INTRODUCTION TO MACHINE LEARNING

Aadirupa Saha

CS 412, SPRING 2025
UIC, TBH 180F

Instructors

Aadirupa Saha (aadirupa@uic.edu)

Office hours: Th 6-7pm
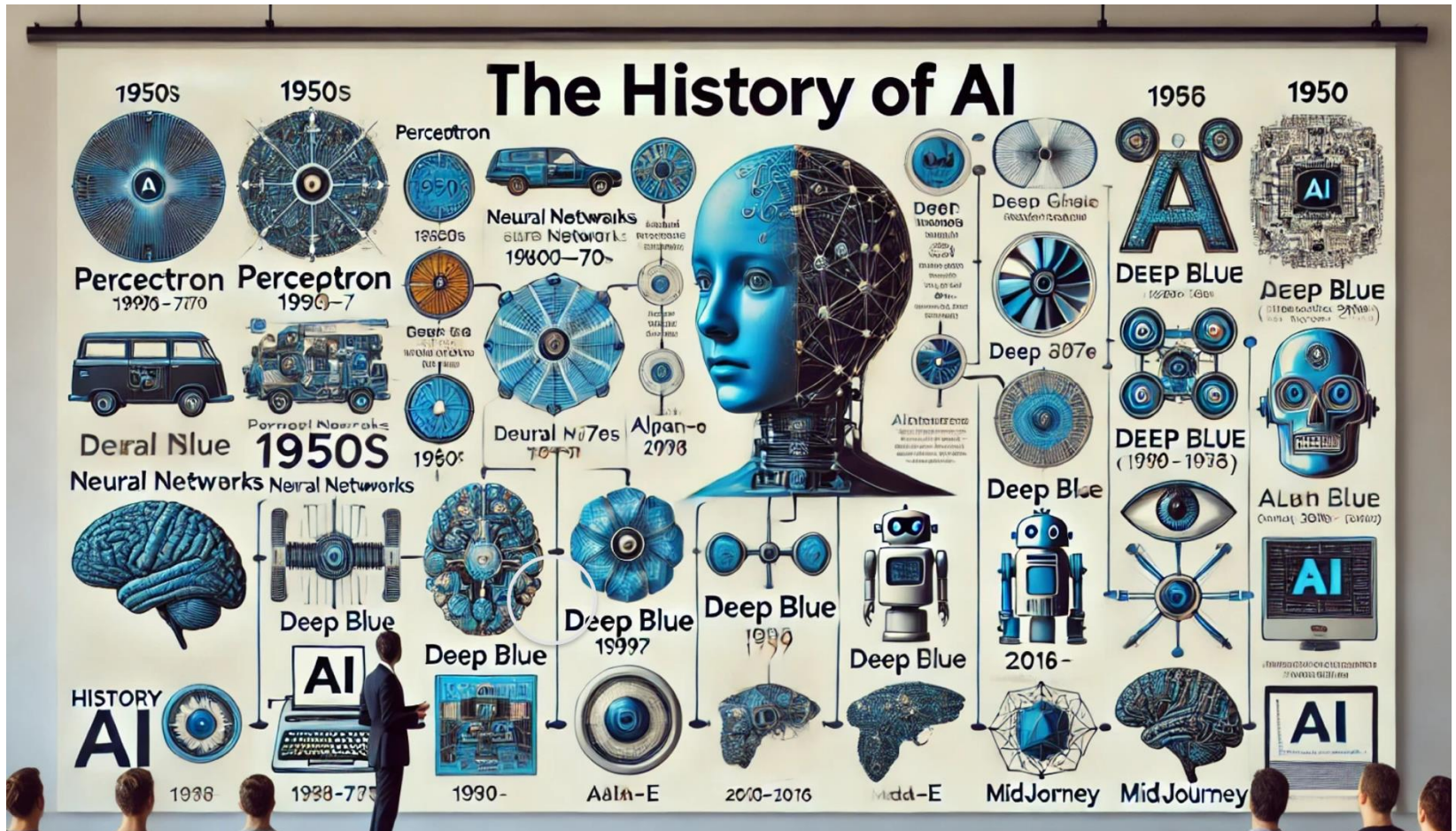SEO 1123 or Zoom (link of Piazza)
[starts from week 2]

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Office hours: Tue – Th (12-1pm)
[Location: TBD][starts from week 2]

(Very brief) History of ML

The Turing Test, 1950

Alan Turing

A machine is intelligent if its answers are indistinguishable from a human's

Checkers Program, 1952

Arthur Samuel

Created a Checkers-playing program that got better overtime.

