Computational Neuroscience
Peter Thomas, Instructor
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Project Instructions

The course requires a project in which you use computational and mathematical modeling to investigate the behavior of a model neural system. Examples could include:

- Model rhythmogenesis in the Aplysia central pattern generator for ingestion & egestion. References: papers by Baxter & Byrne (e.g. translate their SNNAP model into NEURON).
- Implement a model for reliable burst activity in an olfactory circuit as described by Balu & Strowbridge.
- Model extracellular recordings from a bundle of nerve cells. How does the action potential appear different as a function of distance from the fiber? How does the extracellular voltage trace differ from the intracellular waveform?
- Develop bifurcation diagrams for stable phase locking for different neural models driven by sinusoidal current injection, or sum-of-two sinusoids current injection, and look at departures from linear superposition.
- Using the design principles described in Stiefel & Sejnowski 2007, create a multicompartment model neuron in NEURON that selectively responds to simultaneous inputs, and another that corresponds preferentially to staggered inputs.
- Brette & Guigon (2003) claimed that convergence of trajectories is a generic property of most neural models. Read their paper, and test their claim by implementing several different determinstic models that should all show stability of response. Include leaky integrate-and-fire, quadratic integrate-and-fire, Ermentrout's Theta neuron, and at least one conductance-based model (e.g. INaP+K or Morris-Lecar).
- Implement the model in Golomb et al's 2007 paper, *Mechanisms of Firing Patterns in Fast-Spiking Cortical Interneurons* and explore their conclusions.
- Implement the model in Prescott et al's 2006 paper, *Nonlinear interaction between shunting and adaptation controls a switch between integration and coincidence detection in pyramidal neurons*, and explore their conclusions.
- There are many published models on different platforms available on Model DB. See http://www.neuron.yale.edu/course/modeldb.html for examples.

Due to the large class enrollment, you form a team of 2-3 students to work together on a project. Each person should make a distinct contribution to the modeling efforts within the project. For example, in a project looking at phase locking, different group members could examine the same phenomenon in different model cells (e.g. one work with a "resonator", another with an "integrator"). Or two students might work together to develop similar

simulations using two different platforms (NEURON and XPP, for example) and analyze different aspects of the behavior.

Your team should turn in a one page written proposal before 4:00 p.m. Friday 3/7, either electronically or in paper format. The proposal should include a project title, the names of the participants, a paragraph addressing the background and motivation for your proposed work, a synopsis of relevant background references, and a research plan indicating the intended scope of the project and the anticipated division of labor amongst the participants. If you have access to experimental data that relates to your model I encourage you to incorporate comparisons and discussion of the data in your writeup as well.

Each team should prepare a 10-minute presentation of their work, and a report. The project writeups should be organized along the lines of a standard research paper, including the following elements:

Introduction (background and motivation)
Methods (detail your computational and mathematical methods)
Results (including figures with appropriate captions, labels etc.)
Conclusions and Discussion (put the work in context, refer back to the original goals, outline future directions if relevant).
Statement of author contributions (indicate who should get credit for what aspect of the project).
References

The total length should be 15-20 pages, including figures and references.

Course:_____ Students:_____ Date:_____

Grading Rubric for Student Project Reports

Projects are graded on a 40-point scale, with the presentation worth 10 points.
Each of the six items below is worth up to five points.

Substance:

1. (5 pts) **Background or Introduction**
Is the problem motivated convincingly?
Is it described clearly?
Are the relevant equations derived appropriately?

2. (5 pts) **Methods**
Are the numerical and/or analytic methods described clearly, correctly and in sufficient detail?
(Numerical)
(Analytic)

3. (5 pts) **Results**
Are the results significant (given the level expected for the project)?
Are diagrams or figures (if any) clearly labeled and explained?
Are the results presented clearly?

4. (5 pts) **Conclusions**
What is the broader significance of the results?
Did the results turn out as expected?
Did the project members arrive at any new insights?
Do the conclusions follow from the results presented?

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Style:

5. (5 pts) **Composition**
Is the report written in clear English prose with correct grammar, spelling, punctuation and so on?

6. (5 pts) **Overall**
Does the narrative form a coherent whole? Is it organized? Does the report read well?

Presentation: (up to 10 points total)
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