Syllabus for Math 5467: Introduction to the Mathematics of Image and Data Analysis (Spring 2021)

Instructor: Jeff Calder

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Course website: http://www-users.math.umn.edu/ jwcalder/5467S21/index.html

Lectures: Mon, Wed: 1pm–2:15pm on Zoom (link will be provided by email).

Office Hours: To be decided. Office hours will be listed on the course website.

Summary: This course is an introduction to the mathematics of image and data analysis. The course will cover the discrete Fourier and Wavelet transforms, with applications to image and audio processing. We will also cover mathematics of common data analysis algorithms, including principal component analysis (PCA), data ranking (e.g., Google's PageRank for ranking webpages), and clustering algorithms such as k-means and spectral clustering. Time-permitting, we will give an introduction to machine learning (ML), and cover basic ML classifiers, neural networks (in particular, convolutional neural networks for image classification), and graph-based learning.

The course will cover both mathematical theory and practical applications. We will use Python for all computational work in this course. Students will get hands on experience working with real data through a series of computational projects that will be completed throughout the term, on topics such as audio or image compression, facial recognition, or image classification. We will start the course with a gentle introduction to Python; no prior knowledge is required.

Prerequisites: The prerequisite for the course is a solid foundation in linear algebra. Knowledge of Fourier series or Fourier transform is not required (in particular, Math 4567 is not required).

Piazza: We have a Piazza website for student discussions. To sign up, click here. Rather than emailing questions to the instructor, students are encouraged to post questions on Piazza, and to participate in the discussion.

Canvas Site: We have a Canvas site that will be used for posting grades and homework submission.

Lecture Notes: The course will be taught from lecture notes that will be updated throughtout the term.

Recommended Textbooks: There is no required textbook. The course will be taught from lecture notes that will be developed throughout the semester. Some suggested textbooks for further reading are listed below.

(1) Bachman, Narici, and Beckenstein. Fourier and Wavelet Analysis. Springer, 2000.
(2) Ryan, O. Linear algebra, signal processing, and wavelets. A unified approach. Python version. Springer, 2017.
(3) Broughton and Bryan. Discrete Fourier Analysis and Wavelets. Wiley, 2008.
(4) Bishop. Pattern Recognition and Machine Learning. [PDF], 2006.
(5) Goodfellow, Bengio, and Courville. Deep Learning. MIT Press, 2016 [Online].

Final Exam: The final exam will be a take-home exam May 6-7, 2020.

Python Projects: There will be 3 computational projects to be completed in Python, due on Feb 12, Mar 26, and May 9.

Homework: There will be 4 homework assignments, due Jan 29, Feb 26, Mar 12, and April 16.

Grades: Your final grade will be based on homework assignments (40%), projects (30%), and the final exam (30%).

Readings: Readings will be assigned on a weekly basis and posted on the schedule page of the course website. It is very important to do the readings before attending the associated lecture. Unless otherwise noted, readings are from the class lecture notes.

Academic Honesty: The School of Mathematics at the University of Minnesota expects that students in mathematics courses will not engage in cheating or plagiarism. Cheating, plagiarism, and other forms of academic dishonesty will result in a grade of zero on the homework assignment or exam in question, and, in severe cases, a failing grade in the course and a referral to the Office for Student Conduct and Academic Integrity (OSCAI). Students should be familiar with the Student Code of Conduct.