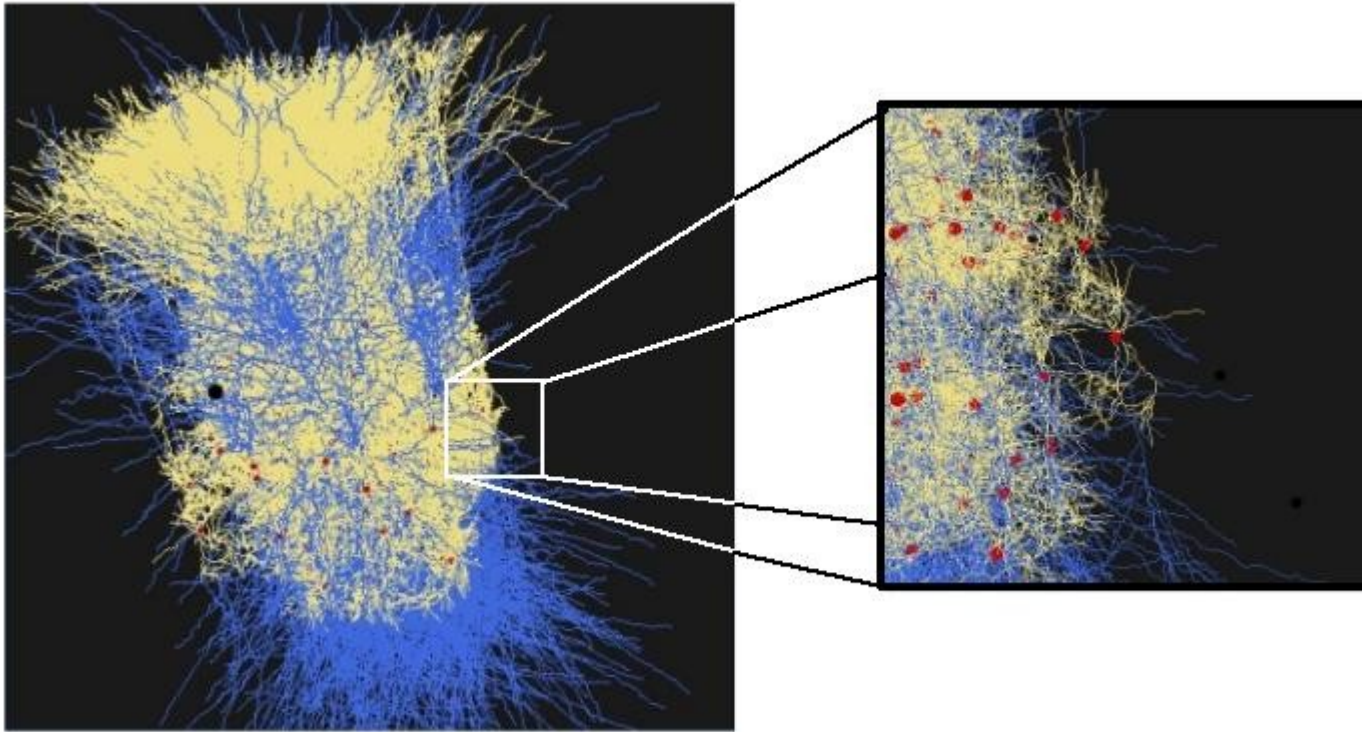
NeuGen

A Generator for Realistic Neurons in 3D



NeuGen

A Generator for Realistic Neurons in 3D

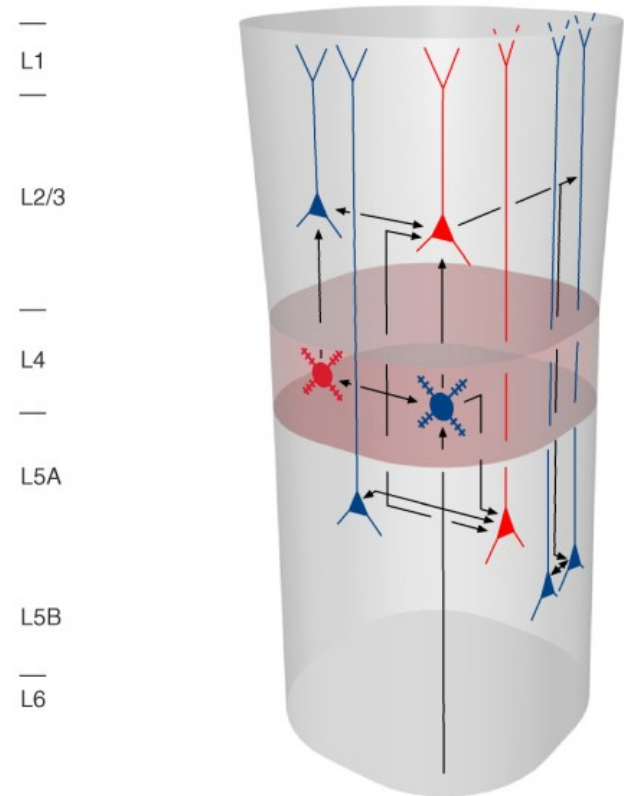


Motivation

- Generation of dendritic and axonal morphology of realistic neurons & networks in 3D
- Simulation of networks of synaptically connected neurons in a cortical column
- Using experimental data to extract the anatomical fingerprints of cells for the synthetic generation

Key Features

- Neurons
 - L2/3 pyramidal cells
 - L4 stellate neurons
 - L4 starpyramidal cells
 - L5A / L5B pyramidal cells
- Synapses and Networks
 - Synapses created by distribution and/or distance
