

Introduction to Probability

About me



Grew up in Lincoln, Vermont



BA: Columbia
Math



PhD: Carnegie Mellon
Computer Science



Faculty: Stanford
Research:

- *Machine learning theory*
- *Algorithm design*
- *Interface between Econ and CS*

Course assistants



Yingxi Li

PhD student in MS&E



Josh Richland

MS student in Statistics



Khanh Hoang Vu

Co-term student in MS&E

See course webpage for office hours, which start **next week**
Except mine, which will start this week

Additional calculus for engineers (ACE)

Students participating in ACE will:

- Attend an **additional weekly section**
 - Monday/Wednesday, 9:30-10:20 am
- Enroll in MS&E 120ACE for **1 additional unit**
- Receive access to:
 - Additional **exam review** sessions
 - Individual **tutoring**
 - Other **study resources**



Evelyn Yee
MS student in CS

See Canvas “Welcome!” announcement for application link
Deadline is **this Friday at 5pm**

Course mechanics

Course webpage

<https://vitercik.github.io/probability/>

Link is on Canvas

Office hours, syllabus, course schedule, ...

Course reader

<https://vitercik.github.io/120notes>

The screenshot shows a website layout for the MS&E 120 Course Reader. On the left, there's a sidebar with a search bar, the course title, and navigation links for 'Stanford MS&E 120: Intro to Probability', '1. Probability and counting' (which is active), and '2. Bibliography'. The main content area has a header '1. Probability and counting' and a sub-section '1.1. Sets'. It contains text about sets in probability theory, a warning about the dry nature of the topic, and a detailed explanation of what a set is.

MS&E 120 Course Reader

Search

Stanford MS&E 120: Intro to Probability

1. Probability and counting

2. Bibliography

1. Probability and counting

Sets

Sample spaces and events

A naive definition of probability

1.1. Sets

In probability, the primary goal is to determine how likely a specific **set** of outcomes is, given a particular experiment. In this section, we'll focus on understanding the concept of sets, which form the foundation of probability theory.

Warning

This first section will admittedly be a bit dry, but bear with me! For the rest of the class, it's necessary that we're all completely comfortable with these definitions and notations.

A set is a collection of objects or elements. For example, the set $\{1, 3, 5, 7\}$ contains four numbers, while the outcomes from flipping a coin twice form the set $\{HH, HT, TH, TT\}$ (where H stands for Heads and T stands for Tails). There's also the empty set, denoted \emptyset , which contains no elements.

Prerequisites

Math 51 or CME 100

- Multivariate calculus:
 - Mostly differentiation $\frac{dy}{dx}$
 - A little integration $\int x \, dx$

Class breakdown

35% Weekly assignments (8 total)

30% Midterm (Monday, 10/28, in class)

35% Final exam (Wednesday, 12/11)

Weekly assignments (8 total)

- Total of 4 late days for assignments, e.g.:
 - No penalty if you submit 1 assignment 4 days late
 - Or 4 assignments 1 day late, ...
- After that, grade drops by 7 points for every 12 hours it's late
 - E.g., 90% to 83%
 - Lasts until week after deadline, then assignment will receive 0%
- (Some exceptions for HWs due before exams.)
- **Ask questions on Ed Discussion** (linked to on Canvas)
 - Fastest way to reach course staff

Policies

Policies intended to cover all

- Sicknesses
- Family events
- Sports events
- ...

Use your late days carefully!

Please come talk to me if you're struggling!

Lectures

- Mondays and Wednesdays, 1:30 - 2:50 PM
- Please **ask questions** during class!!
- Class format: Whiteboard!
 - Studies show that students learn better from whiteboard vs. slides
 - Writing down notes helps you learn
 - As opposed to just following along in slides
 - I automatically go slower

Sections

⚠ **The key to success in this class is doing practice problems** ⚠

- Sections: 1 hour every Friday: 11am, 12pm, and 2pm
- Meet in a small group with a CA and work through problems
- **Sign-up form** for sections will **go out today**
 - Deadline for filling it out is **midnight on Wednesday night**
- We'll let you know which section you are in by the weekend
- You'll have your first section during Week 2

Textbook

“Introduction to Probability” by Blitzstein and Hwang

- Fantastic book!
 - Should be your go-to resource; be careful of confusion caused by Googling
- Freely available online! See course webpage for link

1.9 Exercises

Exercises marked with ⓘ have detailed solutions at <http://stat110.net>.

- Blitzstein also has lectures on YouTube, over 1 million views 🔥
- Another good book w/ practice problems:
A first course in probability by Sheldon Ross

2-minute anonymous surveys

- Watch out for an email about a 2-min anonymous survey
- Random set of students asked each week
 - You'll be asked 2-3 times during the quarter to fill it out
- It's so useful for us!

Please use it to tell us:

- What's going well 😊
- What you're confused about 🤔
- How we can best help you learn!

