

# INTRODUCTION TO DATA SCIENCE

**JOHN P DICKERSON**

Lecture #1 – 08/31/2021

CMSC320

Tuesdays & Thursdays

5:00pm – 6:15pm

<https://cmsc320.github.io/>



**COMPUTER SCIENCE**

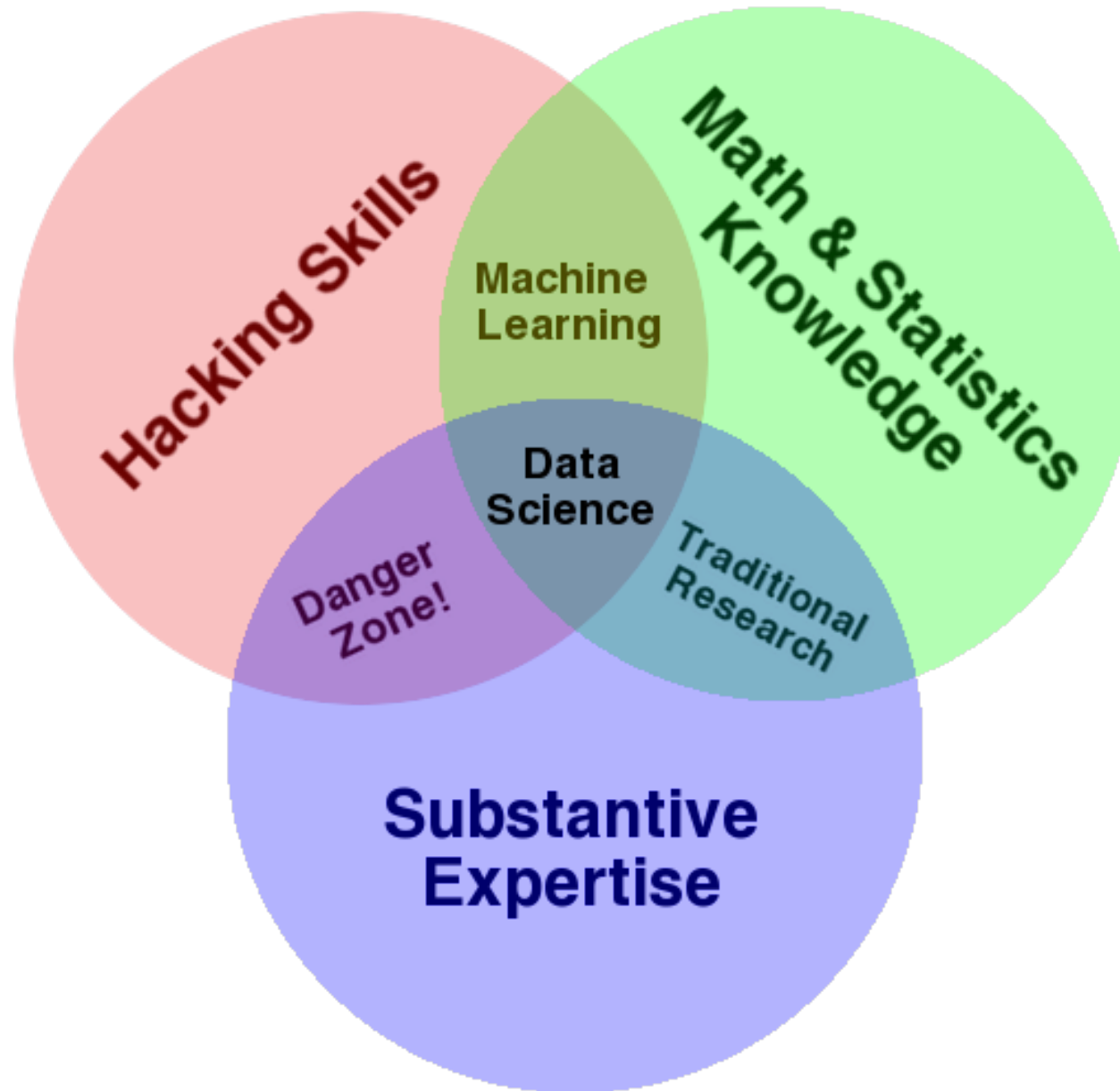
UNIVERSITY OF MARYLAND

**INTRODUCTION TO**

**????????????**

Data science is the application of **computational** and **statistical** techniques to address or gain [managerial or scientific] insight into some problem in the **real world**.

Zico Kolter  
Machine Learning Prof, CMU  
Chief Scientist of AI Research, Bosch



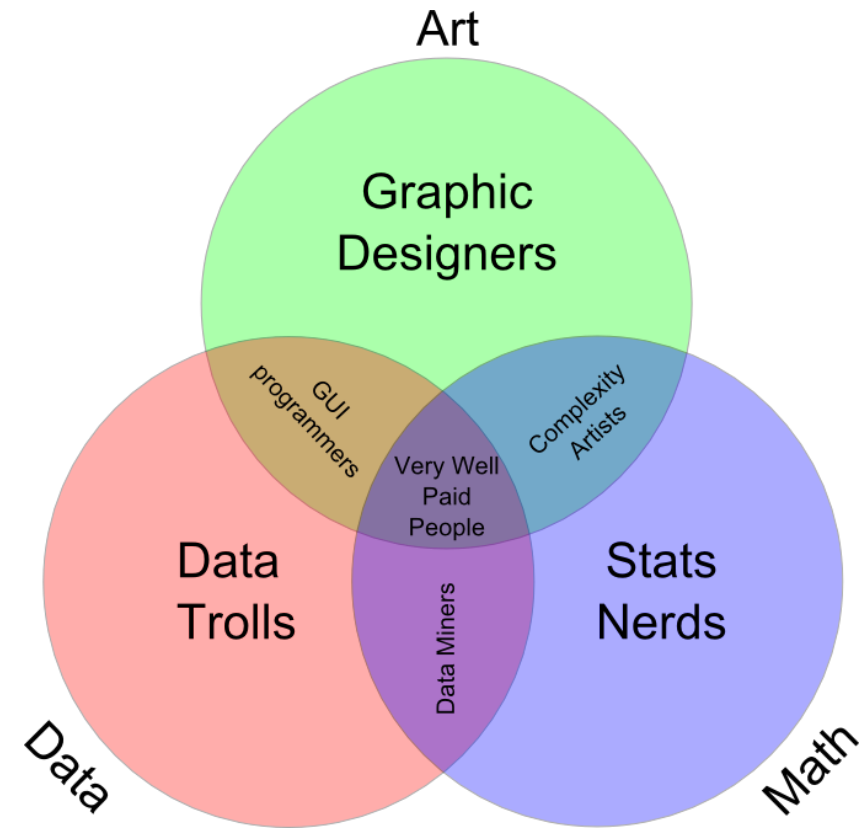
Drew Conway  
CEO, Alluvium (analytics company)