 - Connectivity patterns as found in a cortical column



Key Features

- Simulation
 - Generation of .hoc files for NEURON
 - Using the multi-compartment model of Mainen and Sejnoski
 - ModelDB: Pyramidal Neuron Deep, Superficial; Aspiny, Stellate, 1996
- Visualization
 - Immediately in the GUI's visualization window
 - Via .net files with the OpenDX DataExplorer

Anatomical Fingerprints

Quantification of different axonal and dendritic morphological parameters of generated neurons (gen.) compared with experimental data (exp.)

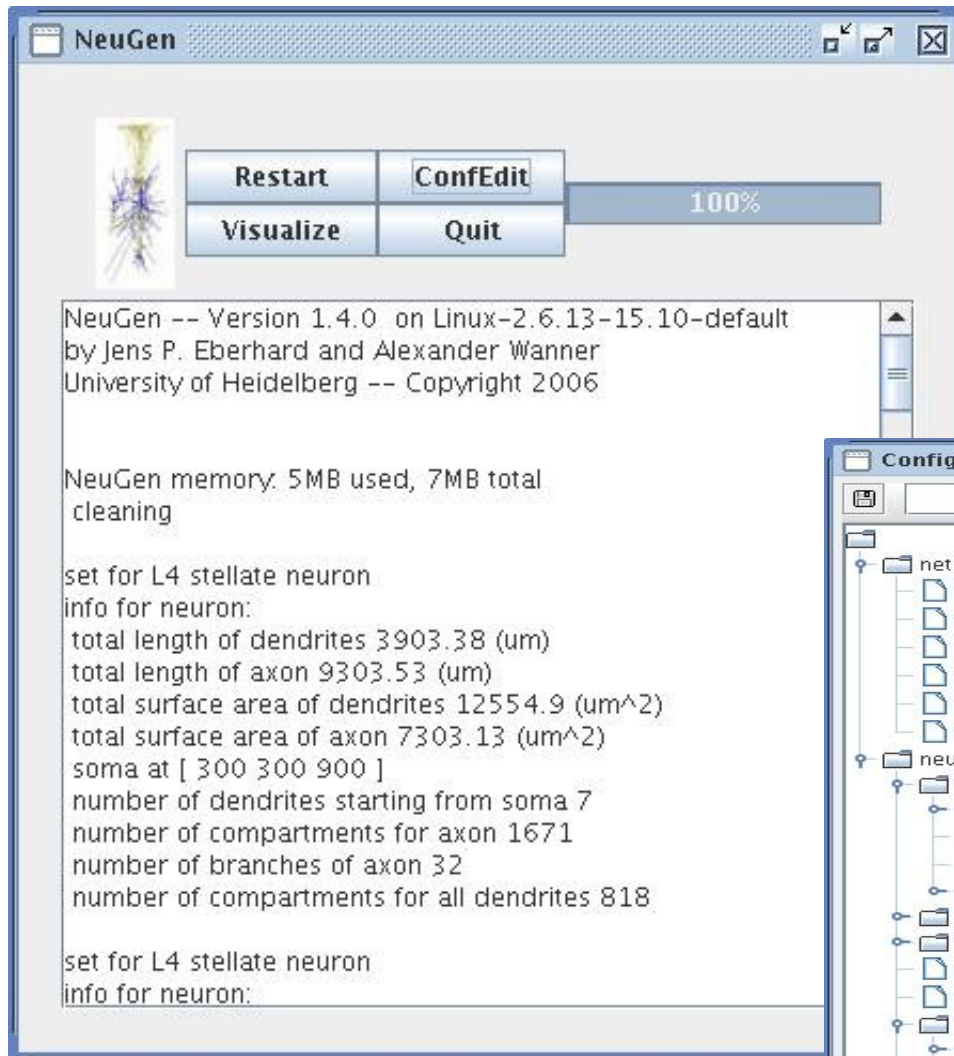
Neuron type		L4	L4 star	L2/3	L5 A	L5 B
Number of dendrites	Gen.	7	7	7	7	6
	Exp.	6.3 ± 2.3	6.4 ± 1.7	6.6 ± 0.9	6.6 ± 1.7	5.4 ± 0.6
Total dendritic length (μm)	Gen.	3598 ± 341	6522 ± 791	13903 ± 3178	7281 ± 771	9568 ± 1662
	Exp.	2835 ± 901	4960 ± 2017	9500 ± 2000	5945 ± 1495	7853 ± 1583
Total number of dendritic segments	Gen.	760 ± 73	1383 ± 167	2992 ± 693	1553 ± 163	2049 ± 359
	Exp.	–	–	–	–	–
Membrane area of dendrites (μm^2)	Gen.	11748 ± 1065	15162 ± 1256	22856 ± 4927	13559 ± 1386	16868 ± 2632
	Exp.	–	–	–	–	22700 ± 7046
Total axonal length (μm)	Gen.	6411 ± 1913	6394 ± 1869	3338 ± 955	7354 ± 2148	7276 ± 2162
	Exp.	6405 ± 2427	–	2551 ± 253	7422 ± 1802	6582 ± 1724
Number of axonal branches	Gen.	25.6 ± 6.7	23.7 ± 6.1	11.5 ± 3.1	23.3 ± 6.1	23.4 ± 6.1
	Exp.	65 ± 45	–	13.3 ± 2.7	–	–

