CS 6316 -- Machine Learning
Course Syllabus

INSTRUCTOR

Prof. Aidong Zhang
Email: aidong@virginia.edu

TAs
Guangzhi Xiong
Email: hhu4zu@virginia.edu

Sanchit Sinha
Email: ss7mu@virginia.edu

Kazi Noshin
Email: epw9kz@virginia.edu

OFFICE HOURS

Rice Hall 509
Mondays and Wednesdays
12:50pm—1:50pm

Office: Rice Hall 442
Tuesdays and Thursdays
3:00pm—4:00pm

Wednesdays and Fridays
4:00pm —5:00pm

Mondays: 11:30am –12:30pm
Fridays: 11:30am – 12:30pm

Course Description

This is a graduate-level computer science machine learning course. Machine learning uses algorithms to mimic the way in which humans learn. Classical machine learning uses statistical methods to train algorithms and make predictions. However, machine Learning is fast growing in both theory and applications. Recently, many successful machine learning applications have been developed, such as large language models (LLMs) for scientific discovery, and autonomous vehicles. There have also been important advances in the theory and algorithms that form the foundation of this field. This course will provide a broad introduction to the field of machine learning, covering both foundational topics about the theory and practical algorithms for machine learning from a variety of perspectives. Specifically, we will cover most of the following topics:

- Introduction to learning theory
- Supervised learning and its theoretical foundations and unsupervised learning
- Boosting and kernels techniques
- Model selection and validation
- Regularization and stability
- Neural networks and deep learning
- Optimization
- Autoencoders
- Multimodal learning
- Interpretable machine learning
- Few-shot learning
- Federated learning
- Shortcut learning
- Large language models (Transformer, In-Context Learning, RAG, and Chain of thought) and their applications, such as benchmarks for LLMs, scientific hypothesis generation, and education
- Other emerging topics.

Textbooks

- **Primary textbook:**

1. Shalev-Shwartz and Ben-David. Understanding Machine Learning: From Theory to Algorithms. 2014.
(https://www.cs.huji.ac.il/~shais/UnderstandingMachineLearning/index.html)
2. Goodfellow, Bengio, and Courville. Deep Learning. 2016
(https://www.deeplearningbook.org/)
3. Christoph Molnar, Interpretable Machine Learning, A Guide for Making Black Box Models Explainable, 2024
https://christophm.github.io/interpretable-ml-book/

- **Additional textbooks:**
  1. Bishop. Pattern Recognition and Machine Learning. 2006.
     (https://www.microsoft.com/en-us/research/people/cmbishop/prml-book/)
  2. Mohri, Rostamizadeh, and Talwalkar. Foundations of Machine Learning. 2nd Edition. 2018.
     (https://cs.nyu.edu/~mohri/ml18/)
  3. Hastie, Tibshirani, and Friedman. The Elements of Statistical Learning (2nd Edition). 2009.
  4. Kevin Murphy: Machine Learning: a Probabilistic Perspective, 2012
     (http://noiselab.ucsd.edu/ECE228/Murphy_Machine_Learning.pdf).

Prerequisite:
Calculus, Matrix Algebra, probability theory and statistics, and algorithms. Students should also have good programming skills in Python.

A recommended book to read for the first week:
Author: Prof. Mor Harchol-Balter
Title: Introduction to Probability for Computing, https://www.cs.cmu.edu/~harchol/Probability/book.html
Published: 2024
Publisher: Cambridge University Press (CUP)
ISBN: 978-1-009-30907-3

Homework:
There will be 4-5 homework assignments. Some assignments will be individual, and some assignments will be in teams (up to 4 people in a team).

Focused project:
Each team (up to 4 people in a team) will be able to choose a topic to work on. The topics can be one of the topics covered in class or a topic your team is interested in and approved by the instructor. Each team will be required to give a brief presentation on the project ideas late November and early December classes. Each project final submission requires a term paper, code, and a set of presentation slides.

