

CS441 Applied Machine Learning

Instructor: Derek Hoiem

Art by Dall-E: "Computer brain gathering knowledge, impressionist"

Today's Class

• A little about me

• Intro to Applied Machine Learning

• Course outline and logistics

About me

Raised in "upstate" NY



About me



1998-2002 Undergrad at SUNY Buffalo B.S., EE and CSE



2002-2007 Grad at Carnegie Mellon Ph.D. in Robotics



2007-2008 Postdoc at Beckman Institute



2009-Prof in CS at UIUC

My research



Neural Radiance Fields: use deep networks to model 3D scenes



Ground Truth

MLP

Lee et al. 2022

General Purpose Learners

a close up of a person

wearing a kn95 mask





covid vaccination card





nasal swab



pcr test

Kamath et al. 2022

Other examples of my research that use machine learning

• Vision

- Object detection
- Image classification
- Photo album organization
- Image retrieval
- Describing objects
- 3D scene modeling
- 3D object modeling
- Robot navigation
- Shadow detection and removal
- Generating animations
- Vision and Language
 - Visual question answering
 - Phrase grounding
 - Video analysis
 - General purpose vision-language
- Audio
 - Sound detection
 - Music identification

Reconstruct: vision for construction



Crunchbase top 50 global startups

https://vimeo.com/242479887

https://www.reconstructinc.com/

What is machine learning?

- Create predictive models or useful insights from raw data
 - Alexa speech recognition
 - Amazon product recommendations
 - Tesla autopilot
 - GPT-3 text generation
 - Image generation
 - Data visualization



ML spins raw data into gold!

The whole machine learning problem

- 1. Data preparation
 - a. Collect and curate data
 - b. Annotate the data (for supervised problems)
 - c. Split your data into train, validation, and test sets
- 2. Algorithm and model development
 - a. Design methods to extract features from the data
 - b. Design a machine learning model and identify key parameters and loss
 - c. Train, select parameters, and evaluate your designs using the validation set
- 3. Final evaluation using the test set
- 4. Integrate into your application

Example: voice recognition in Alexa

- Our focus, but it's important to understand all of it

Algorithm and model development



Course objectives

- 1. Learn how to solve problems with ML
 - Key concepts and methodologies for learning from data
 - Algorithms and their strengths and limitations
 - Domain-specific representations
 - Ability to select the right tools for the job

The global machine learning market is expected to grow from \$21.17 billion in 2022 to \$209.91 billion by 2029, at a CAGR of 38.8%. With the field growing at such an exponential rate the number of jobs is growing too and machine learning is one of the most trending career paths of today. - <u>Emeritus</u> 2. Better understanding of real-life application and social implications of machine learning

- Recommending systems
- Surveillance
- Robots
- Smart assistants
- Text generation
- Autonomous cars
- Social media bots



Tesla accident

3. Appreciation for your own constantly learning mind



Course outline

Prof: Derek Hoiem <u>dhoiem@illinois.edu</u>

TAs

- Joshua Levine (joshua45)
- Ibtihal Ferwana (iferwna2)
- Adam Davies (adavies4)
- Akshat Sharma (akshat7)
- Seemandhar Jain (sj68)
- Xiacong Yang (xy51)
- +1

Website: https://courses.engr.illinois.edu/cs441/sp2024/

Topics

- Fundamentals of learning
 - How to build classifiers and regressors based on provided features
 - Working with data, instance-based methods, linear models, probabilistic methods, trees
- Deep representation learning
 - How to learn effective representations
 - Optimization, MLPs, CNNs, transformers, vision, language, foundational models
- Applications
 - Ethics and impact, bias/fairness, building applications, RL, audio and time series

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Grades

- Experience Points: 500+ points
 - 5 homeworks: 100+ points each
 - 1 final project: 100+ points
 - Participation: up to 50 points
 - 3 credit: target is 500 points
 - 4 credit: target is 625 points
- Exams: 200 pts
 - Midterm: covers first half
 - Final: covers entire semester (can replace midterm grade also)

Final grade calculation:

Course_Grade = (EP + max(Midterm, Final) + Final) / (max(EP, EP_Target) + 200)

Late policy

- Up to ten free days total use them wisely!
- 5 point penalty per day after that
- Project must be submitted within two weeks of due date to receive any points

Covid, masks, sickness

• If you're well, please come to lectures and office hours. Masks are optional, per university policy. You're encouraged to follow CDC guidelines for masking.