For the values generated by NeuGen 1000 cells of each neuron type are produced. The experimental values are found in [3,14,15,28,29,18]. All values are means \pm SD.

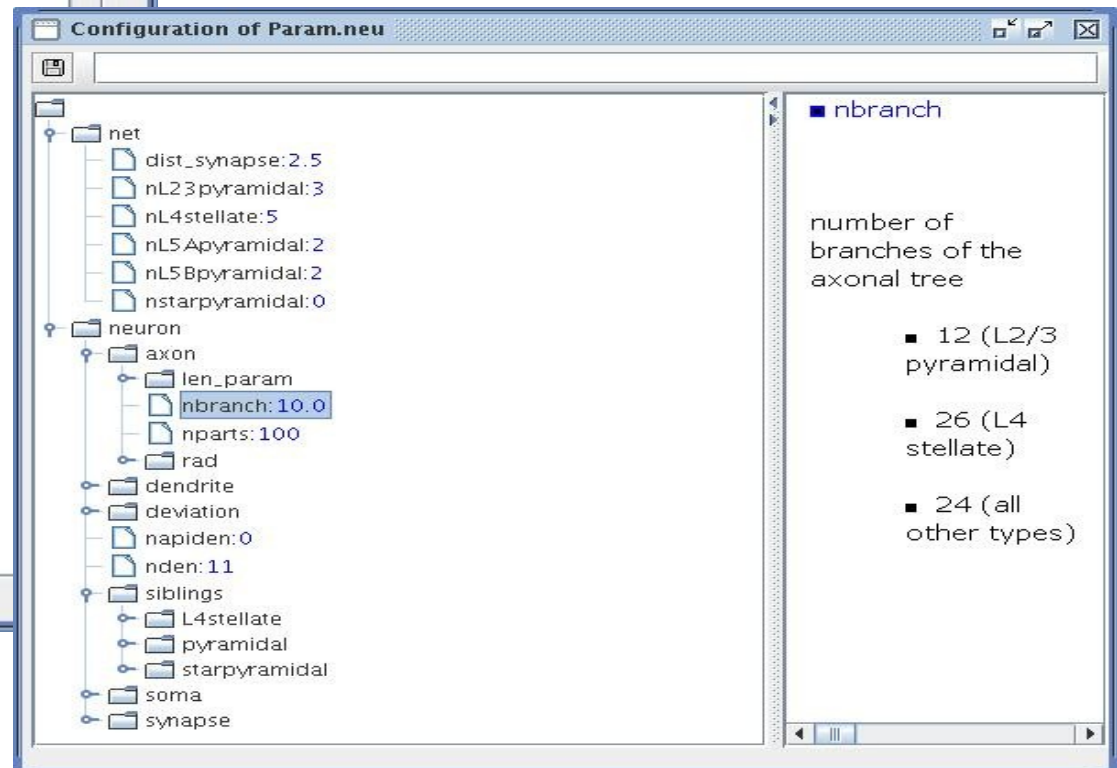
Anatomical Fingerprints

Parameter	L4 stellate	L2/3 pyramidal	L5 A pyramidal	L5 B pyramidal	L4 star
soma_position	$(P_{3l,6l}, P_{3l,6l}, P_{9l,l})$	$(P_{2.6l,4.5l}, P_{2.6l,4.5l}, P_{11l,2l})$	$(P_{3l,6l}, P_{3l,6l}, P_{7l,l})$	$(P_{3l,6l}, P_{3l,6l}, P_{4.5l,l})$	$(P_{2.5l,4l}, P_{2.5l,4l}, P_{9.5l,l})$
soma_radius	5 μm	5 μm	5 μm	5 μm	5 μm
dist_synapse	2.5 μm	2.5 μm	2.5 μm	2.5 μm	2.5 μm
nden	7	7	7	6	7
noblique	0	2	2	2	0
axon.len_param	(50, 50, 375) μm	(50, 50, 400) μm	(50, 50, 500) μm	(50, 50, 500) μm	(50, 50, 400) μm
axon.nbranch	26	12	24	24	24
axon.nparts	90	100	100	100	100
axon.rad.max	0.5 μm	0.5 μm	0.5 μm	0.5 μm	0.5 μm
axon.rad.min	0.1 μm	0.1 μm	0.1 μm	0.1 μm	0.1 μm
nparts_density	0.25 μm^{-1}	0.25 μm^{-1}	0.25 μm^{-1}	0.25 μm^{-1}	0.25 μm^{-1}
branch_angle.max	60	60	60	60	60
branch_angle.min	30	30	30	30	30
basal.rad.max	1.5 μm	1.5 μm	1.5 μm	1.5 μm	0.5 μm
basal.rad.min	0.5 μm	0.25 μm	0.25 μm	0.25 μm	0.25 μm
apical.rad.max	0	1.5 μm	1.5 μm	1.5 μm	2.5 μm
apical.rad.min	0	0.25 μm	0.25 μm	0.25 μm	0.5 μm
Rall.c, Rall.a	0.75, 1.5	0.75, 1.5	0.75, 1.5	0.75, 1.5	0.75, 1.5
low_branching_limit	0	20 μm	900 μm	700 μm	0
top_fluctuation	0	0.1	0.1	0.1	0