# MANY DEFINITIONS

**Broad:** necessarily **larger** than a single discipline

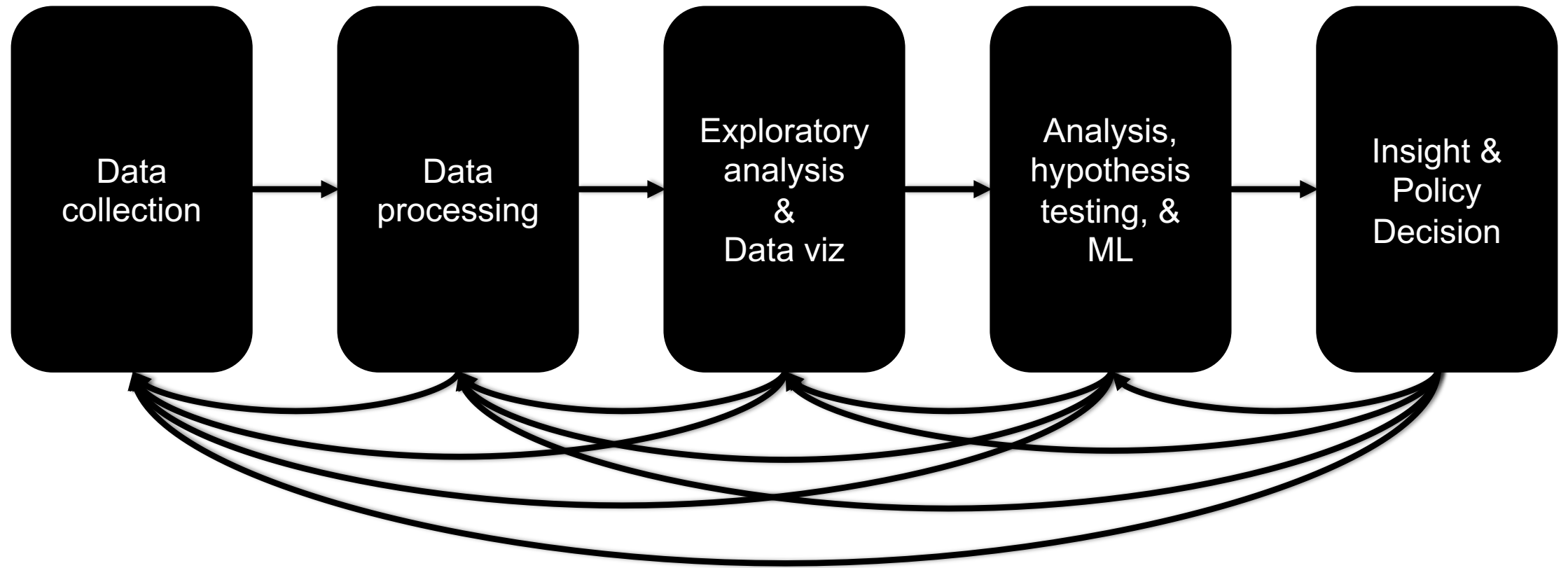
**Interdisciplinary:** statistics, computer science, operations research, statistical and machine learning, data warehousing, visualization, mathematics, information science, ...

**Insight-focused:** grounded in the desire to find insights in data and leverage them to inform decision making



Tuomas Carsey, UNC

# THE DATA LIFECYCLE



“The ability to take data—to be able to **understand** it, to **process** it, to **extract value** from it, to **visualize** it, to **communicate** it—that’s going to be a hugely important skill in the next decades ...”

Hal Varian  
Chief Economist at Google

# THIS COURSE

You'll learn to take data:

- Process it
- Visualize it
- Understand it
- Communicate it
- Extract value from it

**Info:** <https://cmssc320.github.io/>

**Piazza:** [piazza.com/umd/fall2021/cmssc320](https://piazza.com/umd/fall2021/cmssc320)

**ELMS:** (everyone should be registered automatically)

**Panopto recordings available via ELMS / as normal**



Hal Varian



# COURSE STAFF

**Instructor: John Dickerson** (just call me “John”)

- **Office location: Iribe 4128** (elevators to floor 4, take a right, then a right, then go straight and look at the numbers until you see the office that says “4128” or “John Dickerson” or has John sitting in it)
- **Office hours:** TBD, will be posted on Piazza/ELMS/lecture notes
- **More info:** <http://jpdickerson.com/>

