Xolotl

A fast and flexible neuronal simulator

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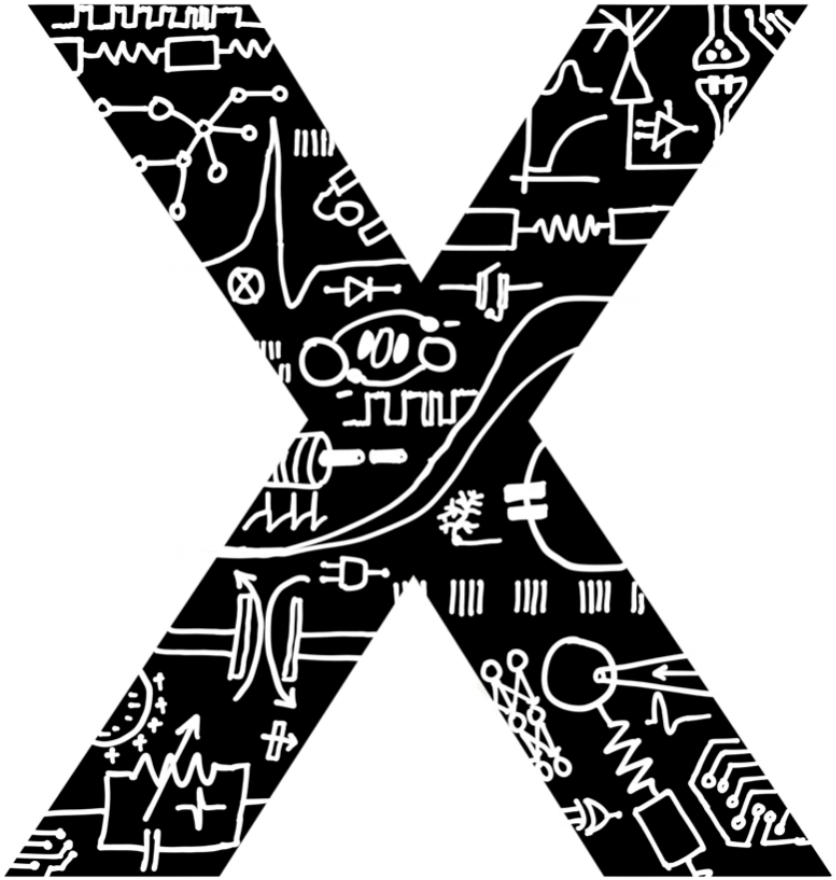
Structure of Talk

"What" more than "Why and How"

1. What is xolotl?
2. Features
3. Demonstrations
    1. My first neuron
    2. My first network
    3. Demos & interactive demos



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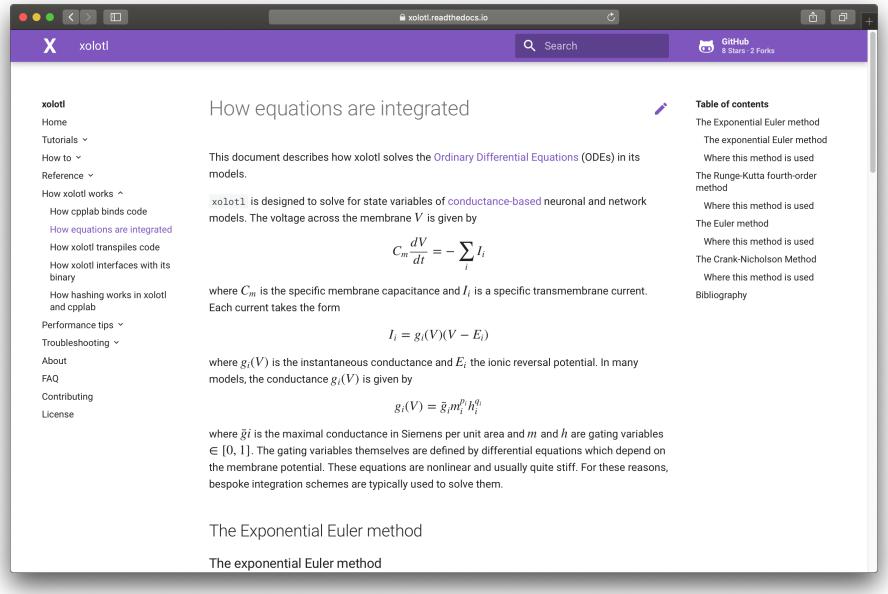
Design Principles

