News Item

ModelDB

Making Models Publicly Accessible to Support Computational Neuroscience

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Introduction

Computational neuroscience as a scientific discipline must provide for the ready testing of published models by others in the field. Unfortunately this pre-requisite has rarely been fulfilled. When exact reproduction of a model simulation is achieved, it is often only after a long and difficult process. Too often, missing or typographically incorrect equations and parameter values have made it difficult to explore or build upon published models. Compounding this difficulty is the proliferation of platforms and operating systems that are incompatible with the author's original computing environment.

Because of these problems, most models are never subjected to the rigorous testing by others in the field that is a hallmark of the scientific method. This not only impedes validation of a model, but also prevents a deeper understanding of its inner workings, especially through modification of the parameters. Furthermore, modular pieces of the model (e.g., ion channels or the morphology of a cell) cannot be reused to build new models and propel research forward.

ModelDB (http://senselab.med.yale.edu/modeldb) is intended to address these issues (Peterson et al., 1996; Shepherd et al., 1998). ModelDB is a database of computational models, either classics in the field or published in recent years. It focuses on models for different types of neurons, and presently contains over 60 models for 15 neuron types. In addition to compartmental models, it contains models covering from ion channels and receptors through axons and dendrites through neurons to networks. Models can be accessed by author name, model name, neuron type,

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topic (e.g., synaptic plasticity, pattern recognition, etc.), or by simulation environment.

ModelDB is a member of a major neuroscience database collection called SenseLab. Each SenseLab database has an easily extensible structure achieved through the Entity-Attribute-Value with Classes and Relationships (EAV/CR) data schema (Nadkarni et al., 1999; Miller et al., 2001). ModelDB is integrated with NeuronDB (Marenco et al., 1999), another SenseLab database that stores neuronal properties derived from the neuroscience literature (http://senselab.med.yale.edu/senselab/NeuronDB). Contributing to the database and use of the models is open to all. Contributions are tested for quality-control purposes before being made public. Here we describe how to find, run, and submit models to ModelDB.

Browsing ModelDB

The use of ModelDB typically starts with a computational neuroscientist who wishes to test the results of a simulation by a published model, and use that as a starting point for further research. Instead of recreating the model from scratch, the user goes to the ModelDB home page (Fig.1, top), to find the model by any of the various ways already mentioned. All the information about a model is shown on a single page (Fig.1, bottom), which also contains tools for finding related models in the database.

The files required to run a simulation are stored in a compressed archive in zip format and can be browsed and/or downloaded (Fig.1, bottom, lower left column). There are links between ModelDB and NeuronDB to show extensive information about the distribution of receptors, currents, and transmitters derived from the experimental literature for the particular neuron or property to which the model refers. For models implemented in the NEURON simulator (Hines and Carnevale, 1997), the simulation can be run directly from

the browser (by clicking on the "Auto-launch" button) if NEURON is already installed on the host computer.

Submitting Models

The value of a database depends on it being populated with data. In order to stimulate input from the community we summarize briefly the submission process. Further details may be found at http://senselab.med.yale.edu/senselab/ModelDB/guide2.html.

A model submission consists of sending the reference to a paper (each model in the database must be associated with a paper published in a peer-reviewed journal) and a compressed archive (e.g., zip file) containing the model files that are needed to reproduce some of the results reported in the paper. The administrator will check the files for consistency, confirm that the model reproduces any intended figure(s), and then add the model to the database.

