

## Institute of Neuroscience and Medicine (INM-6)

Computational and Systems Neuroscience

## Institute for Advanced Simulation (IAS-6)

Theoretical Neuroscience

## JARA Brain Institute I



### Human Brain Project Platform

#### Cortical Microcircuit Simulation Collab

**Michael Denker, Markus Diesmann, Sonja Gruen, Hans Ekkehard Plesser, Bernd Schuller, Johanna Senk, Sacha van Albada, Alper Yegenoglu**

The Collab demonstrates interactive and collaborative research with a full scale neuronal network model (Figure 1). Full scale means that the model represents a particular biological circuit with neurons and synapses at their natural density. The model ( Potjans, T. C., & Diesmann, M. (2014) Cerebral Cortex 24(3):785-806 ) represents 1 mm<sup>3</sup> of cortex and contains around 100,000 spiking point-neurons connected by around 1 billion synapses in four cortical layers. Each layer contains an excitatory and an inhibitory neuron population which are interconnected with cell-type and layer specific connection probabilities derived from experimental data of early sensory cortex.

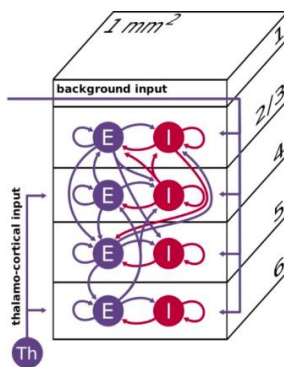


Figure 1: Illustration of the multi-layered microcircuit model (adapted from Potjans, T. C., & Diesmann, M. (2014))

The simulation code is a PyNN-implementation based on a public version with NEST (<http://www.nest-simulator.org/>) as simulator backend.

It is possible to run the simulation either directly on the Collaboratory's local resources (cscs\_viz) or on an HPC system via UNICORE. The Juelich supercomputer JUQUEEN can be selected.

Figure 2 illustrates possible workflows that can be realized in this Collab including interactive computing with Jupyter Notebooks, the Collaboratory's Task framework and submitting simulation jobs to an HPC site.

<https://collab.humanbrainproject.eu/#/collab/569/nav/5287>

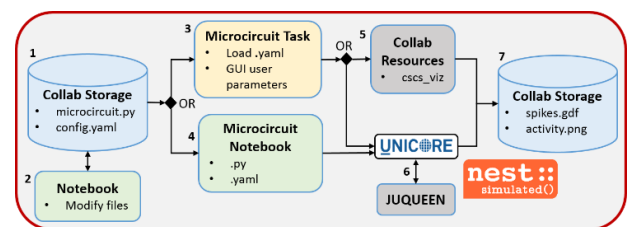


Figure 2 Workflows realized in this Collab.

#### NEST-SpiNNaker-Elephant Demo Collab

**Andrew Davison, Michael Denker, Sonja Grün, Detlef Holstein, Jakob Jordan, David Lester, Anna Lührs, Pietro Quaglio, Vahid Rostami, Andrew Rowley, Bernd Schuller, Johanna Senk, Sacha van Albada, Benjamin Weyers, Alper Yegenoglu, Daniel Zielasko**

The aim of this collab is to validate and compare data obtained by large scale network simulations implemented in the NEST simulator running on the JUQUEEN system here in Juelich. The same model is implemented with the Neuromorphic Hardware SpiNNaker running in Manchester.

The microcircuit simulation, which represents the modeling component of this Demo Collab, is the full scale neuronal network model described in the "Cortical microcircuit simulation collab" above. A sketch of the model is depicted in Figure 1.

The resulting data is collected in the Collab and analysed with a battery of statistical methods using the Elephant library. A first insight into the data can be obtained in an interactive fashion in a Jupyter Notebook, but more complex analysis is carried out using the JURECA HPC system. UNICORE links the Collaboratory with HPC facilities and allows an easy access to distributed computing. Final results of the analysis can be visualized by the visualization framework ViSTA.

Figure 3 shows how the HPAC platform and the Collaboratory enable to simulate the model of the cortical microcircuit using the NEST simulator on the JUQUEEN super computer, simulate the exact same model using the SpiNNaker hardware, pool the data in a central location, validate the results by a battery of comparisons using Elephant and visualize the results.