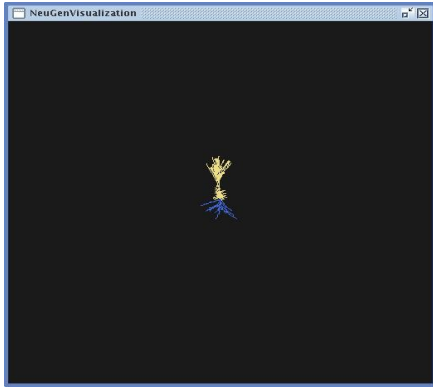
NeuGen GUI



- Facilitates user interaction
- Configuration of all parameters



NeuGen GUI

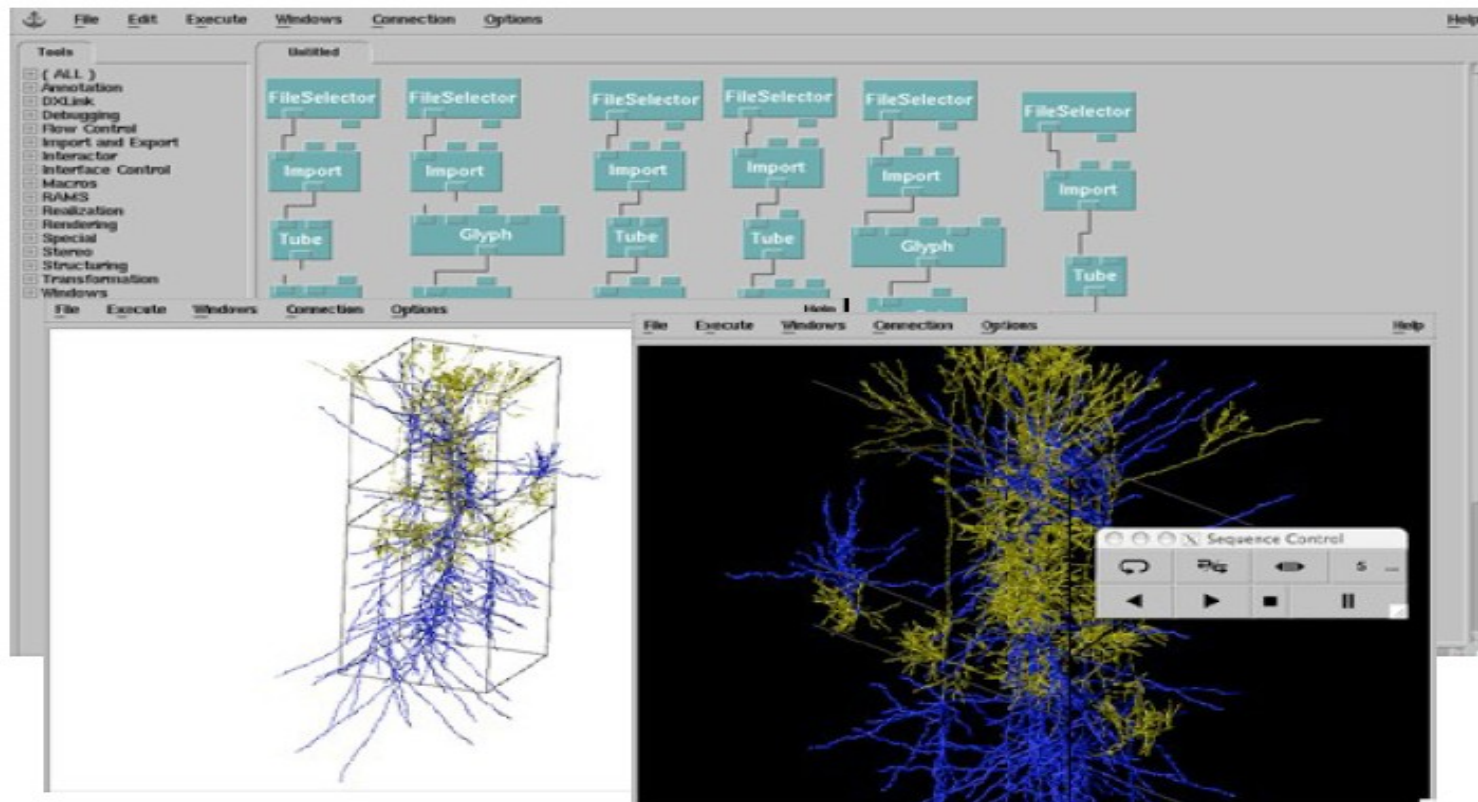


- The visualized image can be moved, rotated and zoomed