**Teaching Assistants (and potential research connections!):**

- **Office hours:** TBD, will be posted on Piazza/ELMS (will cover MTWThF)
- Hirunima Jayasekara
- Kamala Varma
- MG Hirsch
- Alexander Gao
- Tobias Janssen
- Fuxiao Liu
- Neel Jain
- Sazan Mahbub



# PREREQUISITE KNOWLEDGE

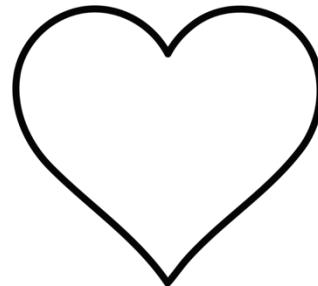
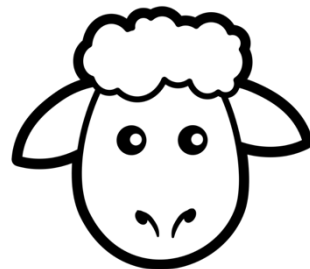
Aimed at **CMSC undergrads** – but likely accessible to others with programming experience and mathematical maturity.

**We do not assume:**

- Experience with Python, NumPy, pandas, scikit-learn, PyTorch, matplotlib, etc ...
- Deep statistics or any ML knowledge
- Database or distributed systems knowledge

**We do assume:**

- You want to be here!



# WHO AM I?



UNITED NETWORK FOR ORGAN SHARING

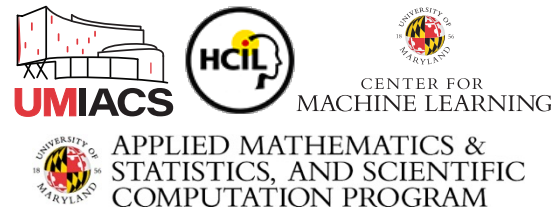


**COMPUTER SCIENCE** 2004 – 2008  
UNIVERSITY OF MARYLAND

**Carnegie Mellon University**  
School of Computer Science 2010 – 2016



**COMPUTER SCIENCE** 2016 – ∞  
UNIVERSITY OF MARYLAND



**OPTIMIZED**  
MARKETS



**facebook research** 2018 – 2020

{ Advisory roles in UMD alumni's startups } 2017 – now  Arthur  govshop

{ Advisory role to a US regulatory agency } Late 2019 - 2021



**THE DIAN FOSSEY**  
**GORILLA FUND**  
INTERNATIONAL

# WHO ARE YOU?

2<sup>nd</sup>-year  
3<sup>rd</sup>-year  
4<sup>th</sup>-year +



STAT400?  
CMSC422?  
CMSC424?



Register on Piazza: [piazza.com/umd/fall2021/cmssc320](https://piazza.com/umd/fall2021/cmssc320)

# (TENTATIVE) COURSE STRUCTURE

**First 4 lectures: intro & primers in the Python data science stack**

**Next 6 lectures: data collection & management**

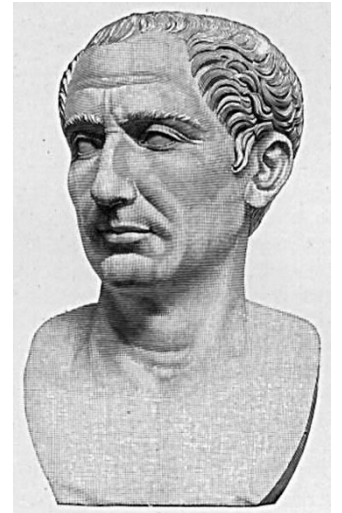
- Best practices, data wrangling, exploratory analysis, ethics, debugging, visualization, etc ...

**Next 9 lectures: statistical modeling & ML**

- Statistical learning, regression, classification, cross-validation, model evaluation, hypothesis testing, etc ...
- (Midterm #1 toward the beginning of this block)

**Final 8 lectures: advanced topics**

- Dimensionality reduction, distributed learning, big data, distributed computation
- (Midterm #2 toward the beginning of this block)



Ambitious ...

# GRADE #1: MINI-PROJECTS

Students will complete **four** mini-project assignments:

- **Case studies** meant to mimic what you, a future data scientist, will see in industry. They should be fun 😊.

**The rules:**

- Allowed: small group **discussions**
- Required: individual **programming & writing**
- Never allowed: public posting of solutions

**Deliverable:**

- Turn in an .ipynb of a Jupyter notebook on ELMS



# GRADE #2: READING HOMEWORKS

We will post (bi)weekly reading assignments. Mix of:

- Blog posts
- Academic articles
- News articles

Weekly quiz to be taken on ELMS covering the readings

Individual quiz grades are **pass/fail**:

- At least 60% correct → Pass
- Less than 60% correct → Fail

Must take at least **ten** of these quizzes over the semester



# GRADE #3: TWO MIDTERMS

You know what these are.

**Will cover roughly the first 1/3, and then second 1/3, of class:**

- Qualitative (more)
- Quantitative (less)

**Currently scheduled for mid-October and mid-November**

- May change, but will nail down exact dates soon.





# GRADE #4: MINI-TUTORIAL

In lieu of a final exam, you'll create a mini-tutorial that:

- Identifies a raw data source
- Processes and stores that data
- Performs exploratory data analysis & visualization
- Derives insight(s) using statistics and ML
- Communicates those insights as actionable text

**Individual or group project – see rubric for exact details, more information.**

**Will be hosted publicly online (GitHub Pages) and will strengthen your portfolio.**



# READY-MADE DATASET REPOSITORIES

<https://www.data.gov/>

- US-centric agriculture, climate, education, energy, finance, health, manufacturing data, ...

<https://cloud.google.com/bigquery/public-data/>

- BigQuery (Google Cloud) public datasets (bikeshare, GitHub, Hacker News, Form 990 non-profits, NOAA, ...)

