Machine Learning (ENGG 408)
Fall, 2024

Instructors

Instructor: Peter Chin (peter.chin@dartmouth.edu)
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Hours

Meetings: two optional weekly synchronous zoom sessions (see schedule for days and times). Students are strongly encouraged to attend one session per week to participate in discussions and clarification of topics related to machine learning. In addition, questions about the team project will be addressed. Session recordings will be made available.

Office hours:

- Peter Chin: available by appointment
- TA: Mounika Reddy Vengama: available by appointment
- TA: Ganesh Rohit Nirogi: available by appointment

Course Description

Machine learning is a set of algorithms in the discipline of AI that enable various systems to learn and improve from data and experience without being explicitly given a set of rules or formulas. Machine learning can seem like magic sometimes, but a goal in this course is to learn that machine learning is not magic but, rather, is based on very rigorous mathematical and engineering principles with a vast number of applications.

This course will start with requisite mathematical backgrounds (probability theory, statistics, some basic linear algebra, etc.). Then we will discuss supervised ML models, namely linear regression/classification models, neural network models, and kernel machine models. Finally, we will pivot to unsupervised learning and discuss unsupervised ML algorithms, such as graphical models, K-clustering algorithm, EM (Expectation Maximization) algorithm, autoencoders, PCA/ICA, etc. Programming using Python and ML software packages (PyTorch, Tensorflow, etc.) will be used to supplement your understanding of the mathematics and algorithms covered in this course and to develop large-scale applications of ML algorithms.

The topics covered in this course are relevant for building, understanding, and analyzing a wide range of current state-of-the-art machine learning models and lay a strong theoretical foundation for understanding how the ideas of machine learning are used in fields such as economics, finance, policy-making, and healthcare, just to name a few.

Teaching Method

Videos and other content will be available over the Coursera platform. Optional weekly live sessions will be available to enrich the learning experience.

Prerequisites

The prerequisites are as follows:

- Multivariable calculus
- Linear algebra
- Probability is a plus but not mandatory
- Some proficiency in a programming language such as C/C++, Julia, Python, R, or MATLAB is helpful

Learning Objectives

By the end of the class students will be able to:

1. Express learning tasks with mathematical rigor using ideas from probability and statistics.
2. Differentiate between Bayesian perspective and frequentist perspective.
3. Build linear models for regression and for classification.
4. Apply the theory of neural networks to building models to solve practical problems.
5. Apply the theory of kernel machines to practical problems.
6. Apply graphical models to understand dependencies and causalities in data.
7. Identify structures in un-labelled data.
8. Apply maximum likelihood estimate (MLE) to find optimal parameters of a model.

Textbook

Pattern Recognition and Machine Learning (2nd Edition, by C. Bishop)

Additional Resources

Some other additional references that may be useful are listed below:

- Linear Algebra and Optimization for Machine Learning: A Textbook 1st ed. 2020 Edition, by Charu C. Aggarwal
- Deep Learning (1st Edition), by Ian Goodfellow
- Mathematics for Machine Learning by A. Aldo Faisal, Cheng Soon Ong, and Marc Peter Deisenroth.

Course Assignments

There will be four problem set assignments and five lab assignments throughout the course. You will be given 7 late days that you can use throughout the quarter to account for various emergencies.

You are encouraged to discuss the assignments with other students in the class, as it promotes a sense of teamwork. However, solutions should be completed and written up individually. Write-ups should be unique. Identical solutions will be viewed as plagiarism. Any plagiarized work will automatically be submitted as a violation of the Academic Honor Principle.

In working on the assignments, you can rely on information in any materials provided as part of this class. You may also use general knowledge materials such as textbooks. However, you may not use old/others' solutions, notes from previous offerings of this course, or textbook solution manuals. The general rule is as follows: do not use resources that contain the specific homework question being asked, unless provided by the instructor.

Generative Artificial Intelligence

Generative AI tools can be useful for researching, developing code, and writing papers. However, you should be aware of their limitations:

Errors: AI generators make mistakes. Assume the output is incorrect unless you check the claims with reliable sources.

Bias: Their output may reflect bias because the data they are trained on may reflect bias or may not include sufficient data from certain groups.

Citation: These tools use existing sources without citation. Using Generative AI outputs puts you at risk of plagiarism. You are responsible for proper citation of all content you present, including any content copy-pasted from Generative AI outputs.

With these limitations in mind, you are welcome to use AI generators in this course provided you cite your sources. Note which AI tool you used and how you used it, including the prompt(s) you used and the date(s).

Grading Scheme

The grading scheme is as follows:

Discussion	5%
Online Exercises*	15%
Lab Assignments	25%
Written Problem Sets	25%
Team Project	30%
Total	100%

*Online Exercises are the activities interleaved with the reading items and videos in our online modules which were designed to help you develop your engineering practice. Activities include reflection and intuition cultivation, skill building and application, and coding work.

