

Point neuron network modeling in the HBP

Sacha van Albada
Research Center Jülich
Jülich, Germany

and few-compartment

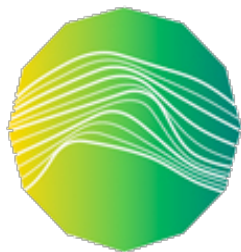
Point neuron network modeling in the HBP

Sacha van Albada

Research Center Jülich & University of Cologne

Jülich/Cologne, Germany

A collaborative effort to simulate the brain



EBRAINS



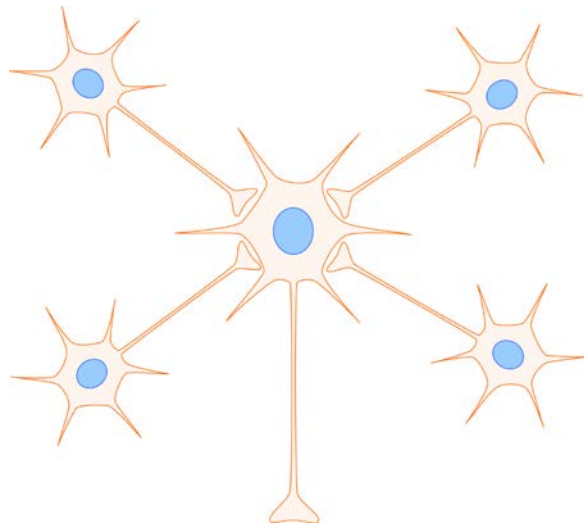
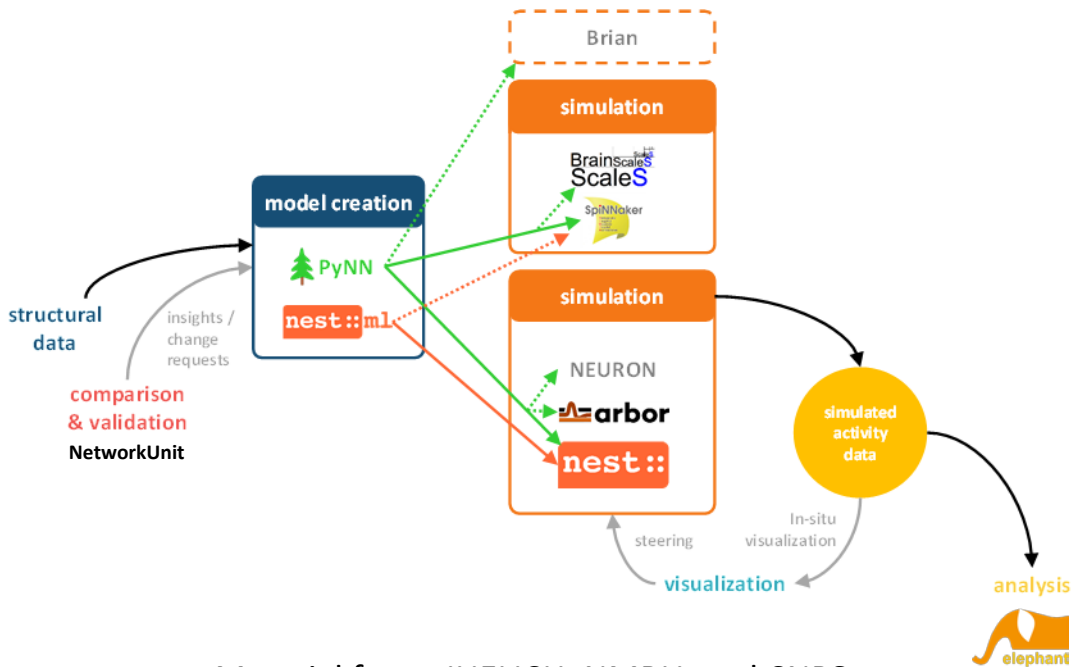
NEURON &
CoreNEURON

nest ::



THEVIRTUALBRAIN.

