COG260(F21): Data, Computation, and The Mind

Yang Xu (yangxu@cs.toronto.edu)

Lecture+Lab: **Tuesday 1-4pm ET** (see Quercus course page for details)
Office Hour: **Thursday 10-11am ET** (see Quercus course page for details)

_Syllabus might be adjusted as the course progresses._

Description

This entry-level course takes an integrated approach to the study of the mind, drawing ideas from cognitive science, computer science, and data science. Why is this integration important? From a scientific perspective, there has been extensive confluence between the fields of cognitive science and computational intelligence over the past 70 years. Many successful approaches to computational intelligence have been inspired by human cognition, but machines have yet to acquire core human cognitive abilities such as how people reason about objects, categories, and relations, or how people learn and communicate. On the other hand, theories of cognition have often drawn on computational ideas and methodologies. The understanding of this confluence requires students to develop a broad vocabulary across the relevant disciplines, so that they may translate fluently between these fields. From a pragmatic perspective, the rise of "big data" has made it almost imperative for students in cognitive science and related disciplines to acquire basic skills in data manipulation, analysis, and modelling.

Central to this course is the theme of _uncertainty_. We will explore how uncertainty might arise and concern cognitive functions such as object recognition, numerical and spatial cognition, categorization, language and communication. In doing so, we will also discuss basic tools for handling uncertainty by drawing topics from exploratory data analysis, probability theory, and statistics.

This course will involve a combination of lectures, labs, and an open-ended project. Each lecture will typically cover one topic of importance in cognitive science. Each lab session will typically involve the analysis of a cognitive dataset, along with discussion of relevant computational concepts and methods. Towards the end of the term, students will work on a project where they will formulate and test their own hypotheses based on an extensive public dataset. There will be no written exam in this course.
Prerequisite CSC108; Corequisite COG250.

Objectives
1. Develop a basic understanding of the relations between uncertainty and cognition.
2. Acquire basic knowledge for characterizing uncertainty computationally.
3. Develop practical skills in scientific exploration and data analytics.

Textbook
We will read a combination of published papers and book chapters. We will use Stats as a reference textbook for elementary statistics and data analytics: De Veaux, R. D., Velleman, P. F., & Bock, D. E. (2012) *Stats: Data and models, 3rd edition*. Pearson. In addition, we will use the reference booklet *An introduction to Python for data science applications* (Salas, 2016) for programming and data analysis with Python.

Deliverables and Assessments
Python Notebooks for the labs and the project write-ups should be submitted via Quercus. Readings will be assessed through the labs. Required reading materials, data, starter Python Notebooks, and submission links for the labs and the project will be posted on Quercus.

| Labs 1-6 | 60% (10% each) |
| Critical summary | 10% |
| Project proposal | 5% |
| Project presentation | 10% |
| Project report | 15% |

Grading Scale
- 90 - 100% A+
- 85 - 89% A
- 80 - 84% A-
- 77 - 79% B+
- 73 - 76% B
- 70 - 72% B-
- 67 - 69% C+
- 63 - 66% C
- 60 - 62% C-
- 57 - 59% D+
- 53 - 56% D
- 50 - 52% D-
- 0 - 49% Fail

Policies and guidelines
- Students should work individually for the labs but collaborate in pairs for the final projects. Plagiarism is strictly forbidden and any such case if identified will be reported according to the university guidelines (see [http://www.governingcouncil.utoronto.ca/Assets/Governing+Council+Digital+Assets/Policies/PDF/ppjun011995.pdf](http://www.governingcouncil.utoronto.ca/Assets/Governing+Council+Digital+Assets/Policies/PDF/ppjun011995.pdf)).
- Project presentation is expected from every student; project reporting styles should follow the guidelines provided at [http://advice.writing.utoronto.ca/types-of-writing/lab-report/](http://advice.writing.utoronto.ca/types-of-writing/lab-report/).
- Late assignments will be discredited at 1 point per delayed hour based on the submission time. Delays should be explained in writing at least 2 days before due date.
- Write a critical summary (500-600 words) on 1 selected Required reading by summarizing the study, discussing at least 2 related papers (via Google/Semantic Scholar) and referencing the papers found, suggesting the limitations and proposing ways to extend the study.
Lecture + Lab Schedules and Readings (due/required items are highlighted)

• Sep 14 (Tue) Introduction + Lab 0 (Jupyter Notebook)

  Required reading:
  – Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits
    on our capacity for processing information. Psychological Review, 63(2), 81–97.

  Optional readings:
    26–58.
    in Cognitive Sciences, 7(3), 141–144.

• Sep 21 (Tue) Numerical cognition + Lab 1 (data exploration)

  Required reading:

  Technical reference:
  – Chapters 1-3 in Stats.

  Optional readings:
    749–750.
    Science, 306(5695), 496–499.
    cognitive technology: Evidence from Pirahã language and cognition. Cognition,
    in non-verbal number acuity correlate with maths achievement. Nature, 455(7213),
    665–668.
  – Carey, S., and Barner, D. (2019). Ontogenetic origins of human integer representa-

• Sep 28 (Tue) Object recognition + Lab 2 (number estimation) (Lab 1 due)

  Required reading:
Technical reference:
- Chapter 4 in *Stats*.

Optional readings:

**Oct 5 (Tue)** Spatial cognition + Lab 3 (mental rotation) *(Lab 2 due)*

Required reading:

Technical reference:
- Chapter 8 in *Stats*.

Optional readings:

**Oct 12 (Tue)** Categories + Lab 4 (prototypicality) *(Lab 3 due)*

Required reading:
– Chapter 7 in *Stats*.

**Optional readings:**

**• Oct 19 (Tue) Categorization + Lab 5 (categorization) (Lab 4 due)**

**Required reading:**

**Optional readings:**

**• Oct 26 (Tue) Words + Lab 6 (word frequency) (Lab 5 due)**

**Required reading:**

**Technical reference:**

**Optional readings:**


**Nov 2 (Tue) Languages + Lab 7: Project orientation (Lab 6 due)**

Readings relevant to the project:


**Nov 16 (Tue) Judgment and decision making + Lab 8: Project analysis (Project proposal due)**

Required reading:

Optional readings:


**Nov 23 (Tue) Human and machine biases + Lab 9: Project analysis (Critical summary due)**
Optional readings:


- **Nov 30 (Tue)** Lab 10: Project walk-in clinics

- **Dec 7 (Tue)** Data blitz *(project final presentation)*

- **Dec 13 (Mon)** No class *(project final report due)*