KIN482D Syllabus

January 5, 2024

1 University of British Columbia – School of Kinesiology

1.1 Basic Course Information

KIN 482D Advanced Seminar in Neuromechanics ("Computational Modeling of Human Sensorimotor Control and Learning"); 2023 Winter Term II; 3 credit hours

1.2 Time and Place

Mon and Wed, 12:30 - 2:00 pm, GEOG-214

This syllabus is subject to change. Changes will be announced in class and via Canvas announcements.

1.3 Description

An introduction to the motivation, rationale, methods, and applications of computational modeling to the study of human sensorimotor control and learning.

Long version: Computational modeling has been central to many recent advances in our fundamental understanding of human cognition, perception, and action. Through a combination of lectures, readings, and hands-on tutorials, this course provides students with an intuitive, yet rigorous, introduction to computational modeling of sensorimotor control and learning. The course begins by discussing the advantages and limitations of modeling, and then proceeds to systematically cover the foundational elements of modeling human behavior, including Bayesian probability theory, learning algorithms, and simulation. Building from this foundation, the course will cover several major classes of computational models used by sensorimotor researchers, including Bayesian and state-space models. The goal is for students to not only come away from this course with an understanding of the goals and techniques of modeling, but to also feel confident applying these techniques to their own questions.

1.4 Learning materials

This course will utilize a combination of required textbook, assigned article readings, and handouts.

Required textbook: "Bayesian Models of Perception and Action: An Introduction" by Wei Ji Ma, Konrad Kording, and Daniel Goldreich. There is a free pdf version provided by the authors at this link. Hardcover editions can be purchased online from Amazon for $86.00 at last check.

1.5 Hardware & Software

Students are required to bring a charged laptop to both lectures and tutorials since there will be many hands-on tutorials and exercises. Students who do not own a laptop may be able to borrow one from the UBC library.

Students will perform their analyses using the Python programming language. Tutorials and assignments/problem sets will be completed using Jupyter Notebooks, which can be accessed via UBC's JupyterHub.

1.6 Prerequisites

Completion of two of the following courses:
- KIN 310 "Human Functional Musculoskeletal Anatomy"
- KIN 311 "Sensorimotor Control of Human Movement"
- KIN 313 "Neuromuscular Integration of Human Movement"
- KIN 316 "Biomechanical Properties of Tissues"
- KIN 411 "Neuroanatomy of Human Movement"
- KIN 419 "Laboratory Investigations in Neuromechanical Kinesiology"

Note: Although there are no formal math or programming prerequisites, by necessity there will be a great deal of both in this course. Resources will be provided for those with no prior programming experience to learn on their own, as it is imperative that you gain *basic* proficiency with Python, Jupyter notebooks, and LaTeX (typesetting environment that allows you to write beautiful equations) within the first few weeks of class.

1.6.1 Learning Resources

Python programming

- KIN 482E: Data Science for Kinesiology (textbook, course materials)
- Plotting and Programming in Python
- Basic Introduction to Maths and Python - I have no direct experience with this one, but others have recommended it

Math

- 3Blue1Brown series on calculus

LaTeX

- Learn LaTeX in 30 minutes

1.7 Learning Outcomes

The course is designed to achieve the following primary learning outcomes:
1. Understand and be able to clearly articulate the motivation and rationale for computational modeling and the types of models that are appropriate for different questions.
2. Understand and apply the fundamental methods of Bayesian modeling: deriving graphical generative models, performing Bayesian inference, computing response probabilities, and model fitting and model comparison.

3. Gain proficiency with simulating Bayesian and non-Bayesian models with Python code and understand the implications of different parameter values, test conditions, and outputs.
4. Gain proficiency with applying modeling to novel questions.
5. Demonstrate the ability to understand, critique, and discuss research articles that incoroporate computational modeling of human behavior.

1.8 Instructor

Professor: Hyosub Kim
Email: hyosub.kim@ubc.ca
Office Hours: By appointment.

Please read the course policy (e.g., late registration, missing quiz/assignment due to sickness) below before contacting the instructor.