Xolotl should be

- fast
- easy-to-use
- well-documented
- hackable and extensible
- auditable

more than **3x** faster



How xolotl works

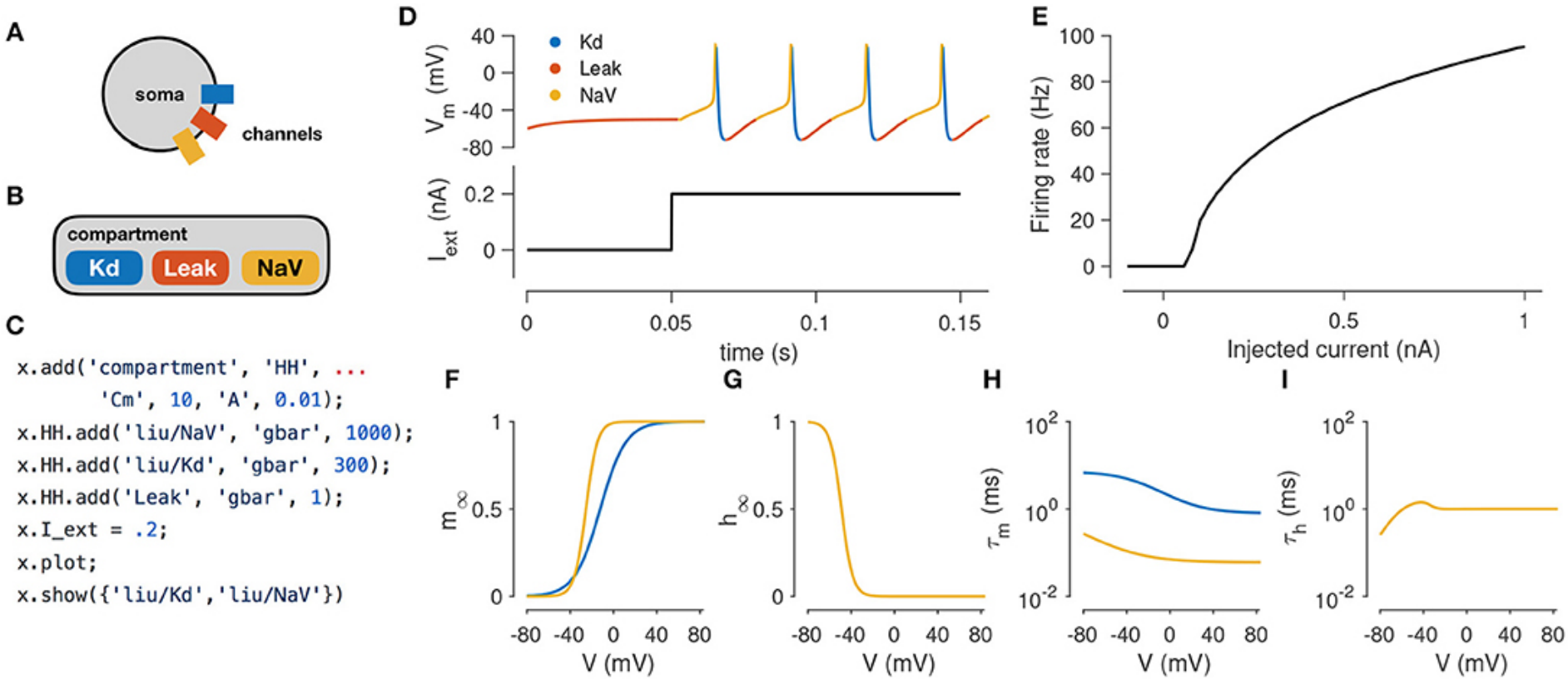


Figure: Model of A & B represented in code C which produces D-I.