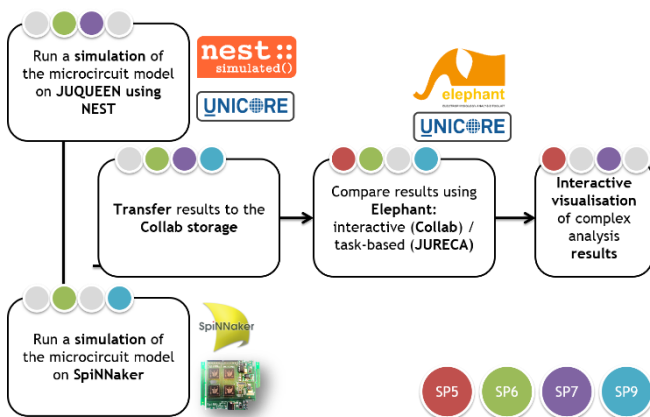


Figure 3 Overview of the NEST-SpiNNaker-Elephant Demo

<https://collab.humanbrainproject.eu/#/collab/507/nav/6326>

## Preprint

### Full-density multi-scale account of structure and dynamics of macaque visual cortex

Maximilian Schmidt et al.

The paper present a multi-scale spiking network model of all vision-related areas of macaque cortex that represents each area by a full-scale microcircuit with area-specific architecture. The layer- and population-resolved network connectivity integrates axonal tracing data from the CoCoMac database with recent quantitative tracing data, and is systematically refined using dynamical constraints. Simulations reveal a stable asynchronous irregular ground state with heterogeneous activity across areas, layers, and populations. Elicited by large-scale interactions, the model reproduces longer intrinsic time scales in higher compared to early visual areas. Activity propagates down the visual hierarchy, similar to experimental results associated with visual imagery. Cortico-cortical interaction patterns agree well with fMRI resting-state functional connectivity. The model bridges the gap between local and large-scale accounts of cortex, and clarifies how the detailed connectivity of cortex shapes its dynamics on multiple scales.

<http://arxiv.org/abs/1511.09364v3>

## Accepted Papers

### Exploring the Usefulness of Formal Concept Analysis for Robust Detection of Spatio-Temporal Spike Patterns in Massively Parallel Spike Trains

Yegenoglu, Quaglio, Torre, Grün, Endres, Proc. International Conference on Conceptual Structures, ICCS 2016 (in press)

### Similarity in Neuronal Firing Regimes across Mammalian Species

Mochizuki, Onaga, Shimazaki, Shimokawa, Tsubo, Kimura, Saiki, Sakai, Isomura, Fujisawa, Shibata, Hirai, Furuta, Kaneko, Takahashi, Nakazono, Ishino, Sakurai, Kitsukawa, Lee, Lee, Jung, Babul, Maldonado, Takahashi, Arce-McShane, Ross, Sessle, Hatsopoulos, Brochier, Riehle, **Chorley, Grün**, Nishijo, Ichihara-Takeda, Funahashi, Shima, Mushiake, Yamane, Tamura, Fujita, Inaba, Kawano, Kurkin, Fukushima, Kurata, Taira, Tsuitsui, Ogawa, Komatsu, Koida, Toyama, Richmond, Shinomoto, Journal of Neuroscience (in press)

## Activities

### NESTML at Modellierung 2016

The NESTML project aims at developing a special high-level description language and the infrastructure to create neuron models for the neuronal simulator.

The results of the work so far have been presented in an article at the conference Modellierung 2016: "[NESTML: a modeling language for spiking neurons](#)" (<http://www.fz-juelich.de/goto?id=1971642>)

The tools are available as open source software: <https://github.com/nest/nestml>.

NESTML is a collaboration between the Chair of Software Engineering at RWTH Aachen University and the department Computational and Systems Neuroscience (INM-6).

### Human Brain Project's Research Platforms Released

The NEST-SpiNNaker-Elephant Demo presented by Michael Denker as part of the event: <https://youtu.be/bvesBlwH2M>

The Neurorobotics demo with the NEST simulator for brain models: <https://youtu.be/uAXzS7SPFG4>

Full recordings of the online publication of the Human Brain Project Platform are available at the following links:

Morning Session: <https://youtu.be/2XXz2quUWFQ>

Afternoon Session: <https://youtu.be/hb7CcwmlRLcs>