Technische Universität München
Neurowissenschaftliche Systemtheorie

Scientific Seminar Neuroengineering

A survey on neural simulation environments

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Problem description:

One of the biggest challenge of the time in scientific area is to solve how brain works [1]. To unravel the mystery, there are lots of experiments conducted in the biology side. However, the experimental data is huge and one of the ways to give them meaning is simulating the neuron models to understand how neurons behave and how information processed. So, there are different scale of neuron models that investigates different scales of information such as neurochemicals and neuron group behaviours. While Hodgkin Huxley models [2] provide very detailed information considering neurochemicals on neurons, some other neuron models (Spiking Neural Networks), such as "Integrate and Fire" and "Izhikevich", model the behavior of neurons when the information is present. There are also artificial neural network models that utilize more simple neuron models and care more about information processing. Since there are different levels of models to understand how brain works, there are also several simulation environments to answer different needs.

This seminar aims to review the strong sides of different neural simulation environments that are used to solve cognitive problems in several scales. Within this seminar the student should provide a broad survey of the recent modeling environments such as Nengo, NEST, Neuron, MATLAB, Pynn, etc.[5]. The strong and weak sides of each environment should also be mentioned in the sense of speed, memory requirement, supported languages and environments, details of neuron models, neuron amounts to be simulated, connection ability to other environments and hardware compatibility, applicability to robotic environments, etc.

Task:

- Introduce different kinds of neural simulation environments
- Determine in which aspects the simulation environments can be compared
- Provide the strength and weaknesses of the simulation environments considering these aspects
- Provide possible constraints of simulating neuron models
- Documentation and report.

Literature:

[1] Bekolay T, Bergstra J, Hunsberger E, et al. Nengo: a Python tool for building large-scale functional brain models. *Frontiers in Neuroinformatics*. 2013;7:48. doi:10.3389/fninf.2013.00048.
[2] Hodgkin AL, Huxley AF. A quantitative description of membrane current and its application to conduction and excitation in nerve. *The Journal of Physiology*. 1952;117(4):500-544.
[3] http://icwww.epfl.ch/~gerstner/SPNM/node26.html
[4] Izhikevich, Eugene M., et al. Simple model of spiking neurons. *IEEE Transactions on neural networks*, 2003, 14.6: 1569-1572.
[5] Davison AP, Hines M and Muller E (2009). Trends in programming languages for neuroscience simulations.*Front. Neurosci.* **3**,3:374- 380. doi: 10.3389/neuro.01.036.2009

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