Course schedule in on webpage

The screenshot shows a course schedule page with the following elements:

- Search Bar:** "Search MS&E 120" with a magnifying glass icon.
- User Profile:** "Ellen Vitercik" in blue text.
- Section Header:** "Schedule" in large, bold, dark gray text.
- Section Subtitle:** "Introduction" in dark gray text.
- Date and Type:** "9/23: LECTURE" where "LECTURE" is in a blue button-like box.
- List of Topics:**
 - Introduction to class
 - Sample spaces and the naive definition of probability
 - [Textbook reading](#): 1.1-1.3
 - [Course reader](#): 1.1-1.3

OAE

Let me know if you have an OAE letter as soon as possible

Thanks!

Honor code

It's against the honor code to enter HW/exam questions into any software, apps, or websites

You cannot use large language models (like ChatGPT) and submit the output as your own

Doing so in this course is a violation of the Honor Code

Large language models

- Your future classes and careers heavily use ideas from 120
 - I can't conceptualize how you'd **deeply understand/apply/verify** ChatGPT's answers without mastering this material
- If you can do the HWs on your own, you will do well on exams
 - If you can't... 😬
- Last year, I took a HW question ~100% of students got correct
 - I put it in the exam, and ~60% of students answered it correctly...

Probability

Origins: gambling

Probability gives tools for reasoning about **uncertain events**



Origins: gambling

Brown and Sandholm built **poker-AI** that beat top humans
Uncertain event: what cards does your opponent have?

The New York Times

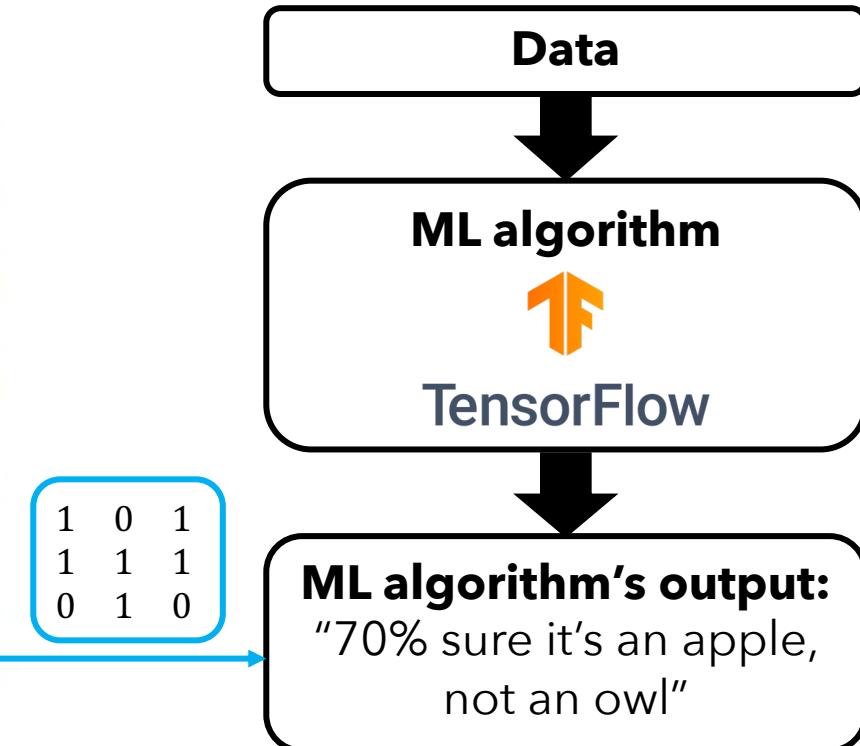
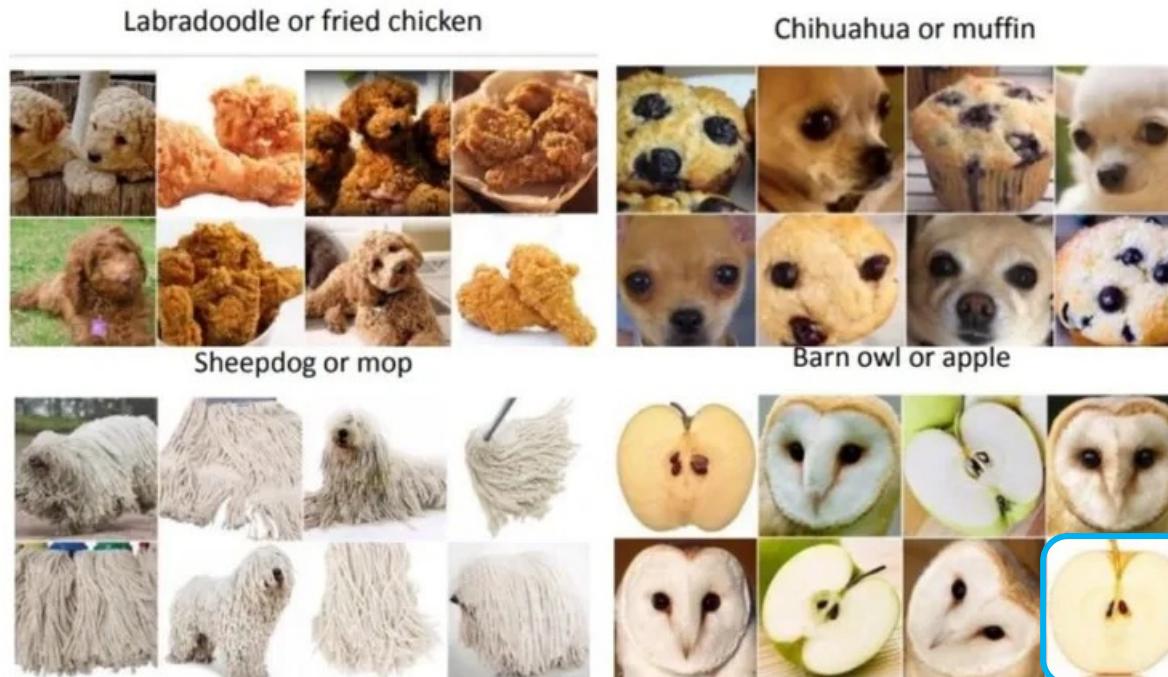
Hold 'Em or Fold 'Em? This A.I. Bluffs With the Best

