CME 216/ME 343
Machine Learning for Computational Engineering
E. Darve, D. Patel
Winter 2023

Stanford University

CME 216/ME 343 Syllabus and Course Information

CME 216/ME 343 covers topics in machine learning and data science primarily for students in engineering. The course is introductory and assumes basic knowledge of multivariable calculus and statistics. Familiarity with Python programming is required.

The instructor is Prof. Eric Darve, darve@stanford.edu. Prof. Darve is a Professor in Mechanical Engineering and a faculty member affiliated with ICME. Dr. Dhruv Patel, the Timoshenko Postdoctoral Fellow in Mechanical Engineering, will assist Prof. Darve. Dhruv will cover primarily the topics on machine learning.

Yizhou Qian yzqian@stanford.edu is the TA for this class. Jason Liang jialiang@stanford.edu will be assisting Yizhou.

**Canvas.** Canvas will be the primary site for course material. Class information, web resources, and schedules will be posted on Canvas canvas.stanford.edu/courses/166332.

**Survey.** There is an online survey you can fill. You will find the link on canvas.

**Forum.** We will use Ed Discussion to manage online Q&A and discussions for this class. The link is available from Canvas.

**Course content.** This is a tentative list of the topics to be covered in this class. This is not a final list and is subject to change. We may skip some topics based on available time.

- Introduction to machine learning, unsupervised and supervised learning
- Dimension reduction, PCA, tSNE, UMAP
- Clustering techniques; K-means, DBSCAN, Gaussian mixtures, spectral clustering
- Support Vector Machine (SVM), classification and regression, Support Vector Regression, linear and kernel SVM, Gaussian Process Regression (GPR)
- Deep learning: context, multi-layer perceptron (MLP), activation function, loss function, regularization
- Backpropagation, optimizers, initialization of neural networks (NN)
- Software: PyTorch, hyperparameter tuning and convergence monitoring, Weights and Biases (wandb), visualization

- DNN structure: convolution neural network (CNN); transpose, stride, padding, dilation; connection to partial differential equations (PDE); U-Nets, Resnets; connection to ordinary differential equations (ODE)
- Applications and current research (depending upon time): reduced order and surrogate modeling for PDEs, uncertainty quantification

**Support.** How to get support? Your first port of call for questions is the online discussion forum on Ed Discussion. The forum will be monitored daily by one of the TAs. Email the instructor at darve@stanford.edu for confidential questions and concerns or if an issue arises with one of the TAs.

On the forum, please observe the following code of conduct:

- Be civil, considerate, and courteous. The forum is meant to be a safe and welcoming space for everyone to get help. This is a space for dialogue and discussions. If your message is not helpful to other students, yourself, or the instructors, you should probably just delete it. Students who harass other students or the teaching staff will be blocked from participating.
- Make sure not to post answers or partial answers to homework assignments. Use private messages if you need to share partial solutions to ask your question or for clarification.

We have set up an anonymous form to report issues and concerns. You will find the URL on Canvas.

You are also welcome to use Ed direct messages to contact us privately.

**Office hours.** Our office hours will be in person. You can meet with your instructors and teaching assistants during office hours to discuss the material being covered in class, questions or concerns you might have, and other related issues. Feel free to attend even if you don't have any questions. You can listen in on the conversation (which might spark a question for you), or we can use the time to get to know each other!

**Programming languages.** The main programming language will be Python. We expect you to be already familiar with Python programming. We will use two main Python libraries: scikit-learn and Pytorch. TensorFlow is also recommended but will not be covered in depth in this class.

**Reading.** Reading material has been posted on Canvas. This will get you started on many important topics and concepts useful for this class.

**Grading.** The grading will be done as follows:

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|---|---|
| Homework | 70% |
| Final project | 30% |

For homework assignments, you are welcome to consult with other students and the teaching staff. **However, the answers you submit must be your own and cannot be copied.**

Please register on **Gradescope** to submit your graded work. You will find the relevant information on Canvas. In most cases, we expect you to write your answers on paper, take a photograph or scan using your phone, and upload an electronic copy to gradescope. Some of our favorite apps are Dropbox, Box, and

Google Drive, which include scanner apps to create PDFs. You are also welcome to type your paper using markdown, LaTeX, Word, or a tablet. Let us know if you cannot access a phone that can take pictures.

Each student will determine their final project. It should be based on one of the topics covered during the quarter, such as unsupervised learning, supervised learning, deep learning, etc. You will have to prepare a 4-page report. For the final project, you will have to:

- propose a machine learning task in engineering,
- review the literature and relevant methods for this problem,
- propose an algorithm and write some Python code to solve the problem,
- present some benchmark results,
- comment and discuss the results of your work.