<https://www.kaggle.com/datasets>

- Microsoft-owned, various (Billboard Top 100 lyrics, credit card fraud, crime in Chicago, global terrorism, world happiness, ...)

<https://aws.amazon.com/public-datasets/>

- AWS-hosted, various (NASA, a bunch of genome stuff, Google Books n-grams, Multimedia Commons, ...)

# NEW DATASET IDEAS



**Fraternal Order of Police vs Black Lives Matter**

**Linking finance data to  $\{\text{anything\_else}\}$**

**Something having to do with Pokémon statistics?**

**Look through <http://www.alexacom/topsites> and scrape something interesting!**

**University of Maryland-related, or College Park-related, stuff**

- Check out <http://umd.io/> – open source project; maybe your data collection and cleaning scripts can be added to this!

**Honestly, pretty much anything! Just document everything.**

**Reproducibility!**

# FINAL TUTORIAL

**Deliverable: URL of your own GitHub Pages site hosting an .ipynb/.html export of your final tutorial**

- <https://pages.github.com/> – make a GitHub account, too!
- <https://github.com/blog/1995-github-jupyter-notebooks-3>

**The project itself:**

- ~1500+ words of Markdown prose
- ~150+ lines of Python
- Should be viewable as a **static webpage** – that is, if I (or anyone else) opens the link up, everything should render and I shouldn't have to run any cells to generate output

**Rubric with more details & example tutorials linked to from website!!**

# FINAL TUTORIAL RUBRIC

**The TAs and I will grade on a scale of 1-10:**

**Motivation:** Does the tutorial make the reader believe the topic is important (a) in general and (b) with respect to data science?

**Understanding:** After reading the tutorial, does the reader understand the topic?

**Further resources:** Does the tutorial “call out” to other resources that would help the reader understand basic concepts, deep dive, related work, etc?

**Prose:** Does the prose in the Markdown portion of the .ipynb add to the reader’s understanding of the tutorial?

**Code:** Does the code help solidify understanding, is it well documented, and does it include helpful examples?

**Subjective Evaluation:** If somebody linked to this tutorial from Hacker News, would people actually read the whole thing?

# CLASS PARTICIPATION

**Please please please please please do the required reading, if available, before (virtually) attending class!**

**Earn brownie points via:**

- Lecture participation
- Piazza participation
- Regular participation at office hours

**Aim to ask/answer a question at least once every two weeks; or attend office hours at least once a month**

# GRADE BREAKDOWN

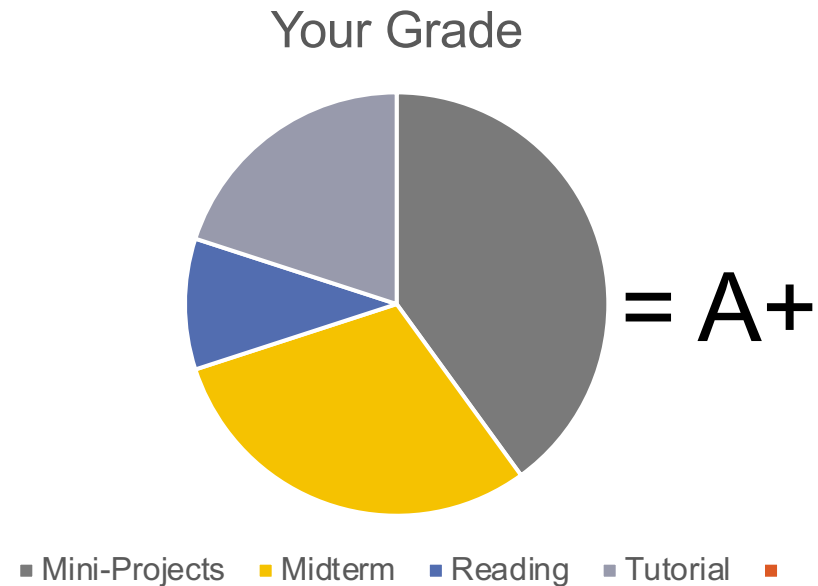
40% mini-projects:

- There are 4 of them
- Equal weighting @ 10%

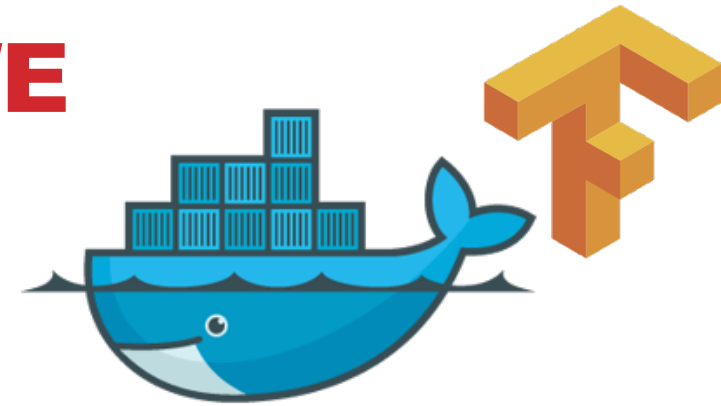
10% reading homeworks (aka weekly quizzes)

30% two midterms (15% each)