Anatomy of a model

Types of Components:

- Compartments
  - Mechanisms
  - Conductances
    - ★ Mechanisms
  - Synapses
    - ★ Mechanisms

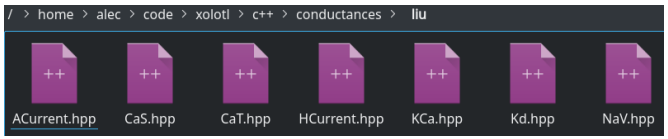


Figure: 100+ components are a searchable, indexed feature of the language.

Code to generate an HH model with constant injected current:

```
x = xolotl;
x.add('compartment', 'HH', 'Cm', 10, 'A', 0.01);
x.HH.add('liu/NaV', 'gbar', 1000);
x.HH.add('liu/Kd', 'gbar', 300);
x.HH.add('Leak', 'gbar', 1);
x.I_ext = 0.2;


-----------------------------------------------
% How xolotl prints in the console
-----------------------------------------------


>> x
xolotl object with
----------------------
+ HH
  > Kd (g=300, E=-80)
  > Leak (g=1, E=-55)
  > NaV (g=1000, E=30)
----------------------
```

Cool features

- `puppeteer`: real-time parameter manipulation
- `xgrid`: parallel simulation across a distributed network
- `xfit`: parameter optimization using particle swarm and genetic algorithms
- `xtools`: spike counting and data analysis
- model hashing and snapshotting
- control over input and output (clamping, full state matrix)
- automatic component generation from MATLAB
- hyperlinking and tab-completion in the console
- multiple solvers, look-up table caching

Coming Soon

- multi-threading of a single simulation
- server-side compilation / stand-alone integration
- (multi-compartment) server-side GPU computation of Hines matrices
- new compartment types (including low-dimensional models)
- universal support for Runge-Kutta integration schemes
- adaptive time-step solvers (quadrature)
- robust front-end unit support
- Julia front-end (compatible with Python, etc.)

Real-time manipulation

Real-time parameter manipulation. Any numerical xolotl property can be manipulated.

xfit: Parameter optimization

Optimized for:

1. Slow-wave troughs at -70 mV.
2. Slow-wave peaks at -40 mV.
3. Spike downswing ends above slow wave trough.
4. Burst frequency of 0.5 Hz.
5. Duty cycle of 0.3.

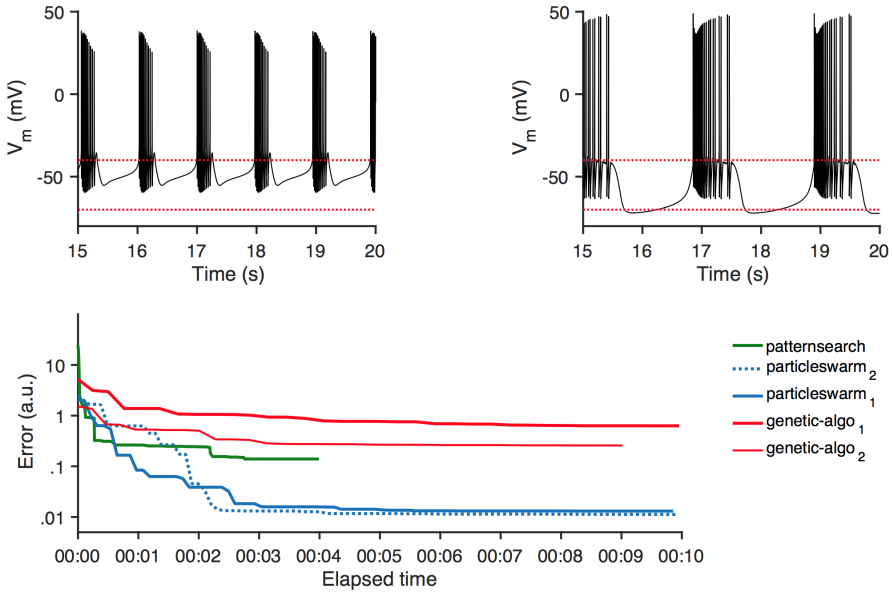


Figure: Fit of 8-conductance model (left to right). PSO #2 shown.