Also introduced the term "**Machine Learning**."

The term **Artificial Intelligence** originated in 1956 at a Workshop at Dartmouth

Perceptron, 1957

Frank Rosenblatt
@Cornell!

Predecessor of deep networks.

Separating two classes of objects
using a linear threshold classifier.
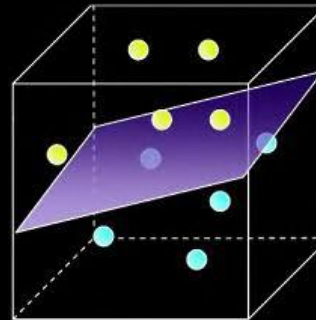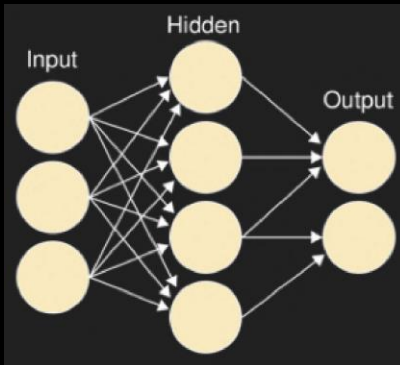
Neural Network Boom, 1960-1979

Frank Rosenblatt
@Cornell!
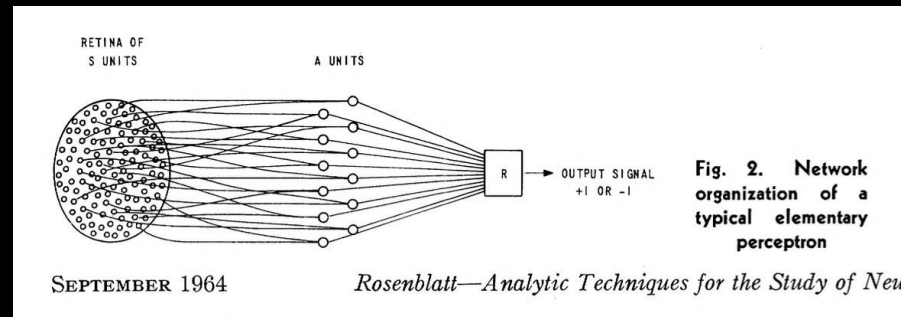
- 1962 Rosenblatt invents Multi-Layer Perceptron (MLP) (fixed hidden layer)
- 1965 Ivakhnenko and Lapa introduce first Feed Forward Neural Net (FFNN)
- 1967 First FFN trained with SGD [Amari 1967]
- 1970 Modern back-propagation is introduced by Seppo Linnainmaa

First AI Winter (1974-1980)

- (1969) Minsky & Papert "killed" AI

  - Perceptron cannot learn XOR function

- Burst huge expectation bubble

- Speech understanding / translation fails

- UK and US stop funding AI research

- Neural Networks and AI become "bad words"

- Rise of Rule based Systems

Expanded Edition

Perceptrons

Marvin L. Minsky
Seymour A. Papert
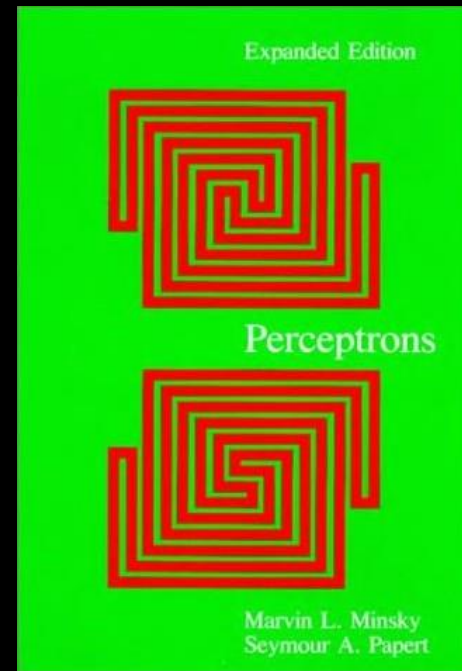
Rebirth of A.I. as Machine Learning

AI

- Machine Learning:

  - Originally: Mostly a name game to get funding.

