Bayesian modeling of behavior
Fall 2018
Wei Ji Ma

This syllabus is subject to change. Changes will be announced in class and by email.

Description

Bayesian inference is the mathematical framework for making optimal decisions and actions when the state of the world is not exactly known. This course will provide an intuitive yet mathematically rigorous introduction to Bayesian models of behavior in perception, memory, decision-making, and cognitive reasoning. While this is primarily a psychology course, we will also discuss connections to economics and neuroscience. This course is not about Bayesian data analysis, but about theories that the brain itself is a Bayesian decision-maker. Nevertheless, we will spend some time on model fitting and model comparison.

Prerequisites

- Strong command of Calculus 1 or equivalent
- Introductory course in probability or probability-based statistics.
- Ability to code in Matlab. If you have not coded in Matlab before, you will be ok if you have other programming experience and do a tutorial before the course starts.

Email Wei Ji if you have any questions about prerequisites.

Lecturer

Prof. Wei Ji Ma, weijima@nyu.edu, 212 992 6530

Weekly schedule

Lecture	Wednesdays, 4-5:50 pm	Meyer 851
Recitation	Thursdays, 4-5:50 pm	Meyer 851
Office hours	By appointment	Meyer 754 (Wei Ji's office)

Materials

- *Bayesian modeling of perception*, by Ma, Kording, and Goldreich. Will be distributed in electronic form.
- You will need Matlab. Instructions for installing Matlab if you are on the Meyer building network: http://localweb.cns.nyu.edu/unixadmin/#august10-2015.

Grading
The total grade will be calculated as follows:

Best 8 of 11 homework sets	55%
Project	30%
Participation	15%

Letter grade
Your numerical grade will be turned into a letter grade according to the following scale: 90-100 A; 87-89 A-; 84-86 B+; 80-83 B; 77-79 B-; 74-76 C+; 70-73 C; 67-69 C-; 64-66 D+; 60-63 D; 57-59 D-; 0-56 F.

Homework

- There will be 11 homework sets. The lowest three homework grades will not be counted.
- Homework is due at 4 PM on Wednesday, through NYU Classes → Assignments. Late homework will not be accepted by the system and will count as 0. No extensions for any reason.
- How to submit:
    - All text answers should be typed (no handwriting).
    - Equations: LaTeX is a free, recommended typesetting software that allows for beautiful equations. In Word, you can use Equation Editor for Word (free, but cumbersome), or Mathtype (not free). Do not submit in-line (ASCII) equations.
    - Insert plots into your homework instead of submitting them as separate files. Convert to PDF before submitting. Name the PDF with the homework number and your last name, e.g. "HW1_Ma.pdf".
    - If a problem involves Matlab coding, pleae submit your Matlab code as separate files. Make sure that the code runs without errors!
- We will not provide answer keys. However, we will discuss any homework problem in recitation upon request.

Policies on collaboration and cheating

- You are expected to work on these homework assignments independently. If you are stuck on a problem: Try your best first – this could mean struggling for hours, but that is often the best way to learn. If you are still stuck, the preferred method is to contact Wei Ji for help.
- If you ask a classmate for help after trying hard yourself, then you must indicate on your homework whom you worked with on what. You will not be penalized for learning with your peers. We ask that you say who you worked with for two reasons: 1) Honesty. 2) We want to know what material is difficult so we can spend more time helping you learn. If you relied on a peer for a challenging question then we want to make sure that you understand the material before test time.

- Under no circumstances should you copy a classmate's answer, even if you modify it slightly. Copying someone else's work is cheating, is easy to detect, and will yield a grade of 0.
- If someone asks you for help on the homework: do not give them your answer – this is cheating and will yield a grade of 0. First, make sure that the person you are helping has tried their best on the homework. Second, explain how you got started and how you thought about the problem. If you can help someone learn that way, that is impressive.

Project

- In the class project, you will develop a Bayesian model yourself.
    - Mathematically develop the details of the model
    - Perform numerical simulations.
    - Characterize behavior, examine effects of parameters.
    - Optional: fit data, compare models.
    - Optional: collect your own data, then fit them and/or compare models
    - Written report (5 to 6 pages, 1.15-spaced)
    - Presentation during last week
- Allowable topics:
    - Variant or elaboration of a task from class
    - Data set or qualitative phenomenon from your own or someone else's research (or from a published paper). Simulations-only is fine.
    - Proposal for a new project
- Constraints:
    - Restrict yourself to something manageable: not too much, not too complicated.
    - There has to be some math that we did not do in class.
    - Choose a well-controlled task with well-controlled stimuli.
    - Own data collection is not necessary, and might be a lot of work.

Participation

- Attendance is mandatory. Your participation grade will be based on attendance, as well as on participation during lecture and recitation. If you cannot attend, email Wei Ji in advance.

Day	What	What is due	Topic
Wed Sep 5	Lecture 1		Chapter 1: Uncertainty and inference in perception and cognition. Illusions.
Thu Sep 6	Lecture 2		Chapter 2: Using Bayes' rule for inference
Wed Sep 12	Lecture 3	Homework 1	Chapter 3: Bayesian inference under sensory noise: Steps 1 and Step 2
Thu Sep 13	Recitation		
Wed Sep 19	Lecture 4	Homework 2	Chapter 4: Step 3: The response distribution
Thu Sep 20	Recitation		
Wed Sep 26	Lecture 5	Homework 3	Chapter 5: Cue combination, evidence accumulation, and learning
Thu Sep 27	Recitation		
Wed Oct 3	Lecture 6	Homework 4	Chapter 6: Discrimination and detection. Link with signal detection theory.
Thu Oct 4	Recitation		
Wed Oct 10	Lecture 7	Homework 5	Chapter 7: Binary classification. Marginalization. Ambiguity.
Wed Oct 11	Recitation		
Wed Oct 17	Lecture 8	Homework 6	Chapter 8: Model fitting and model comparison
Thu Oct 18	Recitation		
Wed Oct 24	Lecture 9	Homework 7	Chapter 9: Ambiguity due to a nuisance parameter. Some color perception.
Thu Oct 25	Recitation		
Wed Oct 31	Lecture 10	Homework 8, project ideas	Chapter 10: Sameness judgment and perceptual organization
Thu Nov 1	Recitation		
Wed Nov 7	Lecture 11	Homework 9, project proposal	Chapter 11: Two-alternative forced choice and visual search
Thu Nov 8	Recitation		
Wed Nov 14	Lecture 12	Homework 10, project formalism	Chapter 12: Inference in a changing world
Thu Nov 15	No lecture!		Conflict with a conference
Wed Nov 21	No lecture!		*Thanksgiving break*
Thu Nov 22	No lecture!		*Thanksgiving break*
Wed Nov 28	Lecture 13	Homework 11, project results	Chapter 13: Combining inference with utility (or psychology with economics)
Thu Nov 29	Recitation		*Work on projects*
Wed Dec 5	Lecture 14	Project results	Chapter 14: Neural basis of Bayesian inference
Thu Dec 6	Recitation		*Work on projects*
Wed Dec 12	Lecture 15	Project results	*Work on presentation*
Thu Dec 13	Recitation	Presentation	*Project presentations*
Fri Dec 14	--	Project report	(send by email)