Passing Thresholds:

HP (High Pass): distinctly superior work (equivalent to A, A-)
P (Pass): good work (equivalent to B+, B, B-)
LP (Low Pass): work deficient but acceptable for graduate credit (equivalent to C+, C, C-)

NC (No Credit): unsatisfactory work, not acceptable for graduate credit (equivalent to D, E)
Overall Course Passing Threshold: 70%

Grading Policy

If you believe that there is an error in the grading of your homework assignment or quiz, you must submit an emailed request to the instructor email group. On the regrade request, you should clearly state the parts that you want re-graded and the reasoning. Note that any work submitted for re-grading will be subject to a full re-grade; therefore, points may be added or subtracted.

In case of Emergency

If you have an unseen emergency on your end that significantly affects your ability to engage in the class, please do ***NOT*** hesitate to contact me. Things happen, and we want to help you through any unforeseen crisis.

Student Accessibility and Accommodations

At Dartmouth, we are committed to providing equal opportunities to all students. Accommodations are determined on an individual basis through an interactive process that includes the student and Thayer.

Our process is based on federal law and Dartmouth guidelines. Students may request accommodation at any time. Note that it may take two to three weeks to complete.

The process is coordinated by the Dartmouth ADA Office in collaboration with Thayer Assistant Dean of Academic and Student Affairs Holly Wilkinson. We aim to make the process straightforward and accessible for all students. More information on the process can be found on the Disability Accommodation Request Process page, or you can contact the Dartmouth ADA Office at ada@dartmouth.edu with additional questions.

Religious Observances

Dartmouth has a deep commitment to support students' religious observances and diverse faith practices. Some students may wish to take part in religious observances that occur during this academic term. If you have a religious observance that conflicts with your participation in the course, please meet with me as soon as possible—before the end of the second week of the term at the latest—to discuss appropriate course adjustments.

Mental Health and Wellness

The academic environment is challenging, our terms are intensive, and classes are not the only demanding part of your life. There are a number of resources available to you on campus to support your wellness, including: UWill Teletherapy and the Student Wellness Center which offers wellness check-ins. The student-led Dartmouth Student Mental Health Union and their peer support program may be helpful if you would

like to speak to a trained fellow student support listener. Please make me aware of anything that will hinder your success in this course.

Title IX

At Dartmouth, we value integrity, responsibility, and respect for the rights and interests of others, all central to our Principles of Community. We are dedicated to establishing and maintaining a safe and inclusive campus where all community members have equal access to Dartmouth's educational and employment opportunities. We strive to promote an environment of sexual respect, safety, and well-being. Through the Sexual and Gender-Based Misconduct Policy (SMP), Dartmouth demonstrates that sex and gender-based discrimination, sex and gender-based harassment, sexual assault, dating violence, domestic violence, stalking, etc., are not tolerated in our community.

For more information regarding Title IX and to access helpful resources, visit Title IX's website (sexual-respect.dartmouth.edu). As a faculty member, I am required to share disclosures of sexual or gender-based misconduct with the Title IX office.

If you have any questions or want to explore support and assistance, please contact the Title IX office at 603-646-0922 or TitleIX@dartmouth.edu. Speaking to Title IX does not automatically initiate a college resolution. Instead, much of their work is around providing supportive measures to ensure you can continue to engage in Dartmouth's programs and activities.

Consent to Record

(1) Consent to recording of course meetings and office hours that are open to multiple students.

By enrolling in this course,

a) I affirm my understanding that the instructor may record meetings of this course and any associated meetings open to multiple students and the instructor, including but not limited to scheduled and ad hoc office hours and other consultations, within any digital platform, including those used to offer remote instruction for this course.

b) I further affirm that the instructor owns the copyright to their instructional materials, of which these recordings constitute a part, and my distribution of any of these recordings in whole or in part to any person or entity other than other members of the class without prior written consent of the instructor may be subject to discipline by Dartmouth up to and including separation from Dartmouth.

(2) Requirement of consent to one-on-one recordings

By enrolling in this course, I hereby affirm that I will not make a recording in any medium of any one-on-one meeting with the instructor or another member of the class or group of members of the class without obtaining the prior written consent of all those participating, and I understand that if I violate this prohibition, I will be subject to discipline by Dartmouth up to and including separation from Dartmouth, as well as any other civil or criminal penalties under applicable law. I understand that an exception to this consent applies to accommodations approved by SAS for a student's disability, and that one or more students in a class may record class lectures, discussions, lab sessions, and review sessions and take pictures of essential information, and/or be provided class notes for personal study use only.

Last Update: 8/27/24