Course Goals

Current neurophysiological techniques allow for the collection of very large amount of data. This data collection is however limited to only a few neurons at a time, or a few trials per neurons, and require labor-intensive experimental paradigms that are focused on very specific hypotheses. Computational neuroscience offers new tools to quickly formulate and test hypotheses on the neural mechanisms underlying behavior. This course will cover the basic simulation techniques available to biophysical modeling. The first part of the class will be devoted to single and multiple compartmental models, intrinsic neuron properties and dendritic integration. The second part of the class will focus on synaptic transmission and networks of biophysical neurons. Modeling papers will be discussed and evaluated for their explanatory and predictive potentials. Knowledge of a programming language (such as Matlab) and basic introductory Neuroscience is required. See Website for self-assessment of computational abilities. The class is hands on and a laptop computer is required.

Texts: Papers distributed in class.
Suggested support textbooks (not mandatory):
Theoretical Neuroscience (Dayan and Abbott)
SNM: Spiking Neuron Models (Gerstner and Kistler)
MNM: Methods in Neuronal Modeling (Koch and Segev)
Biophysics of Computation (Koch)
FCN: Foundations of Cellular Neurophysiology (Johnson and Wu)
Neuroscience, 3rd edition (Purves et al.)
Numerical Recipes in C (Press, Teukolsky, Vetterling, Flannery)

Grading Policy:

There will be 1 midterm exam, 1 final and homeworks. Homeworks (indicated by HW below) will be given bi-weekly on average. Few quizzes will be for extra credits and will be given randomly during the semester. The final is comprehensive. Midterm and final exams cover assigned readings and lecture material. The final grade will be assigned as follows:

Undergraduate grading scale:
- Final 30 %
- Midterm 20 %
- Homeworks + class participation 50%

Graduate grading scale:
- Final 30 %
- Midterm 20 %
- Homeworks + class participation 20%
- Final project 30%

**Syllabus Outline (subject to ‘fine tuning’)**

- **Week 1**: Introduction to modeling: The different kinds of models.
- **Week 2**: Basic recording techniques: Single and multi unit data.

**Part I: Simulations of single neurons**

- **Week 3**: Introduction to the NEURON simulator.
  - Readings: (Hines and Carnevale, 1997)
- **Week 4**: Models of individual currents: activation, inactivation. **HW1**.
  - Readings: (Hodgkin and Huxley, 1952)
- **Week 5**: The currents flora and their functional significance.
  - Readings: MNM (Chapt 5)
- **Week 6**: Multiple channels and calcium dynamics. **HW2**.
  - Readings: MNM (Chapt 4)
- **Week 7**: Morphology and dendritic integration.
  - Readings: (Pyapali et al., 1998; Stuart and Spruston, 1998; Cook and Johnston, 1999)
- **Week 8**: Midterm and intrinsic properties: bursts, frequency preference, excitability.

**Part II: Simulations of neural networks**

- **Week 9**: Kinetics models of synaptic transmission. The receptor flora. **HW3**.
  - Readings: (Destexhe et al., 1994)
- **Week 10**: Stochastic synapses, short-term synaptic dynamics and synaptic noise.
  - Readings: (Dobrunz and Stevens, 1997; Varela et al., 1997; Matveev and Wang, 2000; Destexhe et al., 2001)
- **Week 11**: Small networks: central pattern generators. **HW4**.
  - Readings: (Marder and Selverston, 1992)
- **Week 12**: Large networks: information transfer and neural coding.
  - Readings: (Knight, 1972; Bialek and Rieke, 1992; Samsonovich and McNaughton, 1997)
- **Week 13**: Simplified models of neurons and networks. **HW5**.
  - Readings: SNM (Chapt 4)
- **Week 14**: Projects Presentations and Final.

**References**