Contributors decide which simulations best illustrate the model. Depending on the kind of model that one wants to submit, there are a few obvious choices. For example, realistic implementations of a specific neuron, e.g. the model of thalamic relay neurons (Destexhe et al., 1998; http://senselab.med. yale.edu/senselab/ModelDB/ShowModel.asp?model=279), shows the firing properties under simple current injections. More elaborate models, such as those dealing with network properties (e.g., synchronization), higher brain functions (e.g., memory or vision), or specific computational mechanisms (e.g., dendritic integration, temporal summation, or synaptic plasticity) require a careful selection of what to demonstrate. A user should be able to grasp quickly and simply the main features and capabilities of the model. Auto-launch demonstrations that run longer than one minute tend to tax users' patience. Complex plots drawn during or at the end of long simulations are justified only when they are the most important part of
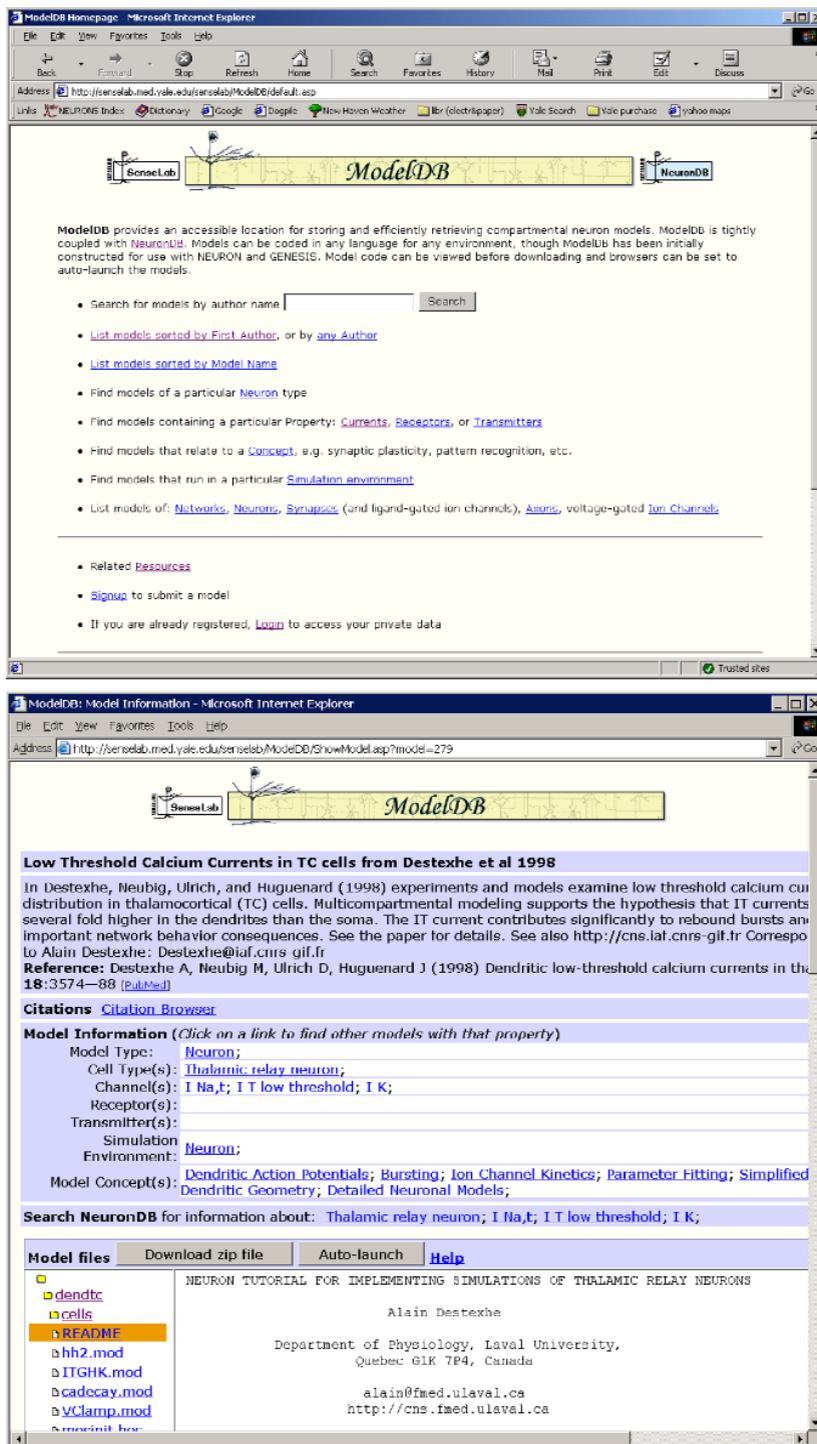
Fig. 1. (Top) The home page of ModelDB. (Bottom) Typical appearance of a model's home page. In this case, a model for thalamic relay neurons is shown.

a model. One of the latter examples is the reduced implementation of the Hopfield and Brody (2001) model (http://senselab.med.yale.edu/senselab/ModelDB/mdbFtof.asp?model=2798) which illustrates how a transient synchrony of many neurons in a network can recognize a spatiotemporal activity pattern.

Some users may prefer to maintain complete control of the entire submission process rather than sending files to the administrator. In this instance, the ModelDB administrator creates a private account via which authors can upload and test different ways to present model(s) before making it (them) public.

Model files are often used by investigators as a starting point to arrange their own models and simulations. To encourage the dissemination and use of the models, contributors should consider simplifying, modularizing, and documenting their code whenever possible. Adding a new model and linking it to the SenseLab searching facilities is a straightforward task. A quick look at several public models will suggest how to define the various fields. Every aspect of the model (name, notes, properties, and the archive file via re-uploading) can be edited as many times as necessary, until the contributor decides that the model is now ready to be made public. Even after a model is made public it can still be subsequently edited.

ModelDB has played an essential role in research on the active properties of dendrites (Shen et al., 1999; Migliore and Shepherd, 2002). Other investigators have used it for creating a network output for driving a particular cell (Chemin et al., 2001) and for tutorials for developing computational modeling skills. Worldwide, many institutions have downloaded files from ModelDB.

Conclusion

ModelDB provides a resource for the computational neuroscience community that enables investigators to increase their under-

standing of published models by enabling them to run the models as published and build on them for further research. Its use can aid the field of computational neuroscience to enter a new era of expedited numerical experimentation.

Acknowledgments

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