Introduction to NEURON(90 Mins):

- 30 mins presentation
    - Who am I? (1 minute)
    - Why use NEURON? (5-10 mins)
        - Use-cases: What does it do?
            - What do i need to use it?
        - Resources
    - Basics of NEURON (20-25 mins):
        - 2 Parts: HOC and .mod files
            - GUI vs HOC
            - Example simulation: Single Compartment HH with current injection
        - Representing cell morphology

- Using channels
- Stimuli
- Running the simulation
- Plotting the results
- 45 mins exercise
  - Based on David Sterrat and Andrew Gillies tutorial
- 15 mins Wrap up
  - nrnivmodl
  - More things with NEURON: cvode,
  - Interfacing with Python (limitations)
  - other simulators - GENESIS, MOOSE
  - other options; morphforge, neuroml, nineml, neuronvisio, pynn;
  - Links to other tools

Why use NEURON (5-10 mins)

From the NEURON website (my bold type):

- is a flexible and powerful **simulator of neurons and networks**

- has important advantages over general-purpose simulators helps users **focus on important biological issues** rather than purely computational concerns

- has a convenient user interface

- has a **user-extendable** library of biophysical mechanisms

- has many enhancements for **efficient network modeling**

- offers customizable initialization and simulation flow control

- is widely used in neuroscience research by experimentalists and theoreticians

- is well-documented and **actively supported**

- is **free, open source**, and runs on (almost) everything

Use-cases - What does it do? I

- **Modelling of multicompartmental neurons**

    - keeps track of ion movements

- Connections between cells through synapses

- Defining your own channels & synapses

- If you are interested in large networks of 'simple', single compartement neurons, there are other options.

Use-cases - What does it do? II

- For a single compartment cell with simple HH dynamics, you can probably write your own solver using ODE solvers in matlab/python.

- As your models develop more complexity:

    - Current dependancies e.g. intracellular $Ca2+$ dependant K channels

    - Solving of Cable Equations for multicompartmental neurons

    - Connections via synapses & gap junctions

- You may find that you are reimplementing lots of mathematical solving, which has been already been done efficiently in NEURON.

- MOD files provide a standard for exchanging channel descriptions (e.g. modeldb)

- There is a python interface

- Highly parallelisable (e.g. BBP) for large networks

What do i need to use it?

- It runs on most operating systems (Windows/Linux/Mac). On the NEURON website:
    - Windows installer
    - Mac package
    - Linux .deb, .rpm package
- Eilif Muller has a precompiled binaries including Python support http://neuralensemble.org/people/eilifmuller/software.html

Resources

- Active questions board
- ModelDB
- The NEURON Book

Basics of NEURON (20-25 mins)

2 Parts: HOC and NMODL files

- Two main types of language:

    - Interpreted languages (Python/matlab) are interactive, but slow

    - Compiled languages (Fortran/C/C++/...) are fast

- NEURON uses both:

    - 'HOC' - which controls the 'structure' of the simulation

    - 'NMODL' - a compiled language for specifying the dynamics of channels/synapses mathematically (e.g. Hodgkin-Huxley type channels).

HOC Interpreter

- HOC is an interactive interpreter which controls the 'structure' of the simulation:

    - creating morphologies

    - defining which channels to apply and changing certain parameters (channel densities)

    - creating stimuli: current clamps, voltage clamps

    - defining what you want to record: voltages, internal states

    - setting simulation parameters: stimulation time-steps,

    - running the simulation
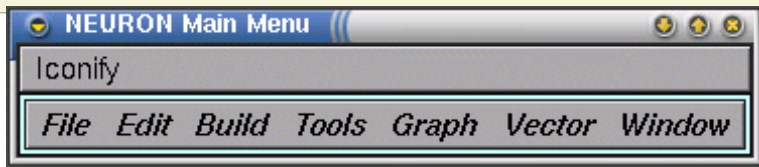
NMODL

- We will discuss NMODL later...

HOC - Graphical User Interface

• NEURON can be used entirely from the commandline and with 'scripts':

```
$ nrnoc
$ oc>
```

• NEURON also has a graphical user interface:

```
$ nrngui
```

Overview of all the components

Example Simple simulation: Soma + Axon Compartment HH with current injection

TODO: Image:

Representing cell morphology

- In NEURON, neuron morphologies are represented as a tree of 'unbranched cylinders'

todo: Image of this:

```
Example1
```

Using channels

Stimuli

Running the simulation

Plotting the results