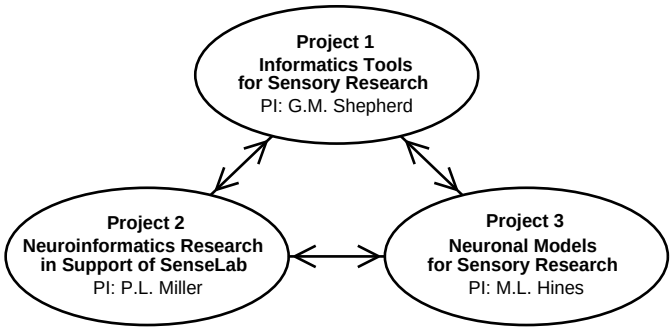
Neuroinformatics and Computational Neuroscience: a Practical Perspective

N.T. Carnevale, Department of Psychology
M.L. Hines, Department of Computer Science
Yale University

Resume of talk

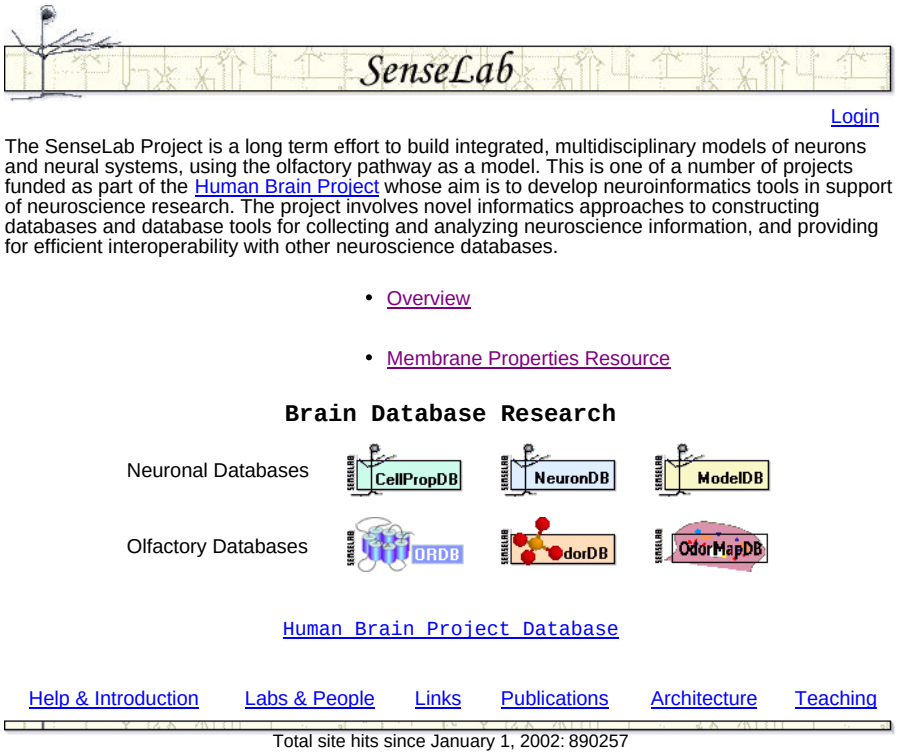
Overview of the SenseLab Project

SenseLab (http://senselab.med.yale.edu/senselab/) is motivated by a specific interest in understanding the neural operations in the peripheral olfactory system that underlie the sense of smell. Its overall aim is to develop databases and database tools that will enhance the experimental and computational analysis of the functional organization of brain cells and circuits. In order to test and demonstrate the generality of its neuroinformatics results, this project is not restricted to the mammalian olfactory system, but also includes cells and circuits in other brain regions. The SenseLab Project emerged from the Human Brain Project and receives support from NIH, which has encouraged data sharing for many years.



The three components of the SenseLab Project

SenseLab is a collaborative research effort that involves three teams working on related projects in close coordination under the overall leadership of Dr. G.M. Shepherd. Dr. Shepherd also the project that is concerned with developing the databases of experimental data (e.g. ORDB, OdorDB, OdorMapDB, CellDB, NeuronDB). The project that addresses database issues, such as the EAV/CR data model and developing a standardized ontology for expressing neuroscience data items, is under the direction of Dr. P.L. Miller. Dr. M.L. Hines is the director of the project that is concerned with computational modeling and development of ModelDB.