**Late policy.** You may submit your assignment up to 48 hours after the deadline for a 10% penalty without any special justification.

For **excused** late submissions, students must request late days at least **24 hours before** the due date of an assignment. This is done using an online form that can be found on Canvas. Students must provide a reason when requesting late days. There is no penalty for instructor-approved late submissions.

After receiving your grade on gradescope, you are welcome to request a regrade using the gradescope interface. No one is perfect. We strive to grade accurately and fairly and provide helpful feedback, but mistakes do happen. We will be happy to address any concerns you have. However, to help with the logistics, we prefer that you submit your regrade request **at most 1 week after** the grade has been released.

**What you can expect from me.** I am here to guide your learning and will challenge you to actively engage in the learning process through class activities, assignments, and more. I will strive for an inclusive and collaborative classroom and welcome suggestions for improvement. I will do my best to give you the tools, feedback, and support to succeed, so let me know if I can do anything more. Learning is a never-ending process, so I hope to motivate students to seek more information on topics we don't have time to cover. I highly encourage everyone to visit me during office hours or to set up a meeting, even if you don't feel you have questions. I want to get to know you and support you in this learning experience! The best way to reach me is by email or Slack. You should expect a response within two business days (but often much sooner).

**Respect for diversity.** I intend that students from all diverse backgrounds, perspectives, and situations be well served by this course, that students' learning needs be addressed both in and out of class, and that the diversity that students bring to this class be viewed as a resource, strength, and benefit. I intend to present materials and activities that are respectful of diversity, including but not limited to: gender, sexuality, disability, age, socioeconomic status, ethnicity, race, religion, political affiliation, culture, and so on. I acknowledge that there is likely to be a diversity of access to resources among students, and I plan to support all of you as best as possible. Please let me know ways to improve the effectiveness of the course for you personally or for other students or student groups. In addition, if any of our class meetings conflict with your religious events, please let me know so we can make arrangements for you.

All people have the right to be addressed and referred to in accordance with their personal identity. In this class, we will have the chance to indicate the name that we prefer to be called (see the survey on Canvas) and, if we choose, to identify the pronouns with which we would like to be addressed. I will do my best to address and refer to all students accordingly and support classmates in doing so.

**Support services.** The COVID-19 pandemic is a stressful time for us all. In addition, you may experience a range of other challenges that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating, or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce your ability to participate in daily life. Stanford is committed to advancing all its students' mental health and well-being. Services are available if you or someone you know is feeling overwhelmed, depressed, or in need of support.

Learn more about the broad range of confidential mental health services available on campus: vaden.stanford.edu/caps

**Access and accommodations.** Stanford is committed to providing equal educational opportunities for disabled students. Disabled students are a valued and essential part of the Stanford community. We welcome you to our class.

If you experience a disability, please register with the Office of Accessible Education (OAE). Professional staff will evaluate your needs, support appropriate and reasonable accommodations, and prepare an Academic Accommodation Letter for faculty. To get started or to re-initiate services, please visit oae.stanford.edu.

If you already have an Academic Accommodation Letter, we invite you to share your letter with us. Academic Accommodation Letters should be shared at the earliest possible opportunity so we may partner with you and OAE to identify any barriers to access and inclusion that might be encountered in your experience of this course.

The OAE is located at 563 Salvatierra Walk; phone: 723-1066; oae.stanford.edu

**Honor Code and Office of Community Standards.** We take the honor code very seriously. Here is an excerpt from the Stanford honor code:

> The Honor Code is an undertaking of the students, individually and collectively, that they will not give or receive aid in examinations; that they will not give or receive unpermitted aid in class work, in the preparation of reports, or in any other work that is to be used by the instructor as the basis of grading

Note that the student who lets others copy his work is as guilty as those who copy. Violations include at least the following circumstances: copying material from another student, copying previous years' solution sets, copying solutions found using Google, copying solutions found on the internet. You will be automatically reported without a warning if a violation is suspected. The Office of Community Standards is in charge of determining whether a violation occurred. OCS does not always contact you during the quarter and may delay until the quarter is over.

Please do not post any material from this class online. This will encourage honor code violations and penalize other students. This is also a violation of copyright.

If found guilty of a violation, your grade will be automatically lowered by at least one letter grade.

Homework is designed to help you learn the material and prepare you for the exams. You will lose all the benefits if someone hands you the solution.

https://communitystandards.stanford.edu/policies-guidance/honor-code

**We hope you will enjoy this class and find it useful.**