1.9 Comunication

There are no formal office hours. However, meetings can be arranged as needed with at least 24 hours of advance notice. To facilitate scheduling, when contacting me about a meeting please provide several blocks of time that you are available.

Please be advised that I will not answer any course content-related questions over email.

1.10 Course Format

The basic breakdown of the course is lecture on Monday and recitation on Wednesday, although there will be several exceptions throughout the semester (see Course Schedule). The recitations are not straight lectures, rather, they provide class time and space for the following: 1) clarifying the material from preceding lecture(s); 2) working on practice problems; 3) discussion of homework problems after the final deadline (if needed); and 4) open discussions around course content, including chapter/article readings and final projects.

1.11 Course Breakdown

Category	Percent Grade
Problem sets	66
Project	24
Participation	10

1.11.1 Philosophy

My assumption is that you are all intrinsically motivated to learn about computational modeling. You would not be taking this elective if you were not motivated, as there is no requirement to take this course, the material is not easy, and really learning the material will require many hours of focused effort each week. Some of you may have some idea of what modeling is and how you might want to use it. Others may simply be curious to learn more. You are all welcome here. *But*, regardless of your motivation, you will all need to engage in active learning, which, practically speaking, means:
- Completing all readings and assignments

- Asking questions and demonstrating your knowledge during class
- Putting in any extra time and effort required to learn skills that will not be formally covered during class (e.g., Python programming, LaTeX, etc.)

With regard to the last point, although this is not a course on learning to code in Python, I realize that some of you will have no prior programming experience. That's okay—again, as long as you are willing to put in the extra effort to learn enough of the basics of programming to complete your assignments and learn the material. The resources are provided so that you can pick-up the necessary skills on your own time outside of class. In addition, there will be some time during tutorials to ask questions, and there may also be a limited number of extra tutorial sessions covering the basics of coding. My view is that the rewards of learning to model will make the extra effort worthwhile.

1.11.2 Problem sets (66%)

The majority of your course grade will be based on completion of problems from the course textbook. These assignments will be turned in as Jupyter notebooks. You are expected to work independently on these problem sets. Many of the problems will be challenging and will likely require struggling for hours (I know this from experience!), but this is often the best way to learn. Bring your questions to the recitations and be ready to describe how you approached the problem. If you are still stuck, arrange for a meeting with me.

Expectations of all homework problems:

- All submissions must be made through Canvas
- You must submit your homework in the form of .ipynb and .html files (we will go over this in class)
- All text answers must be typed in Markdown, with equations written in LaTeX
- Make sure your code runs without any errors (check by clicking on "Restart Kernel and Run All" in Jupyter)

Policies regarding collaboration: You are allowed to ask classmates for help *after* struggling with the problem yourself. It is better to ask for hints, rather than solving problems together. If you do end up working collaboratively on a problem, then you must make that explicit when turning in the assignment. There is no penalty for doing so, but for your own learning, you will want to limit the frequency with which you extensively collaborate in this manner.

Policies regarding AI: You are prohibited from using AI-provided assistance (e.g., ChatGPT), except in a small number of very constrained conditions (see below), for several reasons:
- The point of the assignments is to learn the material by struggling with it on your own; shortcutting that process does you no favors in the long run
- It's a slippery slope from asking ChatGPT for a hint to asking ChatGPT for a full solution
- You are encouraged to learn to collaborate with real intelligences (i.e., your instructor and classmates)
- Using AI to assist your problem solving may bias the instructor's understanding of how well the class understands the material, which can have adverse effects on those students who are adhering to basic principles of academic integrity and trying to learn the material on their own

A potentially excusable use of AI would be to seek advice regarding some implementational detail regarding your code that has no bearing on the conceptual components of the problem. As one example, if you wanted to recall how to write a list comprehension in Python and asked ChatGPT how to write one. **However, if you go this route, you must provide full attribution to the tool that assisted you, providing the name of the AI, the prompt you provided it, and the AI-generated response.** ***Failure to provide attribution will result in an automatic zero on the assignment.***

1.11.3 Project (24% total; 18% written submission, 6% presentation)

You will complete a final project that involves applying the skills you learned in the course to an actual research question. You will turn in a Jupyter notebook that contains a short introduction to the problem, a more detailed methods section describing the tools you are using, results with figures, and a short conclusions section that includes a summary of your results, future directions, and self-reflection on the modeling process. During the final week of the semester, each of you will give a brief presentation on your final project.