The home page of SenseLab

ModelDB

ModelDB (http://senselab.med.yale.edu/senselab/modeldb/) is a key component of the SenseLab Project because of the value of computational modeling as a tool for integrating different types of data (anatomy, physiology, pharmacology, molecular biology) into a consistent conceptual framework. The history of computational modeling in neuroscience research stretches back at least as far as the work of Hodgkin and Huxley, and there are many experimentalists and theoreticians who would testify that it has become increasingly important and useful since the early 1980s. However, until very recently, the Achilles heel of computational neuroscience has been the difficulty of reproducing published results. With very few exceptions, modeling papers generally do not contain the information that is necessary for readers to be able to recreate the model and verify the results that were obtained from it. There are many reasons for this−−omission of important details, incorrect parameter values, typographical errors−−but the end result is the same: it decreases the scientific utility of the work that was done.

Another problem faced by those who want to use computational modeling in their research is the sheer difficulty of finding papers that report models. More computational modeling papers are being published than ever before in the neuroscience literature, but we have found that Medline searches can miss more than 70% of them.

Clearly the field of computational neuroscience needs a convenient and effective vehicle that authors can use to distribute their models for attributed re−use by others, and that other neuroscientists can use to easily find and obtain these models in working form. ModelDB is being developed in order to address this need.

ModelDB provides an accessible location for storing and efficiently retrieving compartmental neuron models. ModelDB is tightly coupled with NeuronDB. Models can be coded in any language for any environment, though ModelDB has been initially constructed for use with NEURON and GENESIS. Model code can be viewed before downloading and browsers can be set to auto-launch the models. Help

- Search for models by author name [ ] Search
- List models sorted by first author, by each author or by model name
- Find models of a particular Neuron type
- Find models containing a particular Property: Currents, Receptors, or Transmitters
- Find models that relate to a Concept, e.g. synaptic plasticity, pattern recognition, etc.
- Find models that run in a particular Simulation environment
- List models of: Networks, Neurons, Synapses (and ligand-gated ion channels), Neuromuscular Junctions, Axons, voltage-gated Ion Channels
- Find models containing the following words [ ] Search ☐ Case Sensitive
- Search for publications in ModelDB or in PubMed

- Signup for an account for creating and editing models privately
- Login to access your models
- Related Resources

Total site hits since January 1, 2002: 236273

ModelDB Home SenseLab Home Help
Questions, comments, problems? Email the ModelDB Administrator
How to cite ModelDB

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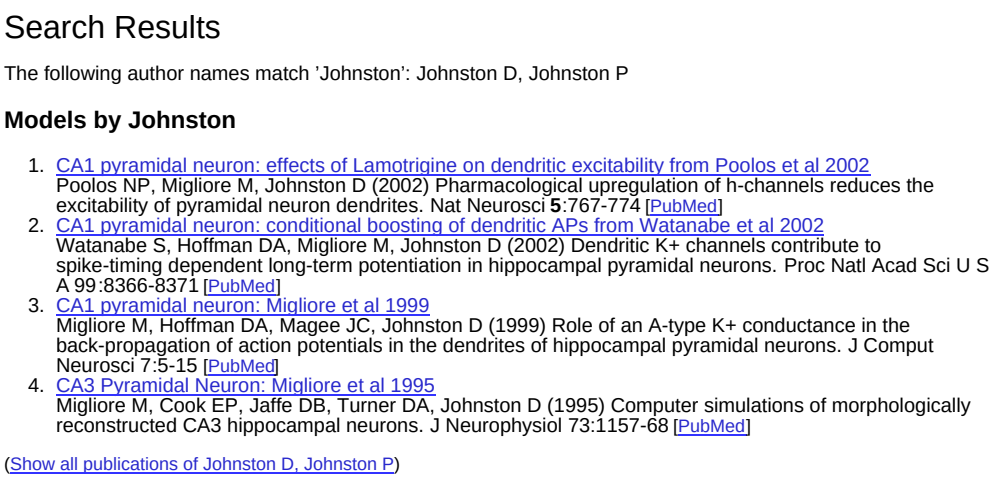
The home page of ModelDB. To conserve space and emphasize substantive content, the standard header and footer have been removed from all subsequent images.