- Differences in approach:

  - ML: Bottom up, AI: Top down

  - ML: More practical smaller goals

  - Based on **Statistics and Optimization, not Logic and Search**

ML
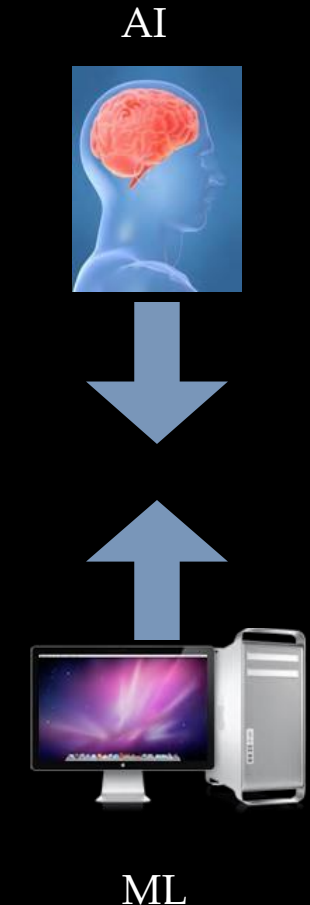
TD-Gammon (1994)

- Gerry Tesauro (IBM) teaches a neural network to play Backgammon. The net plays 100K+ games **against itself** and beats world champion [Neurocomputation 1994]

- Algorithm teaches **itself** how to play so well!!!

- Algorithm found new techniques that people had erroneously ruled out.

Deep Blue (1997)

- IBM's Deep Blue wins against Kasparov in chess. Crucial winning move is made due to Machine Learning (G. Tesauro).

  - (Mostly a more classical AI system)

Expanding the reach, 2000s

Learning to rank

- Powering search engines: Yahoo, Google, Bing, …

Topic Modeling:

- Detecting, organizing documents by subject matter.

- Making sense of the unstructured data on the web.

Online economy:

- Ad placement and pricing.

- Product recommendation.

Machine learning became profitable! Euphoria!   Excitement!

2000-2010 The Convex Years

- Success of **Support Vector Machines** (SVM) and **Convex** Optimization

- **Kernelization** enables non-linear classifiers that are still convex

- Allows **rigorous proofs** about convergence, learning guarantees

- Finally **solid theory** and **empirical success**

- (Non-convex algorithms, e.g. Neural Networks fell out of favor and were frowned upon.)
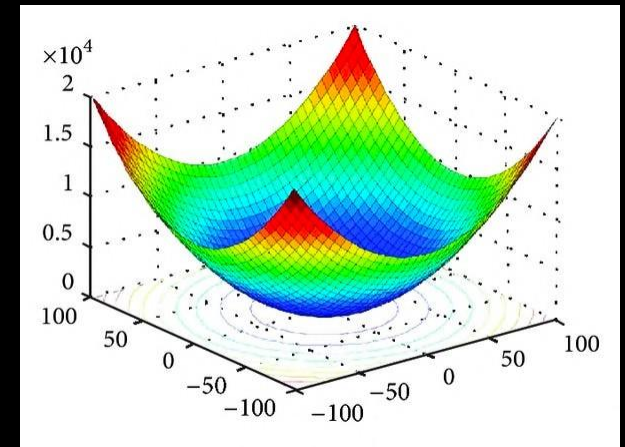
Return of Neural Networks, 2010s

Neural networks (aka Multi-Layer Perceptrons) return and excel at image recognition, speech recognition, …