20% final tutorial



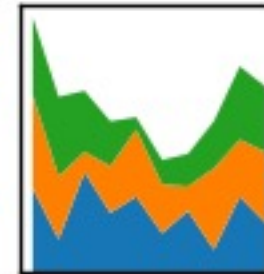
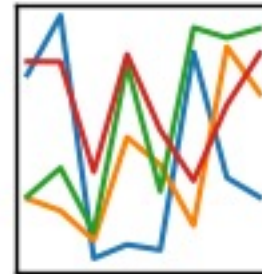
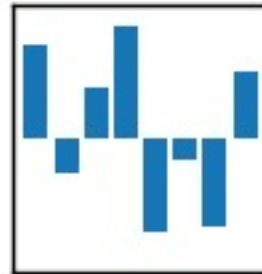
# SOME TECHNOLOGIES WE WILL USE (MOSTLY)



docker

pandas

$$y_{it} = \beta' x_{it} + \mu_i + \epsilon_{it}$$



 PyTorch

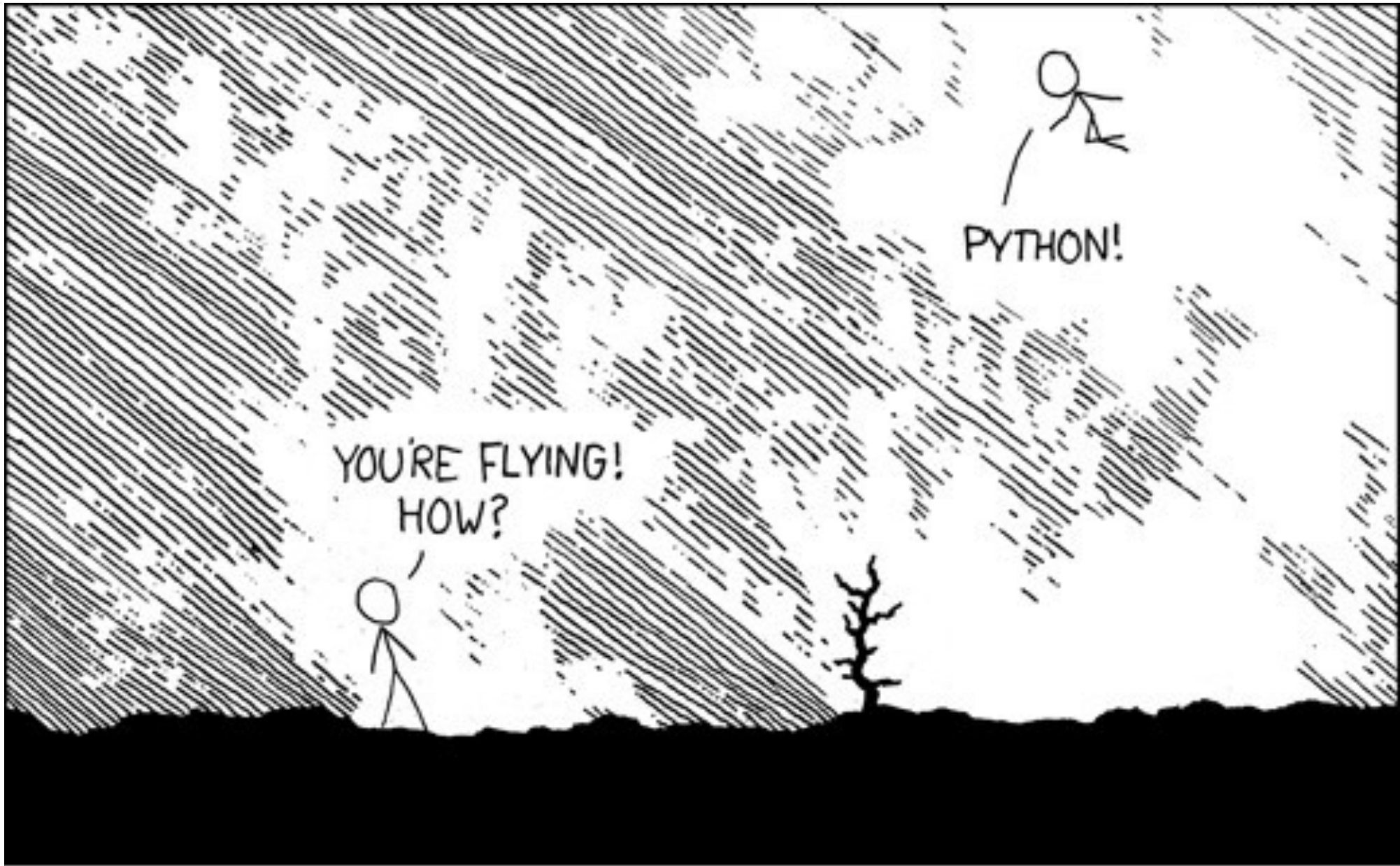


NetworkX  
Network Analysis in Python







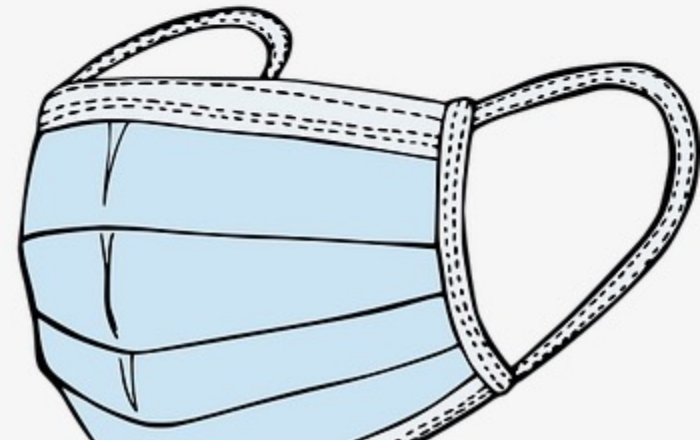
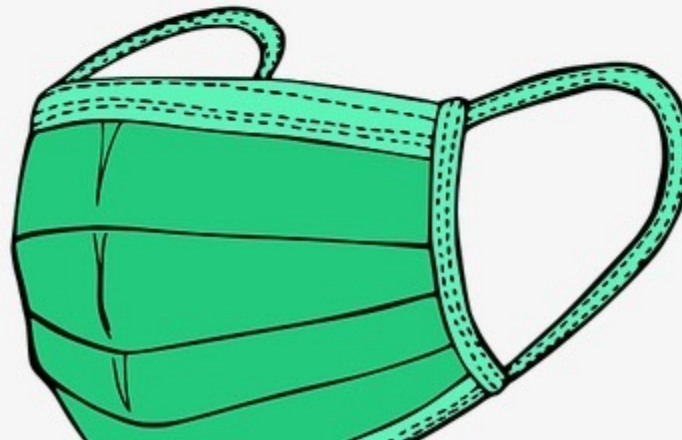
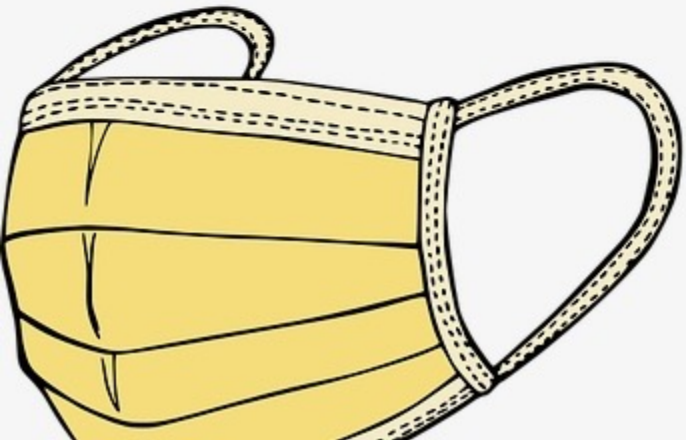
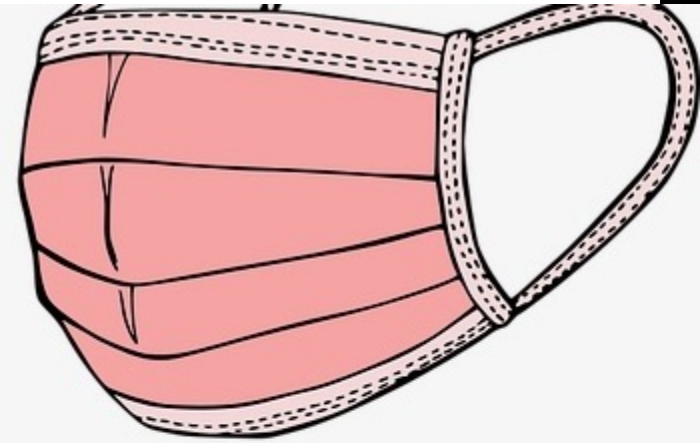
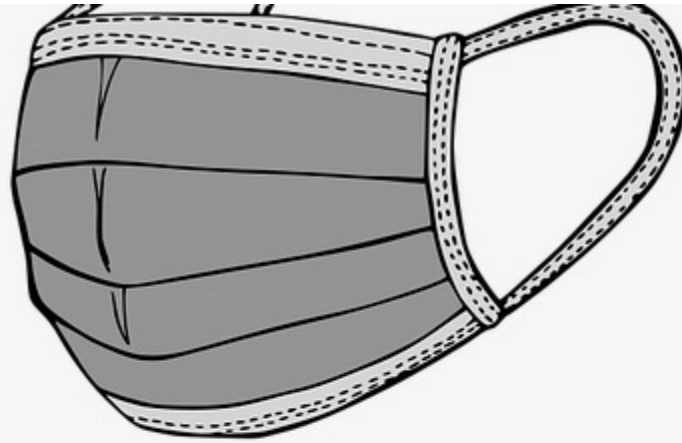
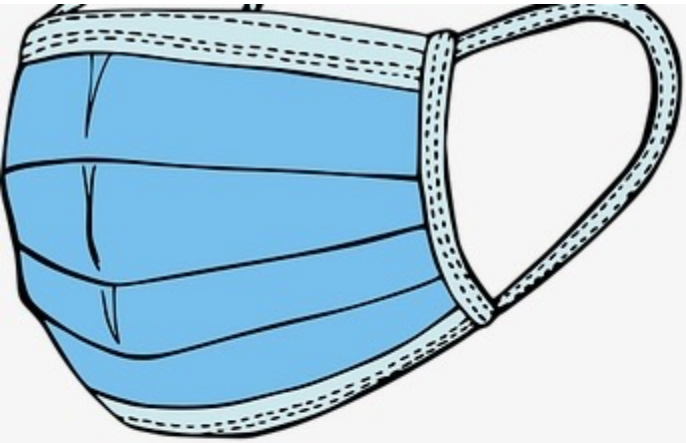


(Don't tell CMSC330 ...)

# **IMPORTANT WALLS OF TEXT**



**PLEASE WEAR A MASK  
(IT'S POLICY! DO IT!)**



# ANTI-HARASSMENT

(Adapted from ACM SIGCOMM's policies)

The **open exchange of ideas and the freedom of thought and expression** are central to our aims and goals. These require an environment that recognizes the inherent worth of every person and group, that fosters dignity, understanding, and mutual respect, and that embraces diversity. For these reasons, we are dedicated to providing a harassment-free experience for participants in (and out) of this class.

**Harassment** is unwelcome or hostile behavior, including speech that intimidates, creates discomfort, or interferes with a person's participation or opportunity for participation, in a conference, event or program.



# ACADEMIC INTEGRITY

(Text unironically stolen from Hal Daumé III)

**Any assignment or exam that is handed in must be your own work** (unless otherwise stated). However, talking with one another to understand the material better is strongly encouraged. Recognizing the distinction between cheating and cooperation is very important. If you copy someone else's solution, you are cheating. If you let someone else copy your solution, you are cheating (this includes *posting solutions online in a public place*). If someone dictates a solution to you, you are cheating.

