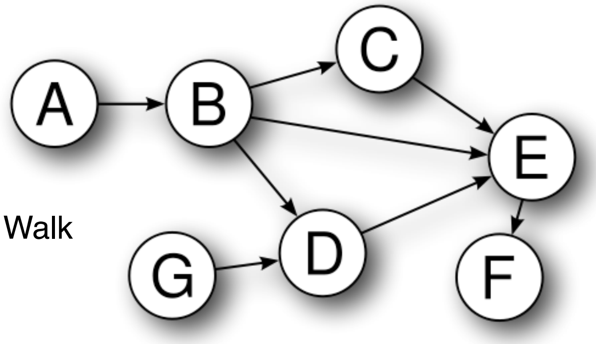
PSYC 7390 - PROBABILISTIC MODELS OF PERCEPTION AND COGNITION

Fall 2023
Time: TR 1.45–3.15p
Location: **GLAB 100**



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SYNOPSIS:
Our information about the world is necessarily limited and thus our conceptions of and reasoning about physical reality remain subject to doubt. How do we perceive and reason in face of such uncertainty? How do we draw conclusions and take decisions? Probability/Information theory is the natural computational framework to model and account for human perceptual and cognitive behavior under uncertainty. This course will provide a careful introduction to probability theory and the various ways it has been applied in psychology and neuroscience. The goal is for students to thoroughly understand probabilistic models of some core tasks (e.g. estimation) in perception and cognition, what they reveal about the brain's underlying computations and strategies in dealing with uncertainty, and how such computations can potentially be performed by populations of neurons.

PREREQUISITES:
A good general math background, although all methods and theories will be developed in the course. Some programming experience in MATLAB or an equivalent high-level programming language (R,PYTHON, JAVA) is required. Contact instructor if unsure.

CLASS STRUCTURE:
The course has five main components: recorded lectures (for self-study), weekly meetings to discuss course material, weekly paper discussions (lead by students), homework assignments, and an individual course project.

- Recorded lectures (~20mins) covering all core aspects of the material are posted on CANVAS. Students are expected to self-study the material with the help of these recordings and the lecture slides.
- Weekly class. The second course slot is intended to discuss and deepen the lecture material as well as the homework assignments (or address any question that may arise).
- Weekly paper discussion of original literature. Starting the second week, we will discuss one important and classic paper each week. Students will take turns in leading the discussion. Schedule depends on the number of students; we will determine the schedule during our first lectures.
- Homework assignments will be given once a week during the first half of the term. They will be discussed as part of our weekly meetings.

- **Course project**: This individual project is an important component of the course. Students will present their projects in a short live online presentation during our last few meetings of the semester and a report at the end of the course. The project is meant to re-implement the core model/method of a paper of choice. Creative solutions are completely fine if data are required (e.g. simulating data). Alternatively, running and modeling your own experiment could make for an even more exciting project. Possibilities are large; just make sure that you discuss your ideas with the instructor before making a final decision.

Attendance is expected for all events.

BOOKS/READINGS:
The lectures in the course will be partially based on chapters of the following books:

* Bayesian Models of Perception and Action, Wei Ji Ma, Konrad Kording, Daniel Goldreich, MIT Press
* Probability Theory - the Logic of Science, E.T. Janes, 2003, Cambridge University Press
* Pattern Recognition and Machine Learning, Christopher Bishop, 2006, Springer

These are great books and will serve as valuable and timeless resources for anybody seriously interested. Relevant chapters will be posted online. In addition, we will read and discuss a series of state-of-the-art papers in the field of cognition and perception.

COURSE-WEBSITE (CANVAS):
Readings, homework assignments, and complete and up-to-date course information will be posted on Canvas.

TENTATIVE LIST OF TOPICS:
* Probability theory
    * Basics
    * Graphical and Hierarchical Bayesian models
* Inference
    * Methods and algorithms
    * Causality
* Probabilistic models of Perception
    * Estimation tasks
    * Decision tasks
    * Ideal observer models
* Model fitting
    * ML fits, Optimization
* Model comparison
    * Occam’s razor
    * BIC, AIC
* Probabilistic models of Cognition
    * Categorization
    * Hierarchical structure learning

    Working memory
    Intuitive physics
* Neural implementations
* Generative AI

FINAL GRADE:
Participation, Homework assignments, Project work and presentation.