The Neuroscience Gateway (NSG) - *enabling large scale simulation and data processing in neuroscience*

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The Neuroscience Gateway (NSG)

The NSG provides simple and secure access through portal and programmatic services, to run neuroscience modeling and data processing software and tools on compute resources
http://www.nsgportal.org

NSG catalyzes and democratizes computational and data processing neuroscience research and education for everybody including researchers and students from underrepresented institutions

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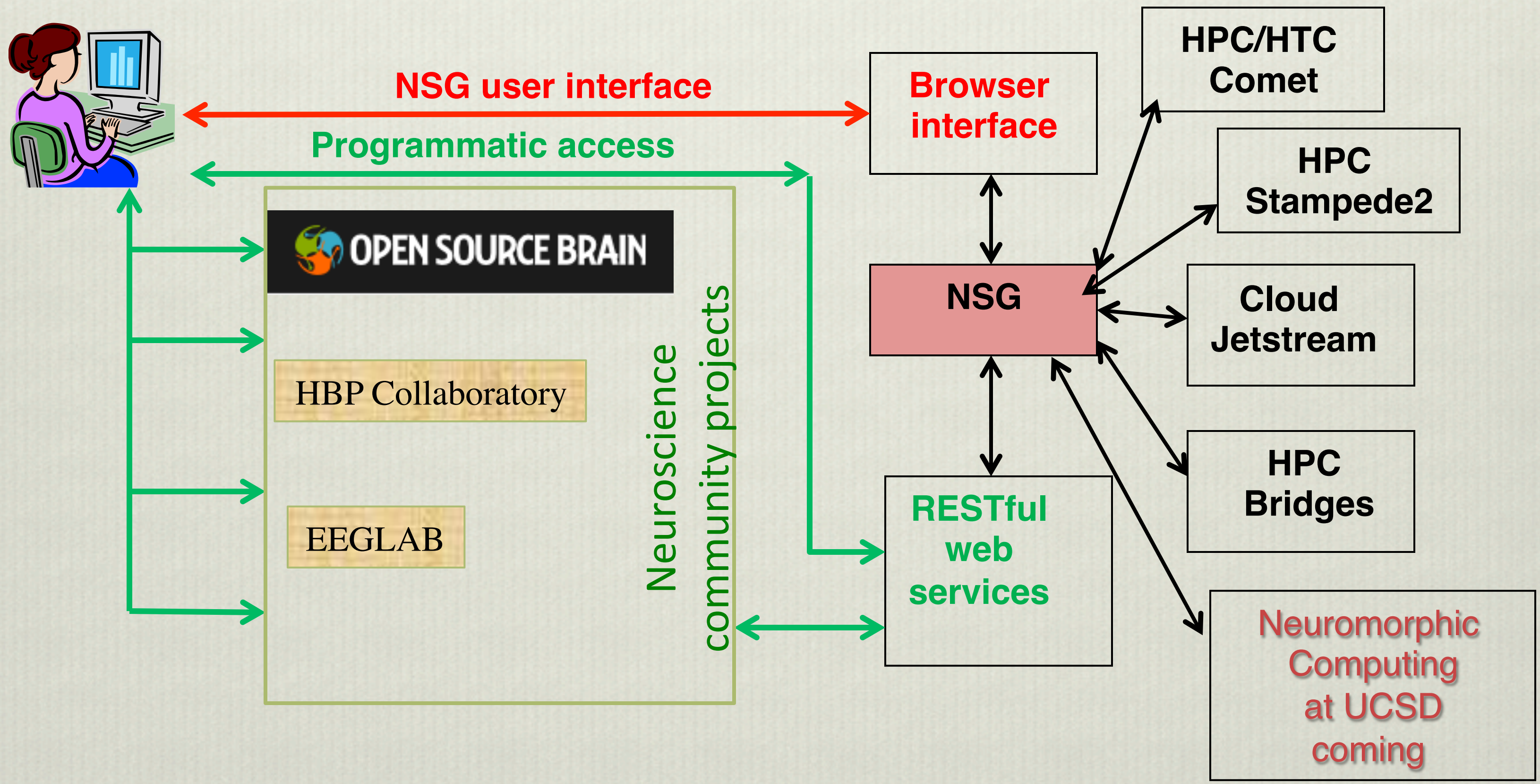
NSG - Portal and Programmatic Access

- NSG Portal: Simple and easy to use web interface
- NSG–R: Programmatic access through RESTful services



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NSG software stack
(new tools added regularly based on user needs)