1.11.4 Participation (10%)

Attendance at all class sessions is required. Your participation grade will be based on attendance, demonstrating that you have done the readings, and active participation during lecture and tutorial sessions.

1.12 Course Schedule

You are expected to have read the textbook chapter indicated under **Topic** *prior* to the lecture. *Subject to change:*

Day	What is due	Topic	Readings for next session
W1D1 Lecture 1		Course Intro - Why computational modeling?	Kording and Wolpert (2006)
W1D2 Lecture 2		Introduction and Ch 1: Uncertainty and inference	Blohm et al (2020) - through *Step 4*
W2D1 Lecture 3		Ch 2: Using Bayes' rule for inference	Appendix A (skip Expected Values), Appendix B1 - B7.2
W2D2 Recitation		Ch 2: Using Bayes' rule for inference	
W3D1 Lecture 4	Problem set 1	Ch 3: Bayesian inference under measurement noise	Kording and Wolpert (2004)
W3D2 Recitation		Ch 3: Bayesian inference under measurement noise	

Day	What is due	Topic	Readings for next session
W4D1 Lecture 5	Problem set 2	Ch 4: The response distribution	
W4D2 Recitation		Ch 4: The response distribution	
W5D1 Lecture 6		Appendix C: Model fitting and model comparison; maximum likelihood estimation	
W5D2 Recitation		Appendix C: Model fitting and model comparison; maximum likelihood estimation	
W6D1 Lecture 7	Problem set 3	Ch 5: Cue combination and evidence accumulation	Ernst and Banks (2002)
W6D2 Recitation		Ch 5: Cue combination and evidence accumulation	
W7D1 Lecture 8	Problem set 4	Ch 6: Learning as inference	
W7D2 Recitation		Ch 6: Learning as inference	
W8D1 Lecture 9		Ch 12: Inference in a changing world / Kalman filter	Jacobs tutorial, Burge et al (2010)
W8D2 Recitation		Ch 12: Inference in a changing world / Kalman filter	
W9D1 Lecture 10	Problem set 5	Ch 13: Combining inference with utility	Trommershauser et al (2003)
W9D2 Recitation		Ch 13: Combining inference with utility	
W10D1 Lecture 11		State-space models	Haith and Krakauer (2013), Smith et al (2006)
W10D2 Recitation		State-space models	
W11D1 Lecture 12	Problem set 6	Reinforcement learning	Wilson and Collins (2019)
W11D2 Recitation		Reinforcement learning	
W12D1	Easter holiday		
W12D2 Recitation		Project work	
W13D1	Presentations		
W13D2	Presentations		

1.12.1 Article readings:

Week 1

- Körding, K. P., & Wolpert, D. M. (2006). Bayesian decision theory in sensorimotor control. *Trends in cognitive sciences*, 10(7), 319-326.

Recommended:
- Wallisch, P. (2020). How to Read a Scientific Article: The QDAFI Method of Structured Relevant Gist. In A. Borst & R. DiYanni (Eds.), *Critical Reading Across the Curriculum* (1st ed., pp. 152–164). Wiley.

Week 2

- Blohm, G., Kording, K. P., & Schrater, P. R. (2020). A how-to-model guide for neuroscience. *Eneuro*, 7(1).

Week 3

- Körding, K. P., & Wolpert, D. M. (2004). Bayesian integration in sensorimotor learning. *Nature*, 427(6971), 244–247.

Week 6

- Ernst, M. O., & Banks, M. S. (2002). Humans integrate visual and haptic information in a statistically optimal fashion. *Nature*, 415(6870), 429-433.