The 2018 Turing award was given to Yoshua Bengio, Geoff Hinton, and Yann LeCun.
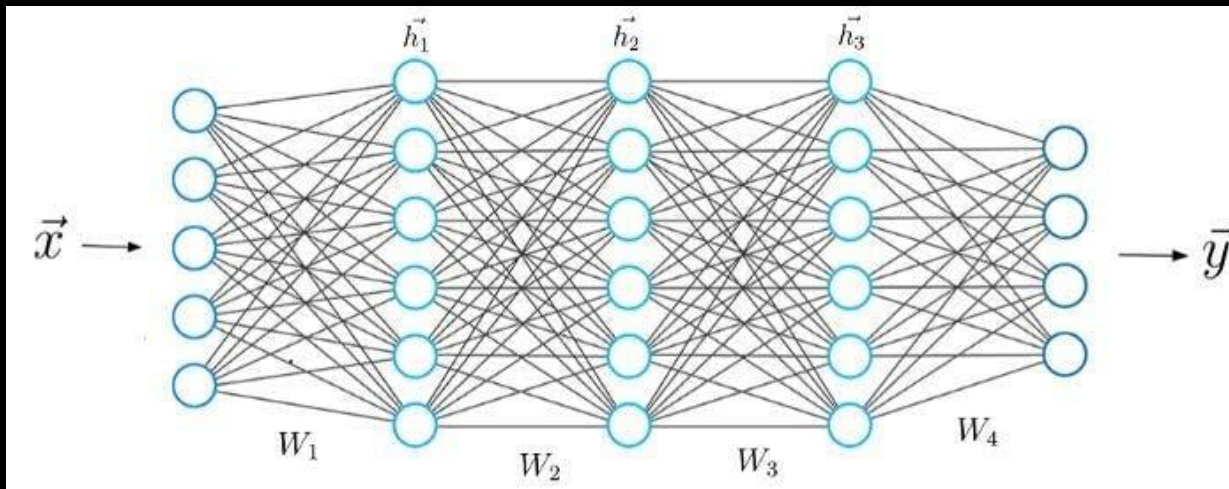
2016 Alpha Go

- 1920 CPUs and 280 GPUs

- Deep Mind's Alpha Go wins against Lee Sedol 5:1

- Big shock

  - China invests heavily in AI research

- Beginning of "AI arms race"

Now: Surrounded by Machine Learning

Euphoria mixed with fear and anxiousness
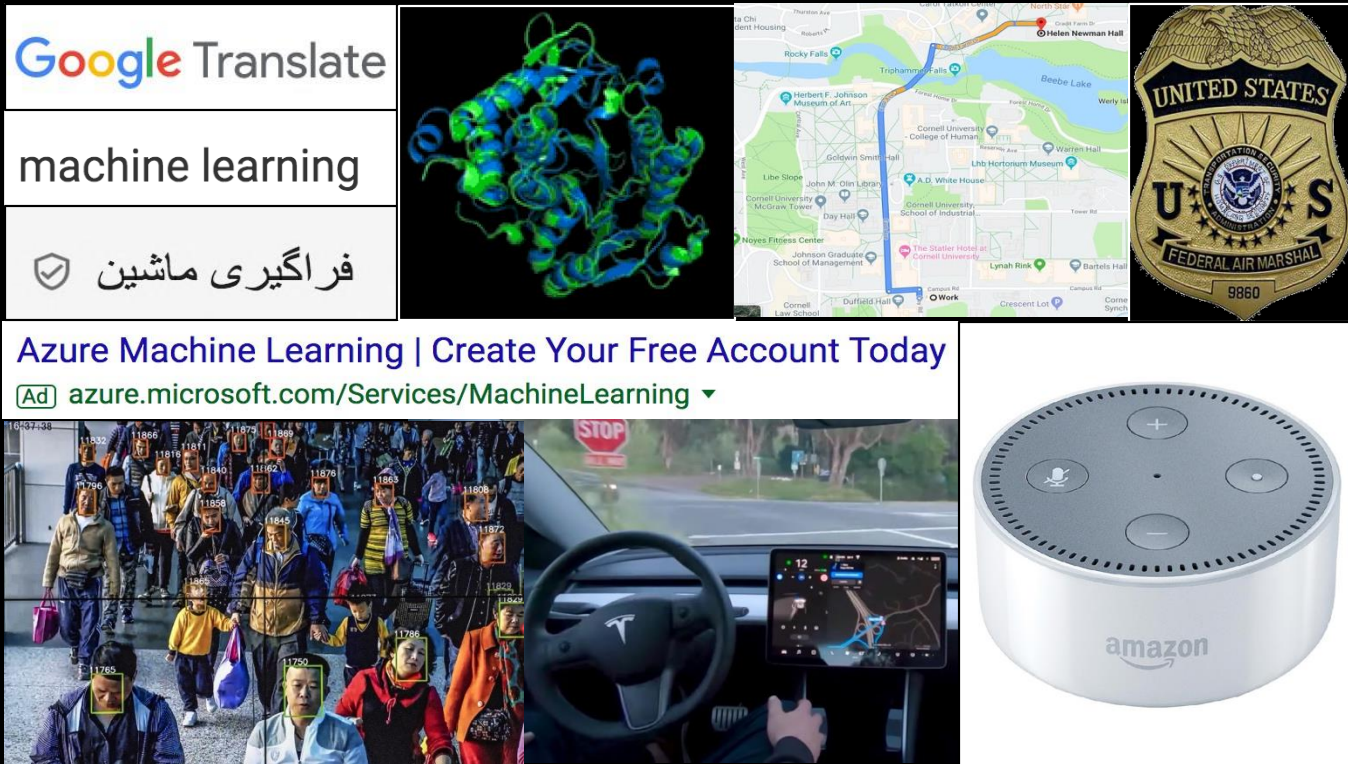
2021 Generative Models become Mainstream

