Math 607: Statistical Learning

University of Oregon, Winter 2022

Time: MWF, 13:00-13:50
Place: University Hall 210
Instructor: James Murray
Teaching assistant: Tatyana Benko (`tbenko@uoregon.edu`)
Office hours: Mon 2-3; Wed 12-1.
Office hours location: In person at M443 Knight Campus (ask receptionist for elevator access) or virtually at our class's usual Zoom link (see below).
Instructor Email: `jmurray9@uoregon.edu`

Class format

This class will be held in person. In the event that you can't attend in person, please email the instructor, and class will be streamed at the following Zoom link:
https://uoregon.zoom.us/j/93327016252?pwd=a1BtVVN4R1UyV295T1Q0Y1JSeHRQZz09.
If the instructor cannot teach in person, an announcement will be made on Canvas, and the class may be conducted entirely on Zoom at the above link.

Summary

This course will cover statistical and machine learning theory using foundational approaches (i.e. not neural-network based). These will include probability theory, regression, classification, kernel methods, mixture models and expectation maximization, as well as inference for sequential data using hidden Markov models and linear dynamical systems. Class time will mostly consist of blackboard lectures combined with live coding demonstrations. Homework assignments will be a mix of pen-and-paper calculations together with implementations and applications of machine learning algorithms to real and synthetic data using Python. Prerequisites for this course include calculus and linear algebra. Students should also have prior experience with probability and statistics and with coding at the level of an introductory undergraduate course, or from the first course in the Applied Math sequence.

Learning outcomes

By the end of this course, students will have obtained the following skills:

- Approach problems involving data from the perspective of probabilistic inference, using statistical thinking to draw conclusions about patterns and relationships in data, as well as to quantify the degree of confidence about these conclusions.
- Derive the equations underlying standard machine-learning algorithms mathematically.
- Implement standard machine-learning algorithms from scratch in Python.
- Use standard built-in implementations of machine-learning algorithms in Python.
- Use simulated data that is designed to contain some interesting structure to develop understanding of machine-learning algorithms.
- Apply machine-learning algorithms to real data to quantify the patterns and relationships that it contains.

Textbook

This course will follow the book Pattern Recognition and Machine Learning by Bishop. A free PDF version of the book is available on the author's website. There will also be a limited number of copies available at the campus bookstore.

Topics

This course will cover the following topics:

- Review of probability theory and introduction to statistical inference (Ch. 1-2)
- Regression (Ch. 3)
- Classification (Ch. 4)
- Kernel methods (Ch. 6)
- Mixture models and the EM algorithm (Ch. 9)
- Sequential data (Ch. 13)

Additional possible topics (if time permits):

- Support vector machines (Ch. 7)
- Approximate inference (Ch. 10)
- Sampling methods (Ch. 11)
- Continuous latent variables (Ch. 12)

Evaluation

Homework assignments will be a mix of pen-and-paper calculations and Python notebooks applying algorithms to real or synthetic data. Midterm and final exams will be take-home and will have a similar format. Final grades will be weighted as 60% homework, 20% midterm, and 20% final exam. The final take-home exam will be due on the date of the formally assigned exam date during finals week.

Inclusion and accessibility

Please tell me your preferred pronouns and/or name, especially if it differs from the class roster. I take seriously the responsibility to create an inclusive learning environment. Please notify me if there are aspects of the instruction or design of this course that result in barriers to your participation! You are also encouraged to contact the Accessible Education Center in 164 Oregon Hall at 541-346-1155 or uoaec@uoregon.edu.

I am committed to making the classroom an inclusive and respectful learning space. Being respectful includes using preferred pronouns for your classmates. Your classmates come from a diverse set of backgrounds and experiences; please avoid assumptions or stereotypes, and aim for inclusivity. Let me know if there are classroom dynamics that impede your (or someone else's) full engagement.

Please see the following page for more information on campus resources, academic integrity, discrimination, and harassment: `https://uo-applied-math.github.io/applied_math/pages/policies.html`.