The design and implementation of ModelDB are a response to three user−oriented problems:

1. Users must be able to find interesting models quickly and conveniently.
2. Models retrieved from the database must work and be reusable.
3. The process of entering new models into the DB must satisfy criteria 1 and 2 while also being as convenient as possible.

The models that authors submit are generally configured for their own private research application, and it can be difficult to enter these into a database in such a way that others can easily understand and reuse them. Therefore model entry is performed by a member of the ModelDB team in collaboration with the model's author. The result is that ModelDB now contains more than 100 high−quality, well−maintained models that are searchable, downloadable, and actually work.

These models can be searched and retrieved according to any of the following keys: the name of any author; the name of the model; a particular type of neuron; the presence of a particular property (currents, receptors, transmitters); the presence of a particular word anywhere in the model's files; relation to a particular concept (e.g. synaptic plasticity); the model's simulation environment or programming language (e.g. NEURON, GENESIS, C/C++). In addition there are preconfigured links that generate lists of all available models of networks, neurons, synapses, neuromuscular junctions, axons, or voltage−gated ion channels.



Search Results

The following author names match 'Johnston': Johnston D, Johnston P

Models by Johnston

1. CA1 pyramidal neuron: effects of Lamotrigine on dendritic excitability from Poolos et al 2002
   Poolos NP, Migliore M, Johnston D (2002) Pharmacological upregulation of h-channels reduces the excitability of pyramidal neuron dendrites. Nat Neurosci **5**:767-774 [PubMed]
2. CA1 pyramidal neuron: conditional boosting of dendritic APs from Watanabe et al 2002
   Watanabe S, Hoffman DA, Migliore M, Johnston D (2002) Dendritic K+ channels contribute to spike-timing dependent long-term potentiation in hippocampal pyramidal neurons. Proc Natl Acad Sci U S A 99:8366-8371 [PubMed]
3. CA1 pyramidal neuron: Migliore et al 1999
   Migliore M, Hoffman DA, Magee JC, Johnston D (1999) Role of an A-type K+ conductance in the back-propagation of action potentials in the dendrites of hippocampal pyramidal neurons. J Comput Neurosci 7:5-15 [PubMed]
4. CA3 Pyramidal Neuron: Migliore et al 1995
   Migliore M, Cook EP, Jaffe DB, Turner DA, Johnston D (1995) Computer simulations of morphologically reconstructed CA3 hippocampal neurons. J Neurophysiol 73:1157-68 [PubMed]

(Show all publications of Johnston D, Johnston P)

The results of a ModelDB search for models by a particular author.

ModelDB also contains a searchable bibliography of modeling−related publications (currently over 8,000 publications from more than 9,600 authors) so that users can more readily grasp the relationship of these models to the rest of neuroscience research. Most of the citations in ModelDB's bibliography include a specific link to the corresponding entry in PubMed, to facilitate more extensive literature searches. In a survey of ModelDB users (see below), most respondents said they found this feature to be a very useful.

Although ModelDB is still at a relatively early stage of development, our webserver's records reveal that it is already being used extensively, with more than 88,000 "hits" over the 16 months from March 1, 2002 through June 30, 2003. This does not include usage by individuals who are affiliated with SenseLab, database developers, and web robots (identified at www.iplists.com).

We recently performed an informal survey to obtain the opinions and recommendations of ModelDB users. Almost all respondents said they were interested in "complete models," i.e. complete sets of anatomical and biophysical properties as specified by model authors. About half reported they were also interested in particular morphologies or biophysical mechanisms and appreciated being able to search for these properties. All agreed strongly and universally on

several key points: models were easy to find and download, and ModelDB was helpful to their project.

The survey also asked for specific recommendations for improving and extending ModelDB. These recommendations included:

- keeping the database as up−to−date as possible
- expanding the bibliography to include more papers about models and the empirical basis for their assumptions
- adding new search topics (e.g. experimental methodologies such as the use of complex stimulus waveforms, optimization)
- adding an advanced search that allows Boolean combinations of keywords
- offering a preview of the properties of a model (anatomy and biophysical attributes) before it is downloaded

Our current research plan includes strategies to address all of these issues. In addition, some users commented on the difficulty of understanding certain model source files, especially with regard to determining the specification of the biology. This is an important and general problem that affects all computational modeling, and we are working to implement a method for dealing with it.