Week 8

- Burge, J., Ernst, M. O., & Banks, M. S. (2008). The statistical determinants of adaptation rate in human reaching. *Journal of vision*, 8(4), 20-20.

Week 9

- Trommershauser, J., Maloney, L. T., & Landy, M. S. (2003). Statistical decision theory and trade-offs in the control of motor response. *Spatial vision*, 16(3), 255-275.

Week 10

- Haith, A.M., & Krakauer, J.W. (2013). Theoretical models of motor control and motor learning. In *Routledge handbook of motor control and motor learning* (pp. 7-28). Routledge.
- Smith, M. A., Ghazizadeh, A., & Shadmehr, R. (2006). Interacting adaptive processes with different timescales underlie short-term motor learning. *PLoS biology*, 4(6), e179.

Week 12

- Wilson, R. C., & Collins, A. G. (2019). Ten simple rules for the computational modeling of behavioral data. Elife, 8, e49547.
- Haith, A. M., Pakpoor, J., & Krakauer, J. W. (2016). Independence of movement preparation and movement initiation. Journal of Neuroscience, 36(10), 3007-3015.

1.13 Policies

1.13.1 Late Registration

Students who register for the class late have 1 week from their registration date on Canvas to complete all prior assignments.

1.13.2 Late Assignments

There will be **no extensions for the assignments**; late assignments will receive a grade of zero.

1.13.3 Device/Browser

Students are responsible for using a device and browser compatible with all functionality of Canvas. Chrome or Firefox browsers are recommended.

1.13.4 Academic Concession Policy

Please see UBC's concession policy for detailed information on dealing with missed coursework, quizzes, and exams under circumstances of an acute and unanticipated nature.

1.13.5 Academic Integrity

The academic enterprise is founded on honesty, civility, integrity, and accountability. As members of this enterprise, all students are expected to know, understand, and follow the codes of conduct regarding academic integrity. At the most basic level, this means submitting only original work done by you and acknowledging all sources of information or ideas and attributing them to others as required. This also means you should not cheat, copy, or mislead others about what is your work. Violations of academic integrity (i.e., misconduct) lead to the breakdown of the academic enterprise, and therefore serious consequences arise and harsh sanctions are imposed. For example, incidences of plagiarism or cheating may result in a mark of zero on the assignment or exam and more serious consequences may apply if the matter is referred to the President's Advisory Committee on Student Discipline. Careful records are kept in order to monitor and prevent recurrences.

A more detailed description of academic integrity, including the University's policies and procedures, may be found in the Academic Calendar.

1.13.6 Plagiarism

Cases of plagiarism may include, but are not limited to:

- The reproduction (copying and pasting) of code or text from another source (e.g., fellow student, AI, answer found online)
- AI-generated code (e.g., ChatGPT, GitHub Co-Pilot) - read AI policy for this course

Plagiarism of any form will result in serious penalties, up to and including failure of the course.

1.14 University Policies

UBC provides resources to support student learning and to maintain healthy lifestyles but recognizes that sometimes crises arise and so there are additional resources to access including those

for survivors of sexual violence. UBC values respect for the person and ideas of all members of the academic community. Harassment and discrimination are not tolerated nor is suppression of academic freedom. UBC provides appropriate accommodation for students with disabilities and for religious observances. UBC values academic honesty and students are expected to acknowledge the ideas generated by others and to uphold the highest academic standards in all of their actions.

Details of the policies and how to access support are available on the UBC Senate website.

1.15 Land Acknowledgment

UBC's Vancouver Campus is located on the traditional, ancestral, and unceded territory of the Musqueam people. The land it is situated on has always been a place of learning for the Musqueam people, who for millennia have passed on their culture, history, and traditions from one generation to the next on this site.

To learn more about the relationship between the Musqueam people and UBC, you may find this webpage helpful.

1.16 Attribution

The Policies section of this syllabus has been adapted from the syllabus for UBC's DSCI 100 course, which in turn is based on UBC MDS Policies and UBC's Campus-wide Policies and Regulations.