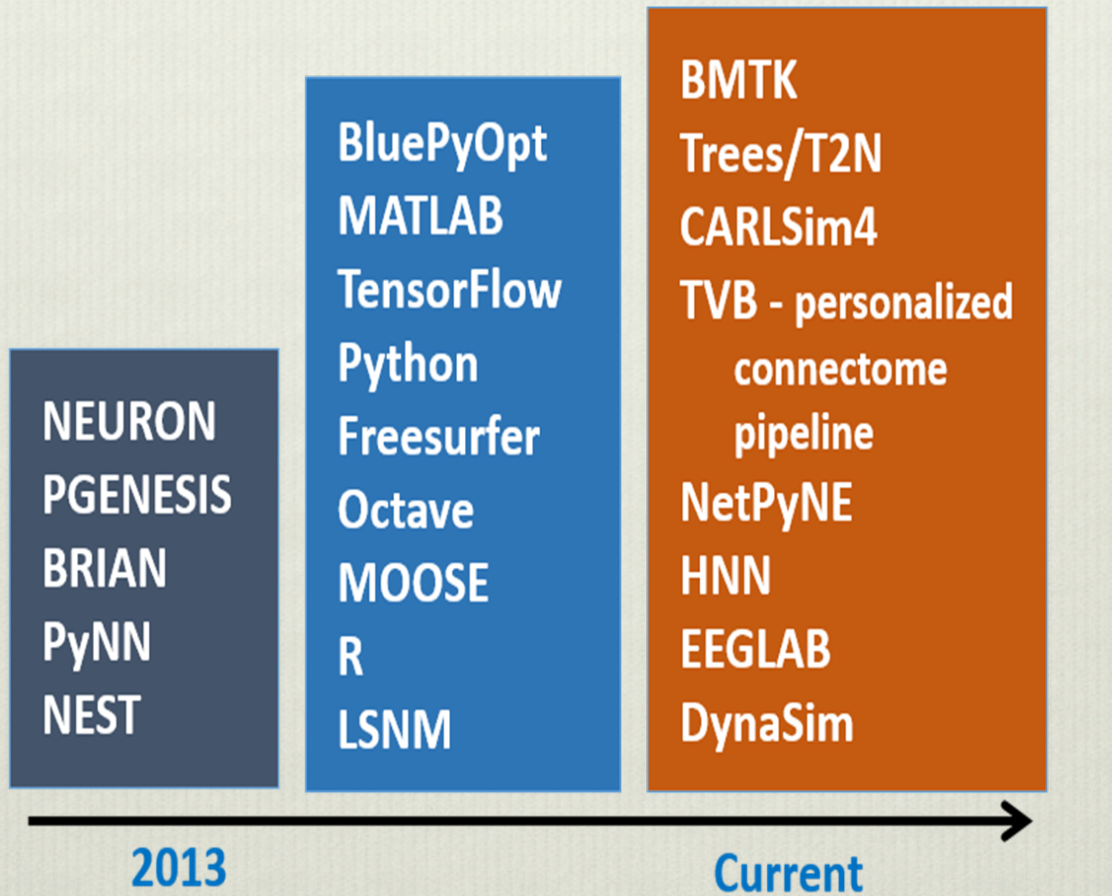

Figure 1. Current NSG tools, pipelines, software.