Neuronal network simulation tools



Material from: JUELICH, NMBU, and CNRS

NEST (NEural Simulation Tool)

neuron models

- integrate-and-fire (IaF) neuron models with current-based synapses (delta-, exponential- and alpha-function shaped)
- IaF models with conductance-based synapses
- adaptive exponential IaF model (AdEx) (Brette & Gerstner, 2005)
- binary neuron models
- Izhikevich model
- MAT2 neuron model (Kobayashi et al. 2009)
- augmented MAT model (Yamauchi et al. 2011)
- Hodgkin-Huxley-type models with one compartment
- neuron models with few compartments

connection models

- static synapses
- spike-timing-dependent plasticity (STDP)
- short-term plasticity (Tsodyks et al. 2000)
- neuromodulatory synapses using dopamine
- distance-dependent connectivity

extensively tested

user support

accurate integration (appropriate solvers)

option of computing precise spike times

not restricted to time grid

Simulation technology from laptops to supercomputers and co-design with neuromorphic hardware

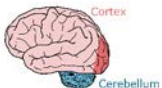
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in Neuroinformatics

ORIGINAL RESEARCH
published: 16 February 2018
doi: 10.3389/fninf.2018.00002

Extremely Scalable Spiking Neuronal Network Simulation Code: From Laptops to Exascale Computers

Jakob Jordan^{1*}, Tammo Ippen^{1,2}, Moritz Helias^{1,3}, Itaru Kitayama⁴, Mitsuhsisa Sato⁴, Jun Igarashi⁵, Markus Diesmann^{1,3,6} and Susanne Kunkel^{7,8}

Previous technology



Previous technology



New technology



Petascale



Post-Petascale



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ORIGINAL RESEARCH
published: 23 May 2018
doi: 10.3389/fnins.2018.00291

Performance Comparison of the Digital Neuromorphic Hardware SpiNNaker and the Neural Network Simulation Software NEST for a Full-Scale Cortical Microcircuit Model

Sacha J. van Albada^{1*}, Andrew G. Rowley², Johanna Senk¹, Michael Hopkins², Maximilian Schmidt^{1,3}, Alan B. Stokes², David R. Lester², Markus Diesmann^{1,4,5} and Steve B. Furber²



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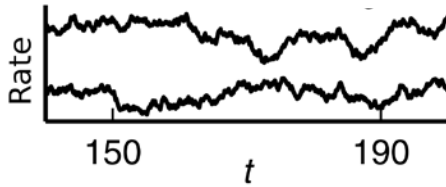
- New 5g simulation kernel ready for exascale computers
- Reference for neuromorphic hardware development

Contact: diesmann@fz-juelich.de, hans.ekkehard.plessner@nmbu.no

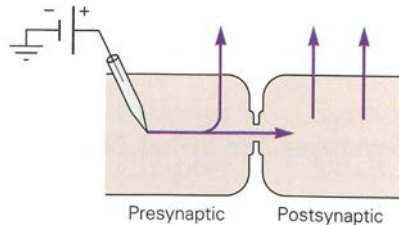


Recently added features and modeling language

Rate neurons



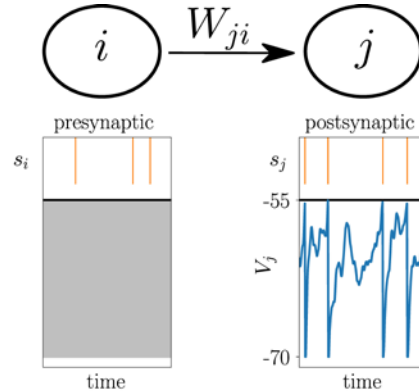
Gap junctions



Kandel et al. Principles of Neuronal Science

Advanced plasticity rules

- Urbanczik, Senn (2014)
- Clopath et al. (2010)



Applications:

- Eprop (Bellec et al. 2019)
- dendritic cortical microcircuits (Sacramento et al. 2017)