- 178 Billion Parameters

- Cost: $4.6 Million (est.)

- 355 GPU years of training (est.)

- Trained on 45 TB of text
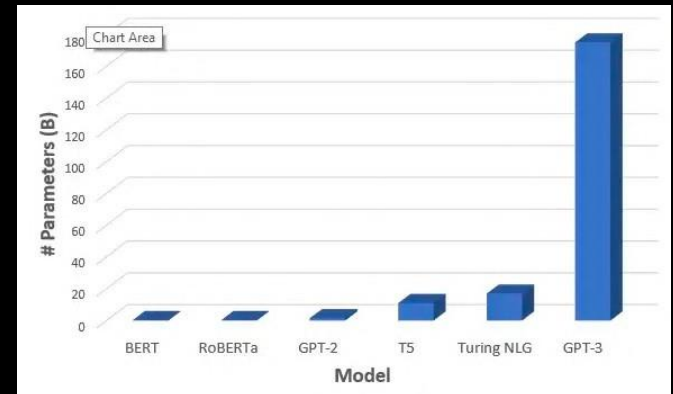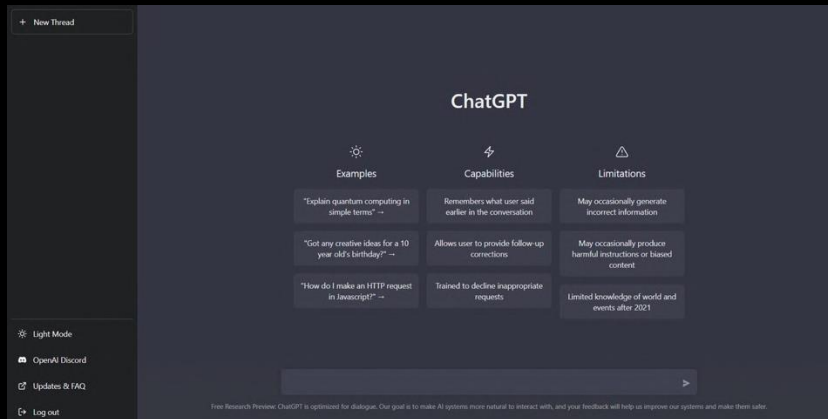
LLMs!

write a biblical verse in the style of the king james bible explaining how to remove a peanut butter sandwich from a VCR

And it came to pass that a man was troubled by a peanut butter sandwich, for it had been placed within his VCR, and he knew not how to remove it.

And he cried out to the Lord, saying, "Oh, Lord, how can I remove this sandwich from my VCR, for it is stuck fast and will not budge?"