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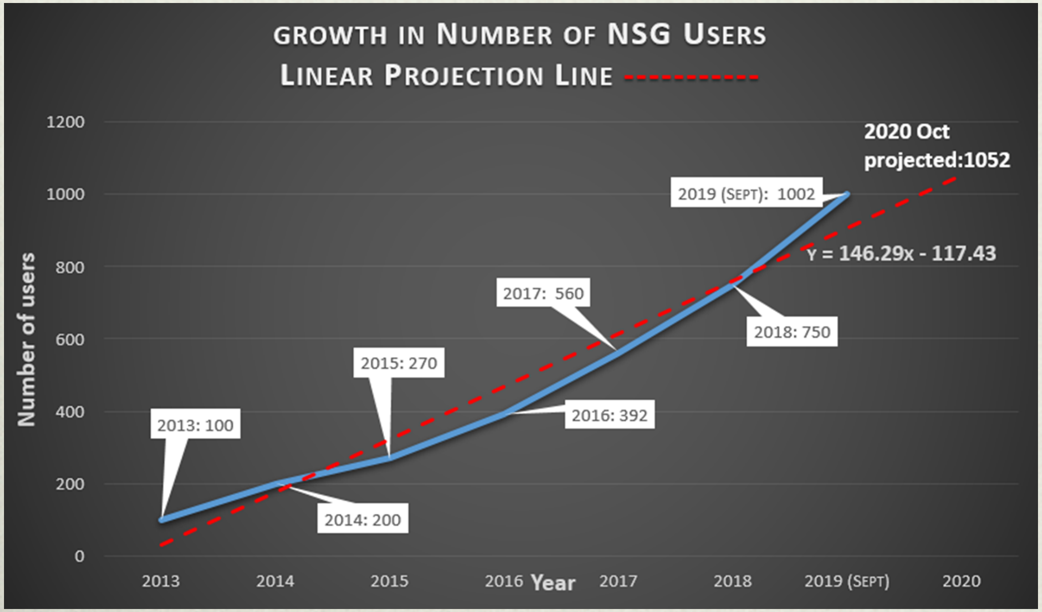
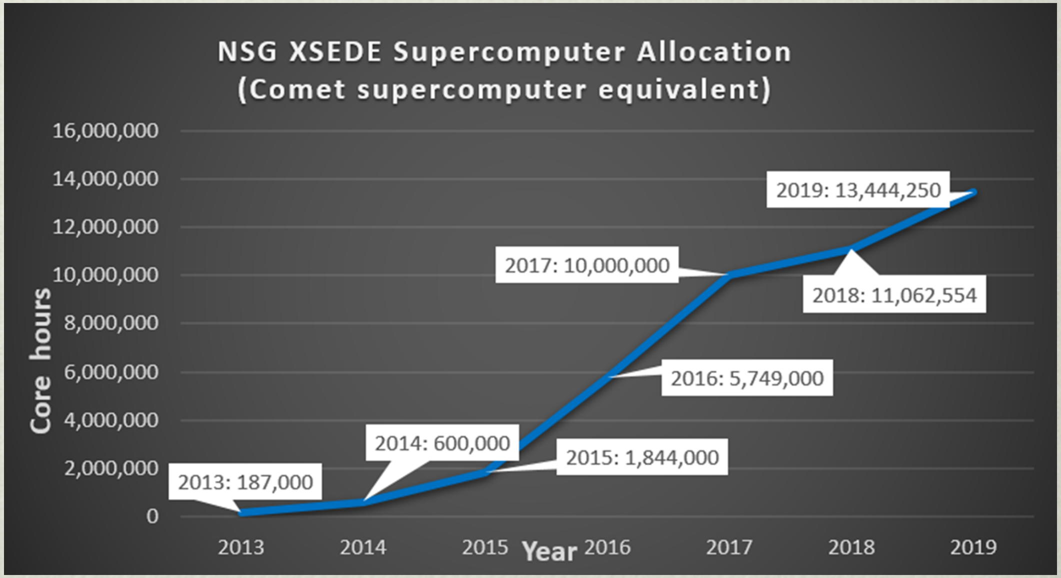
NSG Growth – since 2013





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Summary

- NSG provides programmatic and portal access to neuroscience tools, pipelines, data processing software on HPC, HTC and academic cloud resources
- NSG works with developers for neuroscience related software dissemination
- Encourage collaboration with researchers from around the world; strongly encourage high school, undergraduate student participation in summer projects with NSG.
- Workshops at Society for Neuroscience annual meetings, Computational Neuroscience annual meetings, NEURON Summer Workshops, CogSci18, MSI institutions (New Mexico State University, Cal State San Bernardino)
- Please cite us if you use NSG (http://www.nsgportal.org/citation.html)
  S Sivagnanam, A Majumdar, K Yoshimoto, V Astakhov, A Bandrowski, M. E. Martone, and N. T. Carnevale. Introducing the Neuroscience Gateway, IWSG, volume 993 of CEUR Workshop Proceedings, CEUR-WS.org, 2013
- If NSG was used, please let us know of your talks, presentations, publications, thesis work so that we can include in reports – nsghelp@sdsc.edu

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Running NEURON on NSG

- NEURON (*https://neuron.yale.edu*)
- Advantages:
  - Active community & ongoing development
  - Comprehensive documentation and tutorials
  - Flexible, modular approach: e.g. can swap between integrate-and-fire cells and multi-compartment ones)
  - Manages multiscale modeling: molecules ↔mesoscale ↔macrocolumns
  - Interface with Python, speed of C, and easy to parallelize; network modeling