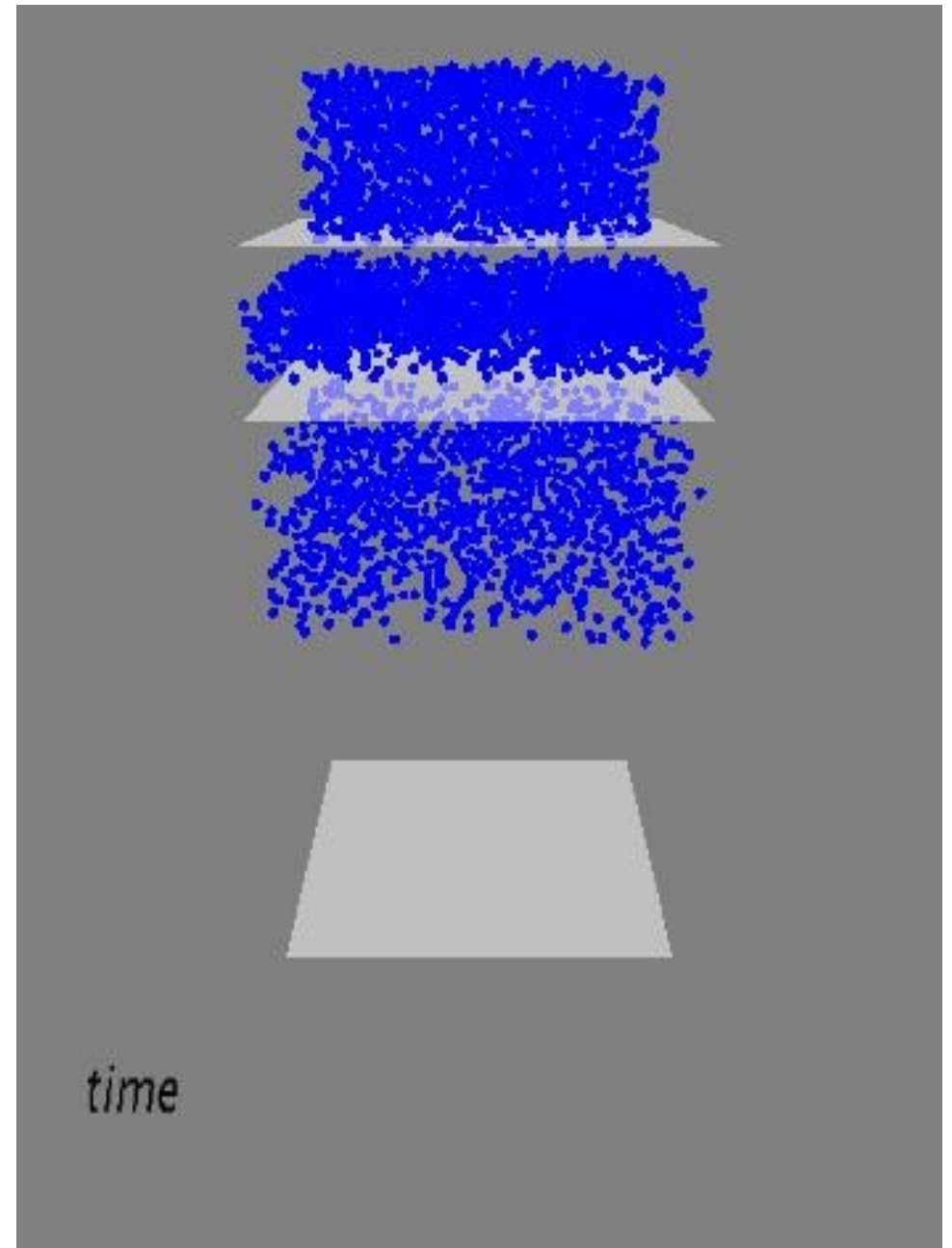
OpenDX Visualization

- The visualization routines of NeuGen allow to write the necessary files for a three-dimensional rendered display of the neurons