Installing

Acquiring the MATLAB toolbox

1. Go to https://github.com/sg-s/xolotl/releases/latest
2. Download `xolotl.mltbox`
3. Find the file in `Downloads` and drag it onto your `MATLAB` workspace
   This will install `xolotl`

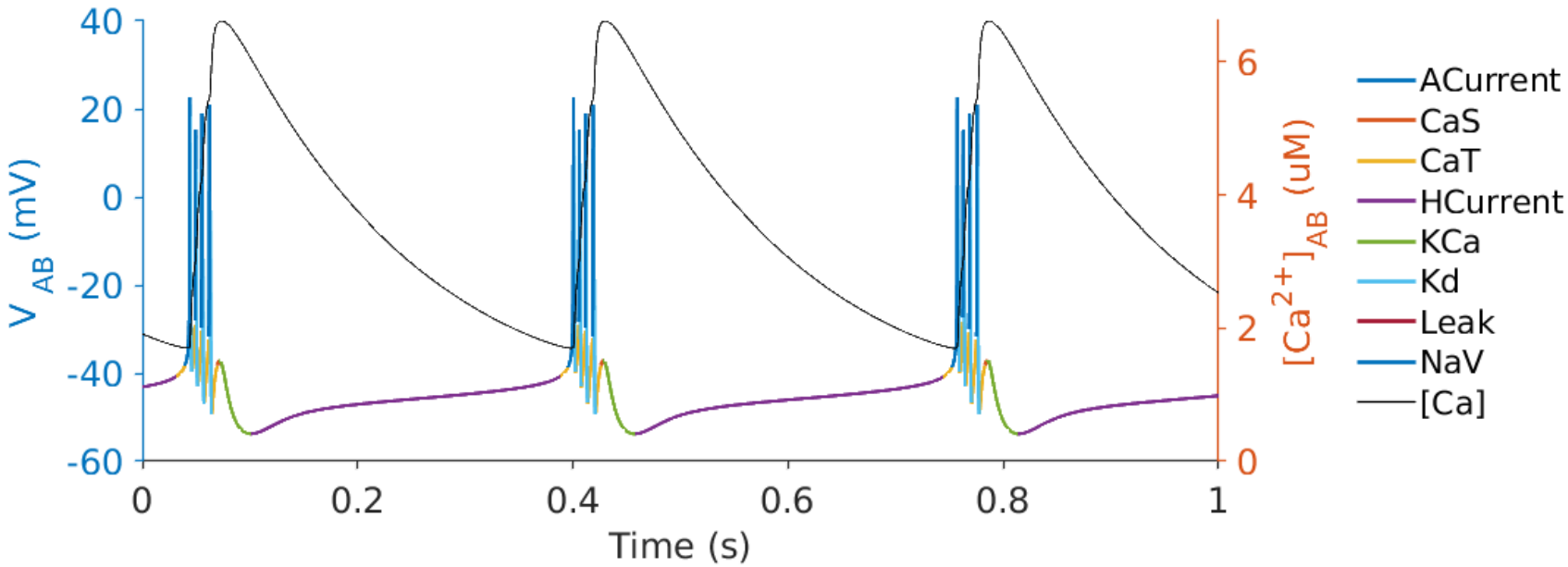
https://xolotl.readthedocs.io/en/master/tutorials/start-here/

Run the following commands in MATLAB. You should see this plot.

```
% setup the C++ compiler
mex -setup c++
mex -setup c
% click the link for the MinGW64 Compiler (C++)

% rebuild the component cache
xolotl.rebuildCache

% test to make sure everything is correct
xolotl.go_to_examples
demo_bursting_neuron
```



https://xolotl.readthedocs.io/en/master/tutorials/built-in-demos/

Demonstrations

Your first neuron

https://xolotl.readthedocs.io/en/master/tutorials/first-neuron/

Your first network

https://xolotl.readthedocs.io/en/master/tutorials/first-network/

All demos

https://xolotl.readthedocs.io/en/master/tutorials/built-in-demos/