Pluribus, a poker-playing algorithm, can beat the world's top human players, proving that machines, too, can master our mind games.



Machine learning built on probability

Probability crucial for understanding machine learning
Both for **engineers** and **managers**



Machine learning built on probability

Applications of probability can have much **higher stakes!**

Probability object in road is **plastic bag** or **animal**?

Should car slam on breaks?



Finance

Stock market behaves randomly!

Given todays events, what's the probability market will crash?

For an **investment portfolio**:

Expected gains in the next 10 years?



Venture capitalism

How to allocate investment funds to **maximize future returns?**

How to predict the next unicorn?

Consulting

Possible **consequences** of a proposed **course of action**

- If raise prices, probability of losing customers
- Probability upcoming storm will disrupt shipping networks
- Probability of construction project delays



Healthcare

Given treatment, what's the **probability the patient survives?**
"50-50 chance of survival if we undergo surgery"



Legislation

Given the evidence, what's the probability **defendant is guilty**?

People have **gone to jail** due to **faulty probabilistic reasoning**
"Prosecutor's fallacy"

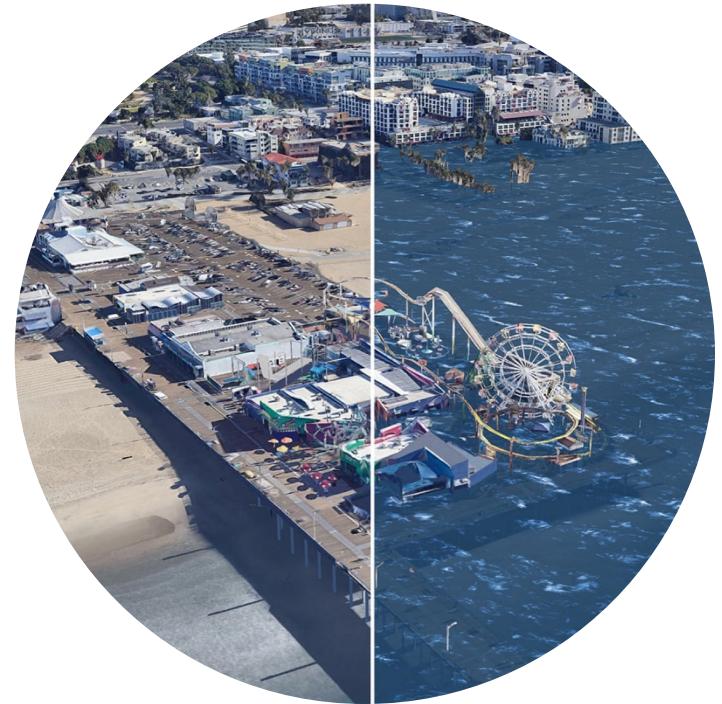
Ethical issues:

If past data is **biased**, probability estimates will be biased



Climate change

If we take certain actions, what's the expected **sea level rise?**



Sports

Outcomes of games depends on skill and **luck/randomness**

- Probability of future wins if sign player
- Is Tom Brady better than Peyton Manning?
- Probability of home run if Jeter bats again Beckett?



Moneyball

Goals of this course

Learn to understand randomness across **diverse applications**

Learn how to **model randomness** in science and engineering



Finance



Healthcare



Consulting



Sports

My goal: you enjoy probability and find it interesting/useful 😊

About you

Probability is used **everywhere**. I want to tailor this class to you!

First homework will include a question about you:

Tell me about your **interests, hobbies, future goals**