Everything you hand in must be in your own words, and based on your own understanding of the solution. If someone helps you understand the problem during a high-level discussion, you are not cheating. **We strongly encourage students to help one another understand the material presented in class, in the book, and general issues relevant to the assignments.** When taking an exam, you must work independently. Any collaboration during an exam will be considered cheating. Any student who is caught cheating will be given an F in the course and referred to the University Office of Student Conduct. Please don't take that chance – if you're having trouble understanding the material, please let me know and I will be more than happy to help.

**(A FEW) DATA SCIENCE SUCCESS  
STORIES & CAUTIONARY TALES**

# POLLING: 2008 & 2012

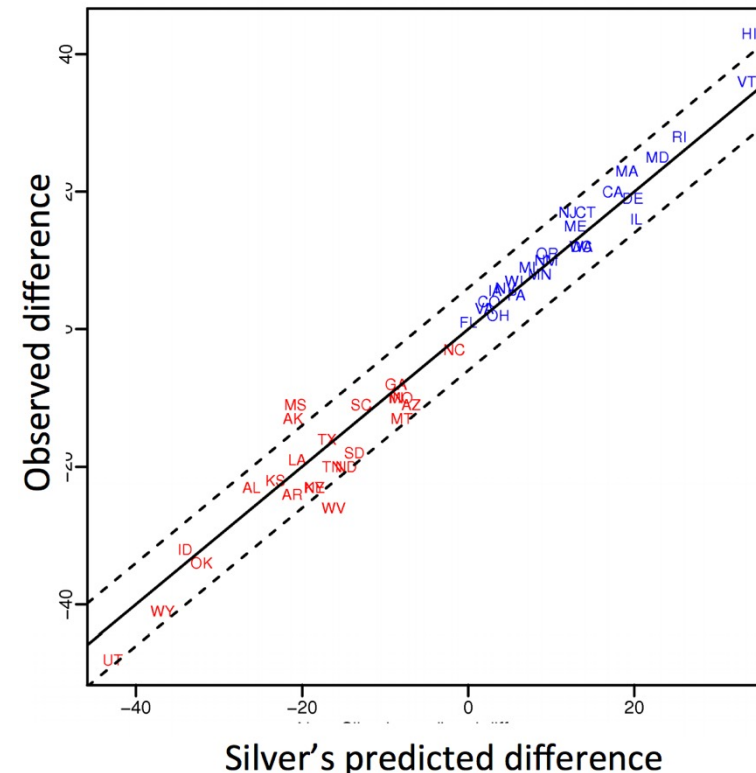
Nate Silver uses a simple idea – taking a principled approach to aggregating polling instead of relying on punditry – and:

- Predicts 49/50 states in 2008
- Predicts 50/50 states in 2012



- (He is also a great case study in creating a brand.)

<https://hbr.org/2012/11/how-nate-silver-won-the-2012-p>



Democrat (+) or Republican (-) in 2012

# POLLING: 2016

## POLITICS

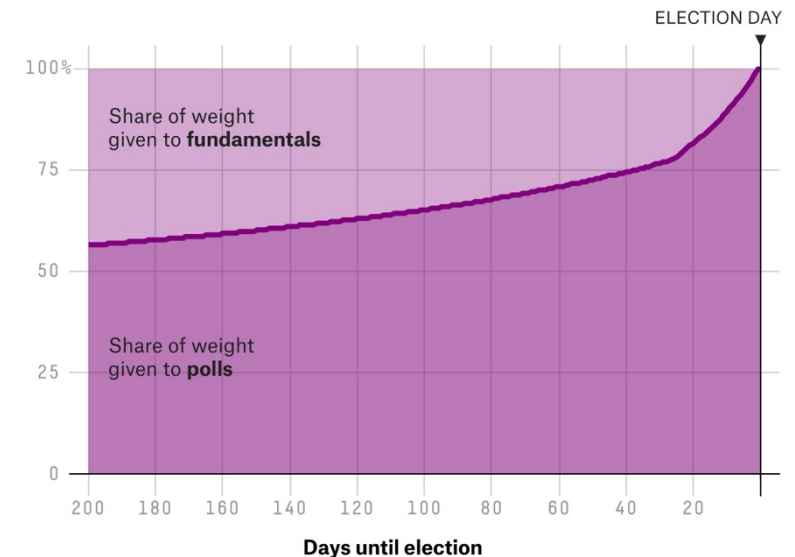
### Nate Silver Is Unskewing Polls – All Of Them – In Trump’s Direction

The vaunted 538 election forecaster is putting his thumb on the scales.

**HuffPo:** “He may end up being right, but he’s just guessing. A “trend line adjustment” is merely political punditry dressed up as sophisticated mathematical modeling.”

