NEUR 634/Beng 434/Beng 699
Computational Modeling of Neurons and Networks
Spring 2020

Instructor: Dr. Kim L. Blackwell
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Office Location: Krasnow Institute, Room 164
Office Hours: Tues 12:00 - 1:00 pm or by appointment

Lectures: Day/time: Tues 9:00 am - 11:45 am**, Location:** Nguyen Engineering Building 4457

Important Dates:

Last Day to Add	January 28
Unrestricted Withdrawal Period	February 12- February 24
Fall Break (Mon classes meet Tues, no class this week):	Oct 8
Projection presentation (no final)	April 28
Last day of classes	May 4

Textbook:
Required: The Book of GENESIS. Free Internet Edition (2003) Bower and Beeman (free online pdf: http://www.genesis-sim.org/iBoG/iBoGpdf/index.html)
Optional: From Computer to Brain by Lytton

Course Description: Introduces the objectives, philosophy, and methodology of neuronal modeling. Instructs students in the use of some of the more popular neural modeling software packages. Students learn the syntax of several software packages, how to create neurons from subcellular components, and how to create networks by connecting neuron models.

Prerequisite: Neur 602 or Neur/Beng 327 or permission of instructor

Course Objectives: To introduce the objectives, philosophy and methodology of neuronal modeling and computational neurophysiology. Topics include how to create models of membrane channels and neurons; how to create networks by connecting neuron models, and how to run simulations of their activity and behavior. The course instructs students in the use and syntax of two neural modeling software packages using their python interfaces. Creating and simulating neural models introduces or reinforces the concepts learned in cellular neuroscience, by illustrating how activity patterns are modulated by different types of membrane channels or different types of neuron connections.

Format: The course meets three hours a week, in a combination of lecture and electronic laboratory. The first part of each class will consist of a brief lecture on the neuronal component to be modeled. The lecture for the remaining class will describe how those components are modeled, including specific syntax and interaction with other neuronal components. Concepts will be reinforced with in-class and take-home exercises.

Assignments and Grading:
The final grade will be based on:

In class model construction	20%	At the end of the class period a copy of the practice commands will be turned in (emailed) to the instructor. *Graduate students:* will need to find a paper in the literature from which to base their final project, and read and create a summary of the paper.
Homework	40%	Homework will consist of using the commands and model components to create novel models or simulations.
Final project	40% (20% written, 20% oral)	Projects will be presented orally either on the last day of class or during Final exam period.

Project Notes:
For graduate students: Development of a model using one of the software packages presented in class. The student is required to explain the research that the project is based on, the goals and significance of project (what is question being answered or hypothesis tested), methodology (which software, which model pieces reused or newly created in the model, which simulations were run to answer the question or test the hypothesis, and how output was analyzed), results, and interpretation or implications of the results.
For undergraduate students: Enhance one of the models that was developed during class by adding one new ion channel and changing one of the synaptic channels. Run simulations with and without each of these changes, and explain how neuron or network activity is modified by the added or modified channels. The presentation and written report must explain which model and software they used, which channels were changed, which simulations were performed, how output was analyzed, and what the main results were.
In both cases, the project will be graded using the project rubric.

Grading Scale: A score of 90 or above generally results in a grade of A- or above, 80 or above corresponds to a B- or above, and 70 or above results in C- or above. The numerical score is only a guideline, and is not absolute. The final grades may be determined on a curve if this is to the students favor and justified in the opinion of the instructor.

Policy regarding missed assignments: Homework may be turned in at most one week late, but there will be an automatic penalty of 10% deducted from the score. If an absence from class is anticipated, homework may be emailed, faxed, or sent in on-time with another student. Make-up project presentations are not allowed, unless the student has written medical documentation for absence on the day of presentations.

No extra credit will be given.

This term I will be using Piazza for posting lectures, syllabus, and for class discussion. The system is tailored to getting you help quickly and efficiently from classmates and myself. Rather than emailing questions directly to me, I encourage you to post your questions on Piazza. If you have any problems or feedback for the developers, email team@piazza.com.

https://piazza.com/gmu/spring2020/beng434699neur634/home

Tentative Syllabus (Subject to change)

Date	Topic	Homework
1/21	Neuron modeling introduction, Python, unix, Moose & Neuron installation on your laptop, Introduce Final Project	python and unix tutorials as needed
1/28	Introduction to Moose, Create single compartment model using functions	READ: chapter 1,2,3 and 5: cable theory in BoG Create function for compartment creation**,** current injection and output tables
2/4	creating neurons with multiple compartments, realistic morphology	Evaluate how the number of dendritic compartments influences the somatic response**.** download swc file from neuromorpho and load into MOOSE software.
2/11	Introduction to NEURON software	Evaluate response to current injection
2/8	Introduction to ion channels, implement sodium and potassium channels	READ: chapter 4: Hodgkin-Huxley Model in BoG; Implement the moose 1comp model using namedtuples and one channel function
2/25	Multi-compartment, multi-ion channel models	READ: chapter 7 in BoG; Integrate your channel function with your morphology code, add in one more channel, inject current with and without new channel. How does it change spiking properties?
3/3	Calcium dependent channels and calcium concentration	add calcium dependent potassium channel and calcium concentration to your model
3/10	**No Class**	
3/17	NEURON software: nmodl or channel builder for new channels	implement the channel from Feb 25 in a neuron mod file by an existing mod file (from modelDB)
3/24	Synaptic channels with MOOSE; activate with pre-synaptic random spike	READ: chapter 6 in BoG; Add excitatory synaptic channels to your model; then add inhibitory synaptic channel in order to stop firing
3/31	NMDA channels, synaptic channel function, using real spike trains	add NMDA synaptic channels and Poisson distributed spike trains to your model, can it overcome the inhibition?
4/7	Synaptic connections using NEURON	Add excitatory synaptic channels to your model; then add inhibitory synaptic channel in order to stop firing
4/14	Neuron: creating functions and classes to instantiate neurons	Create 3 neuron network with “ring” connections to produce continuous spiking. Then add inhibitory synapses and evaluate how weight and delay influences ability to stop spiking.

