2009

A Java-based simulation environment for networks of simplified neuron models

BMC Neuroscience

BioMed Central

Poster presentation

Open Access

A Java-based simulation environment for networks of simplified neuron models

Lucas B Figueira* and Antonio C Roque

Address: Department of Physics and Mathematics, School of Philosophy, Sciences and Letters of Ribeirão Preto, University of São Paulo, 14040-901, Ribeirão Preto, SP, Brazil

Email: Lucas B Figueira* - lucas@neuron.ffclrp.usp.br

* Corresponding author

from Eighteenth Annual Computational Neuroscience Meeting: CNS*2009
Berlin, Germany. 18–23 July 2009

Published: 13 July 2009

BMC Neuroscience 2009, **10**(Suppl 1):P55 doi:10.1186/1471-2202-10-S1-P55

This abstract is available from: http://www.biomedcentral.com/1471-2202/10/S1/P55

Simplified neuron models (low dimensional neuron models and formal spiking neuron models [1]) are generally considered useful because of their level of abstraction, which allow a good mathematical understanding of their behavior and simulations of large-scale network models at relatively low computational costs. Hence, computational environments with facilities for the construction of these neuron models and their synaptic connections in different architectures constitute valuable tools for both modeling research and teaching. This work describes a Java-based environment of this kind. It was designed to be an easy tool for the simulation of small and large networks of neurons but it allows single-neuron simulations as well. In order to make the running task of time-dependent models (neurons, synapses and inputs) easy the computational environment has a kernel that controls all of them in a synchronous way. The environment has several simplified neuron models already implemented to be used, such as integrate-and-fire, Izhikevich, Morris-Lecar, Hindmarsh-Rose, etc. [1-3]. The synapses are modeled using many versions of the alpha function [2]. For example, to create a simple excitatory-inhibitory one-to-one network using integrate-and-fire model neurons it is necessary only to declare two object instances of the "IFNeuron" class and connect then using two instances of the "AlphaSynapse" class, set the time parameters of the simulation and run it. The user also has facilities to extend any already existing neuron and synaptic model in the environment or to create new models. The environment allows the user to create many objects of the same type with their parameters following some probability distribution. This is done using a single line command and is very useful for the creation of networks with many neurons, each one of which assuming a position in Euclidian 3D space. All these objects can handle events so it is possible to simulate their responses to external actions while they evolve in time. To test our environment we used it to build a large-scale model of the olfactory bulb including mitral and granule cells with reciprocal dendrodendritic synapses. The model was adapted from a model of the olfactory bulb by Davison et al. [4]. The cells were modeled by the Izhikevich model [3] and their synapses were modeled by alpha functions. Both bistable and nonbistable mitral cell models were used [5]. The model was successful in replicating results from [4] and can be used as a theoretical tool to investigate synchrony and discrimination processes in the olfactory bulb. Our computational environment, therefore, offers a tool that can be used for the construction and investigation of large-scale networks of simplified neurons.

Acknowledgements

ACR is supported by a research grant from CNPq.

References

1. Gerstner W, Kistler W: *Spiking Neuron Models: Single Neurons, Populations, Plasticity Cambridge, UK: Cambridge University Press*; 2002.

2. Dayan P, Abbott LF: *Theoretical Neuroscience: Computational and Mathematical Modeling of Neural Systems Cambridge, MA: MIT Press*; 2001.
3. Izhikevich EM: *Dynamical Systems in Neuroscience: The Geometry of Excitability and Bursting Cambridge, MA: MIT Press*; 2007.
4. Davison AP, Feng J, Brown D: **Dendrodendritic inhibition and simulated odor responses in a detailed olfactory bulb network model.** *J Neurophysiol* 2003, **90:**1921-1935.
5. Heyward P, Ennis M, Keller A, Shipley MT: **Membrane bistability in olfactory bulb mitral cells.** *J Neurosci* 2001, **21:**5311-5320.