And the Lord spoke unto him, saying, "Fear not, my child, for I shall guide thy hand and show thee the way. Take thy butter knife, and carefully insert it between the sandwich and the VCR, and gently pry them apart. And with patience and perseverance, the sandwich shall be removed, and thy VCR shall be saved."

And the man did as the Lord commanded, and lo and behold, the sandwich was removed from the VCR, and the man was saved.

And the Lord said, "Verily I say unto thee, seek not to put thy peanut butter sandwiches in thy VCR, for it is not a suitable place for such things. Rather, keep thy sandwiches in thy refrigerator or on thy plate, where they belong."

And the man heeded the Lord's words, and from that day forth, he kept his sandwiches in their proper place, and was saved from trouble and woe. Amen.

https://twitter.com/_BRCooper/status/1598569424008667137

DALLE Text2Images - ML is creative

Teddy bears
mixing sparkling chemicals as mad scientists
in a steampunk style

Teddy bears
working on new AI research
underwater with 1990s technology

An astronaut
playing basketball with cats in space
in a watercolor style

https://openai.com/dall-e-2/

Why you should be excited!

- **Solve Real-World Challenges:** ML empowers you to address problems like disease prediction, autonomous driving, and climate modeling.

- **Learn from Data:** Train machines to uncover patterns and make intelligent decisions from massive datasets.

- **Feel Empowered:** ML is the driving force behind groundbreaking tools like ChatGPT—once you learn ML, you'll unlock immense power to shape the world.

- **Shape the Future:** Contribute to cutting-edge technologies and innovations that define tomorrow.

- **Unleash Creativity:** Build tools and applications that revolutionize industries and transform daily life.

Why you should NOT be TOO excited!!

•**Challenging Course Content: E**xpect rigorous concepts and a steep learning curve. Lots of **Assignments!**

•**Math-Intensive:** A solid grasp of mathematics is essential for understanding ML algorithms and methods.

•**Programming Required:** You'll need to be comfortable coding, as hands-on programming assignments are a core part of the course.

•**Scribing (LaTeX):** Prepare to document lectures and assignments using LaTeX, which requires attention to detail and precision.

•**Creative Thinking:** Course projects demand innovation, problem-solving, and originality—no cookie-cutter solutions here!

•**Curious, Learning Mindset:** Success in ML requires a genuine thirst for knowledge and the willingness to explore beyond the surface.

Be thoughtful before enrolling for credit!

Course Prerequisites

Formally: CS251, STAT 381/IE 342, Linear Algebra (e.g. Math 320)

– This course will be MATH-HEAVY. Please familiarize yourself with the basics of Probability-Statistics (PS) and Linear-Algebra (LA). Recommend introductory lectures

- PS review: (1) https://cs229.stanford.edu/section/cs229-prob.pdf (2) https://www2.isye.gatech.edu/~sman/courses/6761/6761-1-ProbReview.pdf (3)https://users.ssc.wisc.edu/~ctaber/410/statrev.pdf

- LA review: (1) https://cs229.stanford.edu/section/cs229-linalg.pdf (2) https://james-chuang.github.io/notes/linalg_review.pdf (3) https://www.cs.cmu.edu/~jingx/docs/linearalgebra.pdf

– Familiarity with latex for scientific writing (for scribing the lecture notes and writing assignments). You can learn the basics from here: https://www.youtube.com/watch?v=lgiCpA4zzGU (many online tutorials available for beginners.)

– Programming assignments (in Python or Matlab).

Familiarity with the above basics is highly recommended for those taking the course for credit — Lack of understanding may impact your grades.

Books

- **ESL** The Elements of Statistical Learning by Hastie, Tibshirani, and Friedman [[Book website]]

- **MLTM**: *Machine Learning* by Tom Mitchell - Online copy.

- **PML**: *Probabilistic Machine Learning: An Introduction* by Kevin Murphy - Book website.

- **PLG**: *Prediction, Learning and Games* by Nicolo Cesa-Bianchi and Gabor Lugosi, Cambridge University Press, 2006 - Local Copy from E1 245 by Aditya Gopalan.