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Model

Hodgkin-Huxley cable equations

$$\frac{1}{4D}\frac{\partial}{\partial x}\left(\frac{D^2}{R_a}\frac{\partial V}{\partial x}\right) = C_m\frac{\partial V}{\partial t} + \bar{g} m^3 h\cdot(V-E_{na}) + \bar{g}_k n^4\cdot(V-E_k) + g_l\cdot(V-E_l)$$

$$\frac{dm}{dt} = -\alpha_m m + \beta_m(1-m) \qquad \alpha_m = \frac{0.1(V+40)}{1-e^{-0.1(V+40)}} \qquad \beta_m = 4e^{-(V+65)/18}$$

$$\frac{dh}{dt} = -\alpha_h h + \beta_h(1-h) \qquad \alpha_h = 0.07e^{-0.05(V+65)} \qquad \beta_h = \frac{1}{1+e^{-0.1(V+35)}}$$

$$\frac{dn}{dt} = -\alpha_n n + \beta_n(1-n) \qquad \alpha_n = \frac{0.01(V+55)}{1-e^{-0.1(V+55)}} \qquad \beta_n = 0.125e^{-(V+65)/80}$$

Simulation

Representation

```
create axon
axon {
   nseg = 43
   diam = 100
   L = 20000
   insert hh
}
```

```python
from neuron import h, gui
from matplotlib import pyplot as plt

# create soma section
soma = h.Section(name='soma')
dend = h.Section(name='dend')

h.psection(soma)

# create dend section and connect to soma
dend.connect(soma(1))
h.topology()

# set geometry
soma.L = soma.diam = 12.6157 # Makes a soma of 500 microns squared.
dend.L = 400 # microns
dend.diam = 1 # microns
dend.nseg = 11

# Set membrane properties
for sec in h.allsec():
    sec.Ra = 5    # Axial resistance in Ohm * cm
    sec.cm = 1      # Membrane capacitance in micro Farads / cm^2

# Insert active Hodgkin-Huxley current in the soma
soma.insert('hh')
soma.gnabar_hh = 0.12  # Sodium conductance in S/cm2
soma.gkbar_hh = 0.036  # Potassium conductance in S/cm2
soma.gl_hh = 0.0003    # Leak conductance in S/cm2
soma.el_hh = -54.3    # Reversal potential in mV

# Insert passive current in the dendrite
dend.insert('pas')
dend.g_pas = 0.001  # Passive conductance in S/cm2
dend.e_pas = -65    # Leak reversal potential mV

# Change the maximum sodium conductance of the middle segment of the soma to 0.13
soma(0.5).hh.gnabar = 0.13

# Change the equilibrium potential of the passive mechanism in the middle segment of the dend to -65
dend(0.5).pas.e = -65
```

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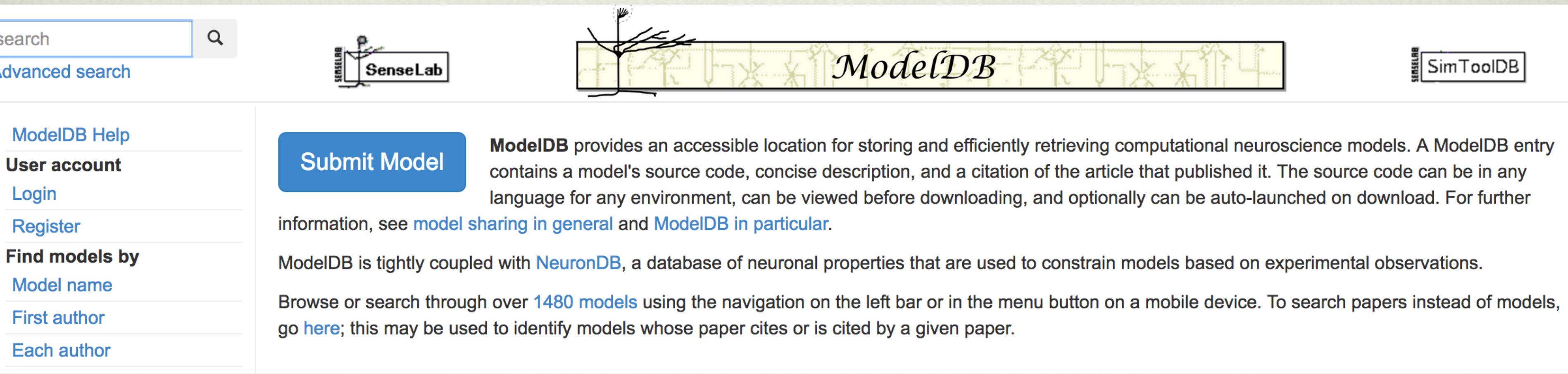
ModelDB

https://senselab.med.yale.edu/modeldb/



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Using NSG

http://www.nsgportal.org

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