• If you're sick, please stay home. No need to show proof of illness or get permission to miss.

• Lectures will be recorded, and exams can be taken from home

Homework details

Overall

- Mostly implementing and applying machine learning methods in Python notebooks
- Some conceptual questions
- Complete/submit Report PDF and Jupyter notebook

Assignments

- HW 1: Instance-based methods
 - Retrieval, clustering, KNN classification and regression
- HW 2: Linear Models
 - PCA and embeddings, linear regression, logistics regression, SVM
- HW 3: Probabilistic Methods
 - Estimating PDFs, robust estimation
- HW 4: Trees and MLPs
 - Decision trees, random forests, boosting, multi-layer perceptrons
- HW 5: Deep learning and applications
 - Linear probe, fine-tuning, investigating a real-world application area
- Final Project: Disaster tweet classification, house price regression, or custom project

Learning resources

Website: https://courses.engr.illinois.edu/cs441/sp2024/

- Syllabus
- Recordings
- CampusWire Discussion
- Canvas Submission
- Assignments
- Schedule
- Lecture slides and readings

Lectures

• In-person, recorded

Office hours

• Will be updated on pinned CampusWire post

Readings/textbook: Forsyth Applied Machine Learning

Attendance

- Class attendance is strongly encouraged
 - Having a critical mass of students in class makes class more fun and leads to good questions and increased learning
 - Regularly attending helps make sure you stay on top of things
 - Some classes have significant discussion components
 - Can get credit for in-class question answers

Academic Integrity

These are OK

- Discuss homeworks with classmates (don't show each other code)
- Use Stack Overflow to learn how to use a Python module
- Use GPT/Co-Pilot etc to learn how to use a Python module, or streamline coding
- Get ideas from online (make sure to attribute the source)

Not OK

- Copying or looking at homework-specific code (i.e. so that you claim credit for part of an assignment based on code that you didn't write)
- Using external resources (code, ideas, data) without acknowledging them

Remember

- Ask if you're not sure if it's ok
- You are safe as long as you acknowledge all of your sources of inspiration, code, etc. in your write-up
- If you use GPT or Co-Pilot, acknowledge it

Other comments

Prerequisites

- Probability/stats, linear algebra, calculus
- Experience with Python will help but is not necessary, understanding that it may take more time to complete assignments

 Watch tutorials (see schedule: intro reading) for linear algebra, python/numpy, and jupyter notebooks.

How is this course different from...

- CS 446 ML
 - This course provides a foundation for ML practice, while 446 provides a foundation for ML research
 - This course has less theory, derivations, and optimization, and more on application representations and examples
- Online version of CS 441 AML
 - This course has fewer, larger homeworks, a final project, and exams (vs. many small homeworks and quizzes)
 - This course focuses more on concepts and modern usage of ML
- CS 444 Deep Learning for CV, other domain-oriented courses
 - This course is much broader

Should you take this course?

Take this course if ...

- You want to learn how to apply machine learning
- You like coding-based homeworks and are OK with math too
- You are willing to spend 10-12 hours per week (maybe even more) on lectures, reading, review, and assignments

Do not take this course if ...

- You want more of a theoretical background (take 446 instead)
- You want to focus on one application domain (take vision, NLP, or a special topics course instead)
- You want an "easy A" (it will be achievable with hard work but not easy)

Feedback is welcome

I will occasionally solicit feedback through surveys – please respond

 You can always talk to me after class or send me a message on CampusWire

 My goal is to be a force multiplier on how much you can learn with a given amount of effort

What to do next

- Bookmark the <u>website</u>
- Sign up for campuswire
- Read the syllabus and schedule
- Unless you consider yourself highly proficient in Python/numpy and linear algebra, watch/do the tutorials linked in the web page