4/21	Networks in MOOSE: put neuron creation into a function, specify distance dependent connections	Work on model for presentations
4/28	**Presentations**	
5/5	**Written reports due**	

Additional assignments for Graduate students:
Due Feb 4: find and summarize paper that uses computational modeling to address question in
Due Feb 11: use shape shifter to simplify morphology and evaluate how compartment size (frequency used to calculate lambda) influences results
Due Mar 3: add channel from your publication into your model.
Due Mar 17: add calcium channel to your model, connect calcium channel to calcium concentration

More may be added later

GMU Policies and Resources for Students:

- Students must adhere to the guidelines of the George Mason University Honor Code [See http://academicintegrity.gmu.edu/honorcode/].
- Students must follow the university policy for Responsible Use of Computing [See http://universitypolicy.gmu.edu/all-policies/].
- Students are responsible for the content of university communications sent to their George Mason University email account and are required to activate their account and check it regularly. All communication from the university, college, school, and program will be sent to students solely through their Mason email account.

- The George Mason University Counseling and Psychological Services (CAPS) staff consists of professional counseling and clinical psychologists, social workers, and counselors who offer a wide range of services (e.g., individual and group counseling, workshops and outreach programs) to enhance students' personal experience and academic performance [See http://caps.gmu.edu/].
- *Students with disabilities who seek accommodations in a course must be registered with* the George Mason University Office of Disability Services (ODS) and inform their instructor, in writing, at the beginning of the semester [See http://ods.gmu.edu/].
- *Students must follow the university policy stating that all* sound emitting devices shall be turned off during class unless otherwise authorized by the instructor.
- The George Mason University Writing Center staff provides a variety of resources and services (e.g., tutoring, workshops, writing guides, handbooks) intended to support students as they work to construct and share knowledge through writing [See http://writingcenter.gmu.edu/].

Professional Dispositions:

- Students are expected to exhibit professional behaviors and dispositions at all times.

Core Values Commitment:

- The College of Education & Human Development is committed to collaboration, ethical leadership, innovation, research-—based practice, and social justice. Students are expected to adhere to these principles. [See http://cehd.gmu.edu/values/].

WAVES: Wellness, Alcohol and Violence Education and Services:

WAVES promotes wellness within the Mason community through health education, alcohol/drug assessment and education, and violence awareness, prevention and sexual assault response. We help students make healthy, safe choices and encourage lifelong, thoughtful healthy decision-making through individualized support, creative programming, and evidence-based education and outreach.

WAVES office 703-993-9999
SUB I, Suite 3200
24-Hour Sexual and Intimate Partner Violence Crisis Line 703-380-1434
waves.gmu.edu

- 703-360-7273 (Fairfax County Office for Women and Domestic and Sexual Violence Services 25 hotline)
- 703- 228-4848 (Arlington County Domestic Violence Services Hotline)
- 703-368-4141 (Prince William County Sexual Assault Victims Advocacy Services (SAVAS) hotline
- 1-800-838-8238 (Virginia Family Violence and Sexual Assault Hotline)
- 1-800-656-HOPE (Rape, Abuse and Incest National Network) https://ohl.rainn.org/online/

CAPS: Counseling and Psychological Services:

Counseling and Psychological Services (CAPS) provides a wide range of free *confidential* services to students, faculty, and staff. Services are provided by a staff of professional clinical psychologists, social workers, counselors, learning specialists, and psychiatric providers. CAPS individual and group counseling, workshops, and outreach programs are designed to enhance students' personal experience and academic performance.

Visit us at **caps.gmu.edu** for additional resources.

- For consultation or emergency assistance during office hours call 703-993-2380.
- For assistance during non-office hours, call University Police at 703-993-4357.
- 703-527-4077 (CrisisLink)
- 1-800-273-8255 (National Suicide Prevention Lifeline)
- 1-877-838-2838 (Veterans' Crisis Hotline)

Student Health Services (SHS) — Provides *confidential* health care to enrolled students in emergency and non-emergency circumstances on the Fairfax, Arlington and Prince William campuses. If there is a medical emergency and Student Health Services (SHS) is closed, please contact the free after-hours nurse ((703) 993-2831), a hospital emergency room, an urgent care facility, or call 911.

SUB 1, Suite 2300
703-993-2831

University Police:
Emergency: 911 Non-Emergency: (703) 993-2810
Reporting a Crime (Crime Solvers Anonymous Tip Hot-Line): (703) 993-4111
Mason Police Website: http://police.gmu.edu/
Eric Heath, Chief of Police Phone: (703) 993-3840 E-mail: eheath2@gmu.edu