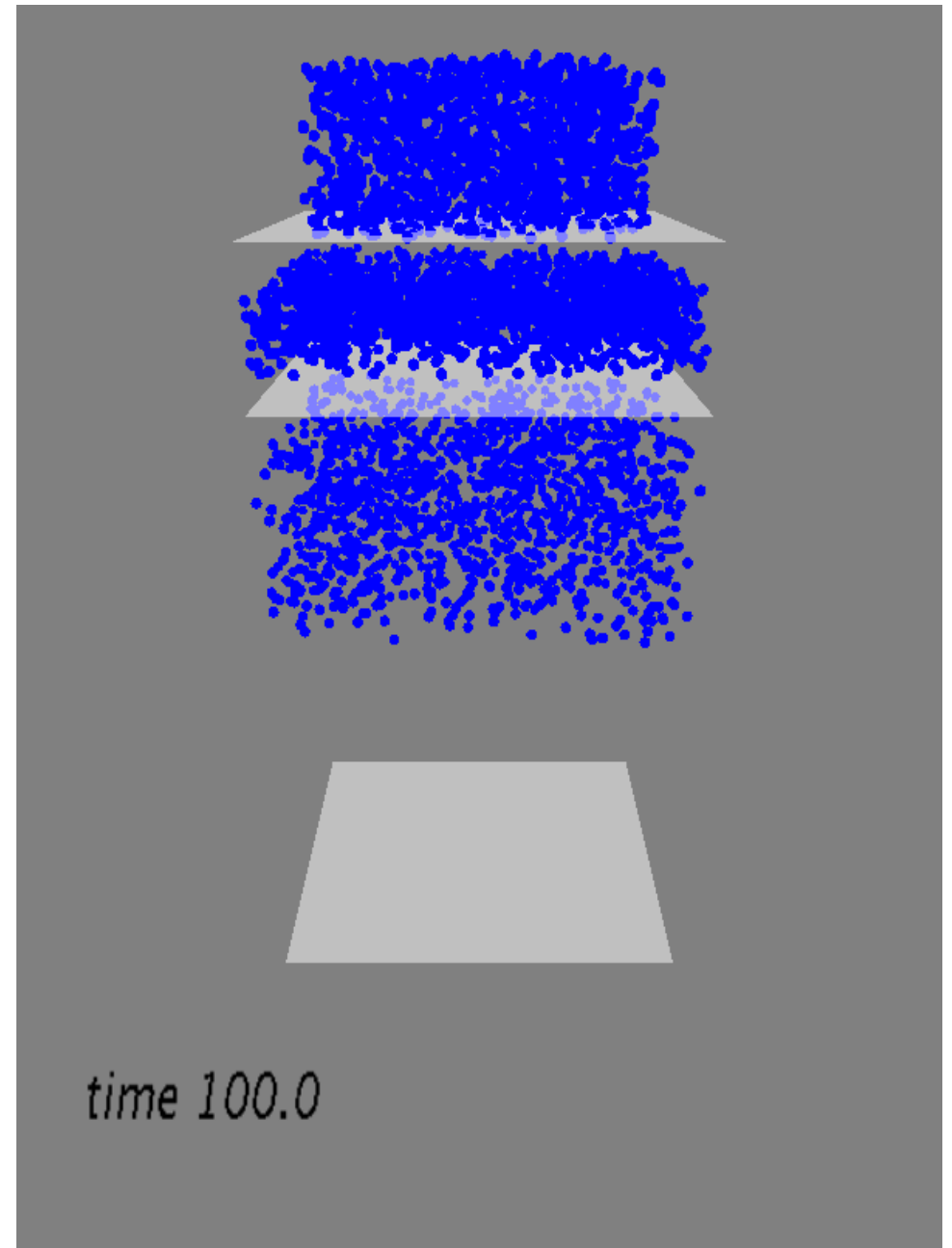
Simulation

- network of 5000 cells
 - L2/3 1500
 - L4 2000
 - L5A 750
 - L5B 750
- synapses 3480427
 - exp2syn 3308741
 - alpha 171686



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The NeuGen Homepage

- <http://www.neugen.org/>

NeuGen

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NeuGen

NeuGen is made for the generation of dendritic and axonal morphology of realistic neurons and neuronal networks in 3D.



Cells generated by NeuGen, from left: L2/3, L4, L5A, L5B, starpyramidal, network with 15 cells

The idea for the development of NeuGen has been to be able to simulate networks of synaptically connected neurons in a cortical column. The NeuGen project is mainly a result of the fact that experimental data is available nowadays to extract the anatomical fingerprints of the cells and to generate synthetic neuron geometries.

News

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Summary

- Efficient generation of anatomically accurate neurons and neural networks
- The generator stochastically samples parameter values from statistical distributions induced by experimental data
- Graphical user interface facilitates program control and value assignment
- Intended for scientists aiming at simulations of morphologically realistic networks in 3D

Outlook

- Implementation of other cell types and spines
- Validation of the stochastic model and the derived generation of neurons and neural networks against available databases of manually traced neurons in 3D
- Demonstration of extraction of experimental data and results from the synthetic network
- NeuGen is an on-going software project

The NeuGen Development Team