Model definition language

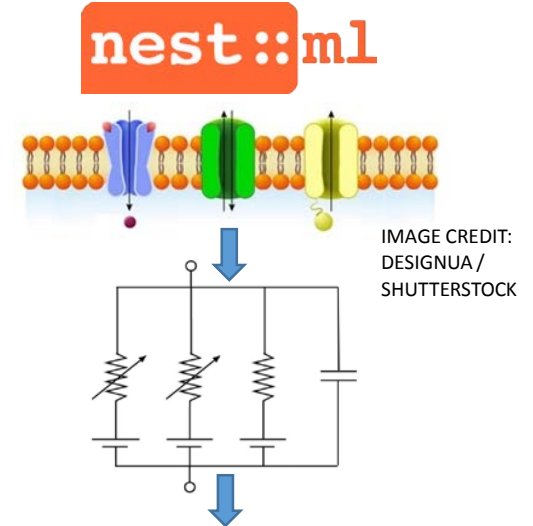


IMAGE CREDIT:
DESIGNUA/
SHUTTERSTOCK

neuron rc_neuron:

equations:

$$V_m' = -V_m/\tau_m + I_{syn}/C_m$$

end

Contact: diesmann@fz-juelich.de, hans.ekkehard.plesser@nmbu.no

NEST Desktop

Online use of NEST

e.g. for education

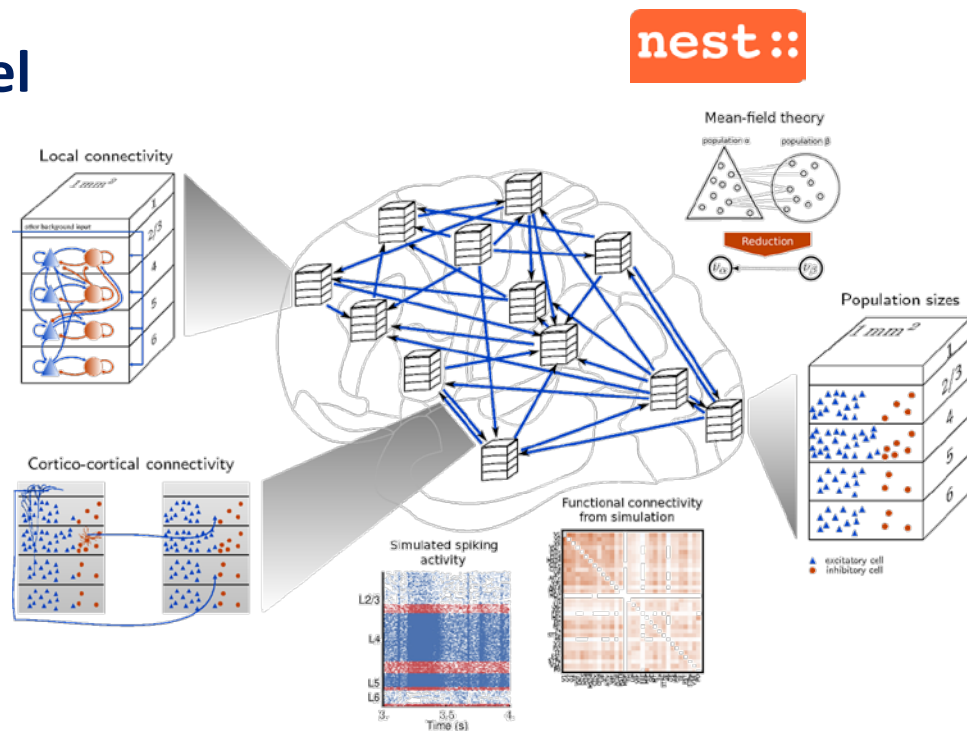


Multi-area macaque cortex model

Supercomputational model of all vision-related areas of macaque cortex

- based on microcircuit building block
 - use case for neuromorphic benchmarking
- novel area-, layer-, and population-specific connectivity map
- model relates connectivity to microscopic and macroscopic resting-state dynamics

- Schuecker, Schmidt, van Albada, Diesmann, Helias (2017) *PLoS Computational Biology* 13(2): e1005179
- Schmidt, Bakker, Shen, Bezgin, Diesmann, van Albada (2018) *PLoS Computational Biology* 14(10): e1006359
- Schmidt, Bakker, Hilgetag, Diesmann, van Albada (2018) *Brain Structure Function* 223: 1409



- Re-use of the model: forked 19 times on GitHub (14 external) (<https://inm-6.github.io/multi-area-model/>)
- Tutorial videos watched >1000 times

THANK YOU!

& Sandra Diaz for slides



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