Description of master thesis project in Computer Science/Computational Biology

Title: Characterization of activity in a multi-area brain model with encoded memory attractors.

Background: Many existing brain models represent a small piece of cortex with a spiking neural network. Much fewer models though, represent the “hierarchical” multi-area structure of the cortex. In the Jülich multi-area model [1] each area is represented by a layered microcircuit and connectivity is derived from pairwise statistics as well as from databases like Cocomac [6] and data from the Kennedy lab [7]. The model has no memory attractors embedded.

Goal: To investigate,
(i) How the activity spreads in a multi-area network structure with regard to spatio-temporal and oscillatory activity and how it depends on the state of the network.
(ii) What differences are seen with and without memory attractors embedded in the connection matrix.

Approach: Starting from the existing Jülich multi-area brain model [1], pick a subsystem of some five areas, simplify each patch– possibly retain just layers 4, 2/3, and 5 - introduce a modular structure in each area patch (hypercolumns, minicolumns [4,5]), and embed some attractors in the model, with on-line or off-line training. Evaluate the spread of activity and oscillations at different frequencies seen in the model.

Tools: PC, KTH Supercomputer, Python scripting language, PyNEST

Supervisor: Arvind Kumar

Examiner: Anders Lansner

Literature:

1. http://www.opensourcebrain.org/attachments/download/194/Sardinia14_Diesmann_published.pdf
2. Schmidt, Maximilian, et al. "Integrating multi-scale data for a network model of macaque visual cortex." *BMC Neuroscience* 14.Suppl 1 (2013): P111.
3. Potjans, Tobias C., and Markus Diesmann. "The cell-type specific connectivity of the local cortical network explains prominent features of neuronal activity." *arXiv preprint arXiv:1106.5678* (2011).
4. Lundqvist, Mikael, Martin Rehn, and Anders Lansner. "Attractor dynamics in a modular network model of the cerebral cortex." *Neurocomputing* 69.10 (2006): 1155-1159.
5. Lansner, Anders. "Associative memory models: from the cell-assembly theory to biophysically detailed cortex simulations." *Trends in neurosciences* 32.3 (2009): 178-186.
6. http://cocomac.g-node.org/drupal/?
7. Markov, N. T., et al. "A weighted and directed interareal connectivity matrix for macaque cerebral cortex." *Cerebral Cortex* (2012): bhs270.
8. Kumar, Arvind, Stefan Rotter, and Ad Aertsen. "Spiking activity propagation in neuronal networks: reconciling different perspectives on neural coding." *Nature Reviews Neuroscience* 11.9 (2010): 615-627.