Piazza
We will use Piazza as our discussion board. This is the primary place where you can ask for help, offer help, find your teammate, share your thoughts and discoveries, or discuss technical difficulties and potential troubleshooting. You can visit our class Piazza site through the course collab. All class materials including syllabus, class slides, and HW/project handouts will be posted via Piazza. Please address all technical questions about the course material or the assignments on Piazza. The sign-up link to our Piazza page is at: https://piazza.com/class/m0bfq5v09z54yw

Grading (subject to change)

Quizzes or working problems – 25%
Homework -- 45%
Project -- 25%

Class participation – 5%

Assignment due dates, Lateness and Extensions

- Unless otherwise specified, assignments should be submitted through canvas and are due **at 11:59pm on the due date**.
- Programming solutions should be placed in each student's appropriate canvas directory.
- Each student has three extension days to be used at his or her own discretion throughout the entire course. Your grades would be discounted by 20% per day when you use these late days. After you've used all late days, you cannot get credit for anything turned in late.

Note: This syllabus may be adjusted through the course of the semester to address changing needs.

Other Related Statements
(*Adapted from a SEAS-wide example)*

Honor code
We are proud of our honor system and we trust every student in this course to fully comply with all of the provisions of the University's Honor Code. By enrolling in this course, you have agreed to abide by and uphold the Honor System of the University of Virginia, as well as the following policies specific to this course.

- All graded assignments must be pledged.
- All suspected violations will be forwarded to the Honor Committee, and you may, at my discretion, receive an immediate zero on that assignment regardless of any action taken by the Honor Committee.

Please let me know if you have any questions regarding the course Honor policy. If you believe you may have committed an Honor Offense, you may wish to file a Conscientious Retraction by calling the Honor Offices at (434) 924-7602. For your retraction to be considered valid, it must, among other things, be filed with the Honor Committee before you are aware that the act in question has come under suspicion by anyone. More information can be found at http://honor.virginia.edu. Your Honor representatives can be found at: http://honor.virginia.edu/representatives.
Adapted from Honor Syllabus Example Statement on the UVa Honor Committee website

Students with disabilities or learning needs
It is my goal to create a learning experience that is as accessible as possible. If you anticipate any issues related to the format, materials, or requirements of this course, please meet with me outside of class so we can explore potential options. Students with disabilities may also wish to work with the Student Disability Access Center (SDAC) to discuss a range of options to removing barriers in this course, including official accommodations. We are fortunate to have an SDAC advisor, Courtney MacMasters, physically located in Engineering. You may email her at cmacmasters@virginia.edu to schedule an appointment. For general questions please visit the SDAC website: sdac.studenthealth.virginia.edu. If you have already been approved for accommodations through SDAC, please send me your accommodation letter and meet with me so we can develop an implementation plan together.

Harassment, Discrimination, and Interpersonal Violence
The University of Virginia is dedicated to providing a safe and equitable learning environment for all students. If you or someone you know has been affected by power-based personal violence, more information can be found on the UVA Sexual Violence website that describes reporting options and resources available - *www.virginia.edu/sexualviolence*.

The same resources and options for individuals who experience sexual misconduct are available for discrimination, harassment, and retaliation. UVA prohibits discrimination and harassment based on age, color, disability, family medical or genetic information, gender identity or expression, marital status, military status, national or ethnic origin, political affiliation, pregnancy (including childbirth and

related conditions), race, religion, sex, sexual orientation, or veteran status. UVA policy also prohibits retaliation for reporting such behavior.

If you witness or are aware of someone who has experienced prohibited conduct, you are encouraged to submit a report to Just Report It (justreportit.virginia.edu) or contact EOCR, the office of Equal Opportunity and Civil Rights.

If you would prefer to disclose such conduct to a confidential resource where what you share is not reported to the University, you can turn to Counseling & Psychological Services ("CAPS") and Women's Center Counseling Staff and Confidential Advocates (for students of all genders).

As your professor and as a person, know that I care about you and your well-being and stand ready to provide support and resources as I can. As a faculty member, I am a responsible employee, which means that I am required by University policy and by federal law to report certain kinds of conduct that you report to me to the University's Title IX Coordinator. The Title IX Coordinator's job is to ensure that the reporting student receives the resources and support that they need, while also determining whether further action is necessary to ensure survivor safety and the safety of the University community.

Religious accommodations
It is the University's long-standing policy and practice to reasonably accommodate students so that they do not experience an adverse academic consequence when sincerely held religious beliefs or observances conflict with academic requirements. Students who wish to request academic accommodation for a religious observance should submit their request to me by email as far in advance as possible. Students who have questions or concerns about academic accommodations for religious observance or religious beliefs may contact the University's Office for Equal Opportunity and Civil Rights (EOCR) at *UVAEOCR@virginia.edu* or 434-924-3200.