- **PRML**: *Pattern Recognition and Machine Learning* by Christopher Bishop (optional) - Free copy.

- **[PyAG]** *Optional*: Hands-On Machine Learning with Scikit-Learn & Tensorflow by Aurelien Geron [[Online. Github]].

- **CIML**: *A Course in Machine Learning* by Hal Daume III - Online copy, Errata.

- **UML**: *Understanding Machine Learning: From Theory to Algorithms* by Shai Ben-David, Shai Shalev-Shwartz - Online copy.

Course Dynamics

Classes: Tuesday & Thursday 2-3:15pm, TBH 180F

Homeworks: Approximately every 2-3 weeks
- Written: Conceptual understanding
- Lab: Implementation and evaluation (Python)

Submit via **Gradescope** [1st assignment out!]

Exams: Midterm (Mar 13th, Thu) and Final (May 6th, Tue)

Earn your grade!

	Quiz	Midterm	Final	Assignments	Project	Scribe
Graduate	10%	15%	15%	20%	30%	10% + [Bonus!]
Undergraduate	10%	20%	20%	25%	25%	Bonus!

Homework Tasks -- Labs + Written

Quiz + Attendance – iClicker (class time)

Scribe – For Grads (needs Latex!) [Bonus grades!]

Mid Term – March 13th (class time)

Final Exam – May 6th (class time)

Course project – Will maintain a list of topics
                              Report Due (May 1st)

Homework Tasks

Due at <u>11:59pm</u> central (unless otherwise indicated)

Late homework/ project reports:

     3 late days per semester: Full credit

     After that: no credit (unless "emergency")

Collaboration:

- Discussion with others is allowed

- Each student must write own solutions, **strict policies in place against copying**.

Project Report

Will post a list of topics soon (the list will be updated continuously)

Late homework/ project reports:

  3 late days per semester: Full credit

  After that: no credit (unless "emergency")

Collaboration:

- Be ready to work in a group of 2 / 3 people

- Expectations: **Reading papers, implementation, thinking open-ended questions, coming up with solutions, project report.**

- Each student must contribute equally / mention what they did in their part.

Scribing

Due at in 1 week, <u>11:59pm</u> central (unless otherwise indicated)

Latex it! Should read like a professional lecture note. (Use Overleaf)

Late scribe reports:

    2 late days per semester: Full credit

    After that: no credit (unless "emergency")

Collaboration:

- Group size: 1 or 2 (depends on the final class strength)

- Each student must contribute equally / mention what they did in their part.

Bonus!

Scopes to earn extra scores!

Scribe and earn! (10%)

- UGs can scribe too (but remember the quality matters!)
- Scribe additional notes
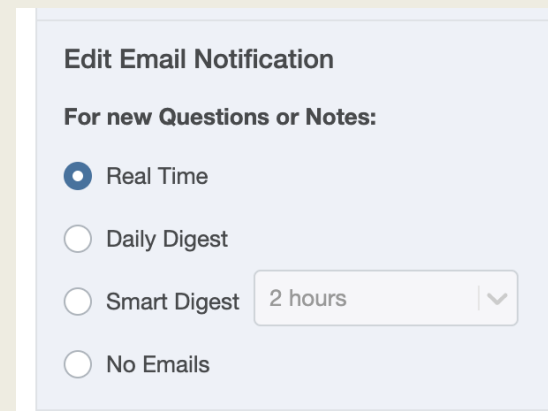
Class Participation (10%):

- Good questions!
- Good answers!
- Good suggestions!

More logistics

Will do **~4 extra classes**. Mostly on Fri/Sat (based on a common free slot!) – 1st class Feb 8 (tentative!)

Will have a **detailed** logistics (pdf) out soon! – **FAQs**!

Make sure you set your **email notifications right** on Piazza!

Edit Email Notification

For new Questions or Notes:

- ● Real Time
- ○ Daily Digest
- ○ Smart Digest — 2 hours
- ○ No Emails

Set Thu (Jan 23) class online? – Severe weather alert!

Enrollment

Additional seats may open up

Please **email me** (aadirupa@uic.edu) next week if you are unable to enroll.

Lecture 1: Basics of Supervised Learning

Let's do some board work!