**538:** Offers quantitative reasoning for re-/under-weighting older polls, & changing as election approaches

Polls-plus becomes pure polling by Election Day

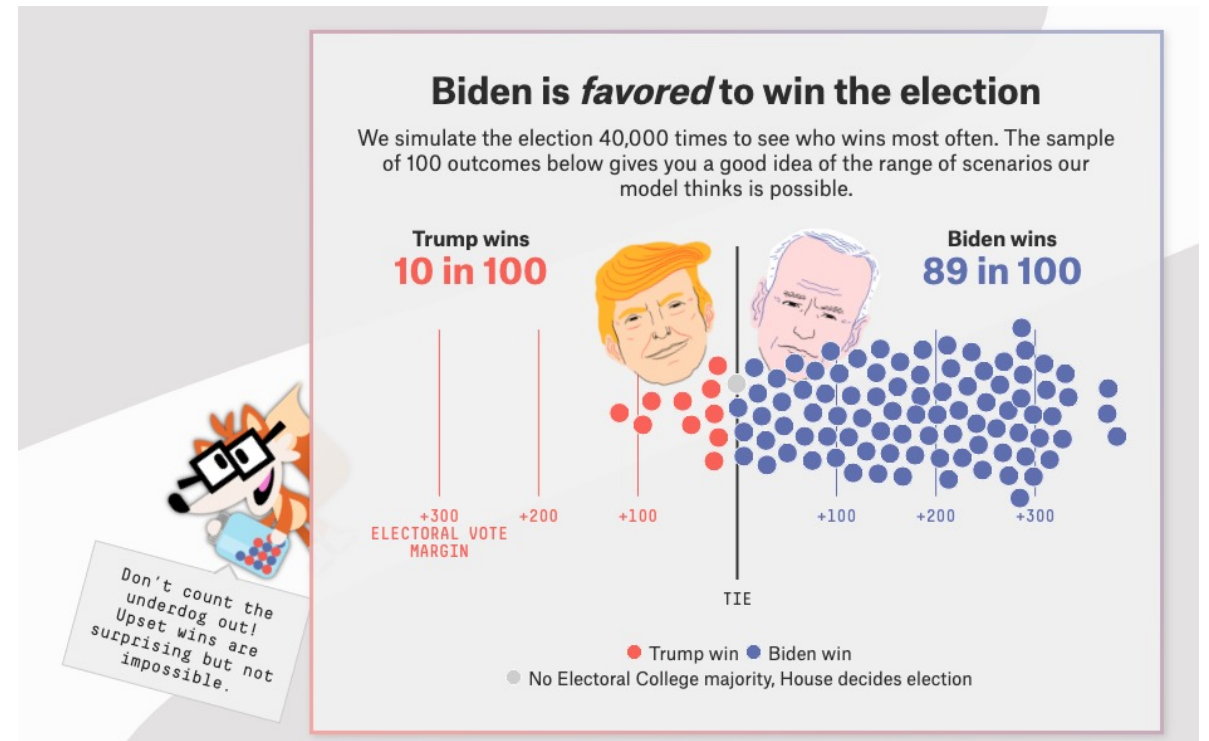
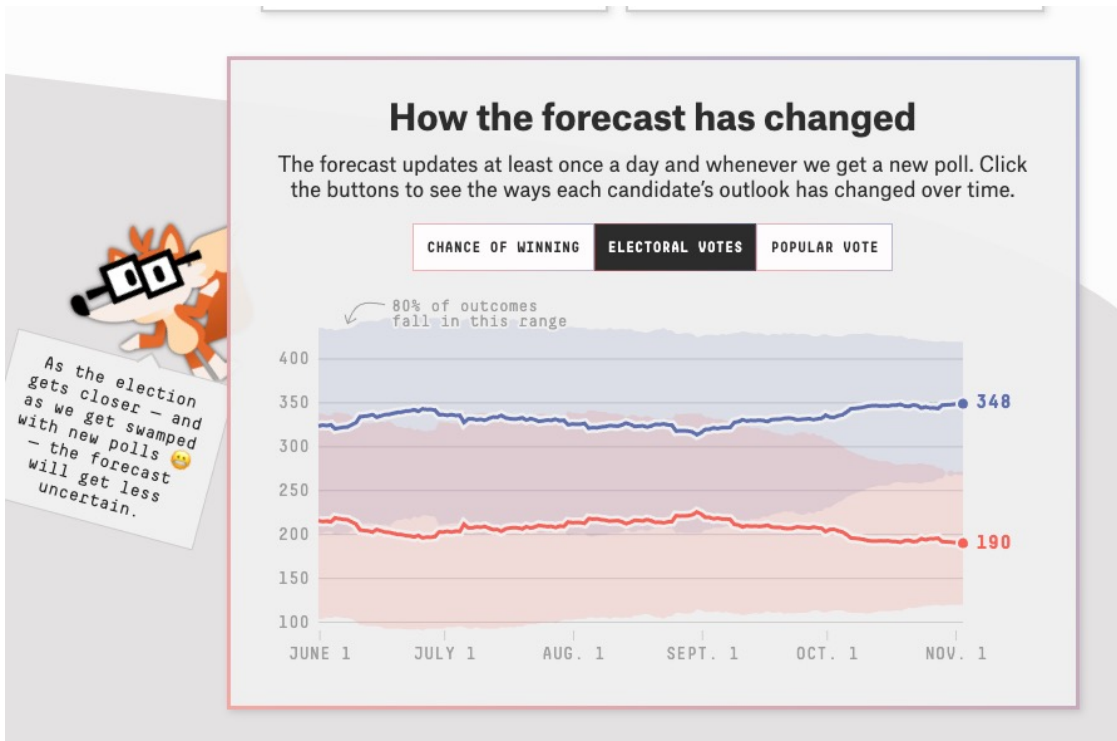




# POLLING: 2020

Lessons learned: don't just communicate a binary prediction (X loses, Y wins):

- Communicate uncertainty over that prediction
- Communicate variance in the underlying model(s), modeling errors, etc



# AD TARGETING



**TARGET**

Pregnancy is an **expensive & habit-forming** time

- Thus, valuable to consumer-facing firms

2012:

- Target identifies 25 products and subsets thereof that are commonly bought in early pregnancy
- Uses purchase history of patrons to predict pregnancy, targets advertising for post-natal products (cribs, etc)
- Good: increased revenue
- Bad: this can **expose** pregnancies – as famously happened in Minneapolis to a high schooler

# AUTOMATED DECISIONS OF CONSEQUENCE

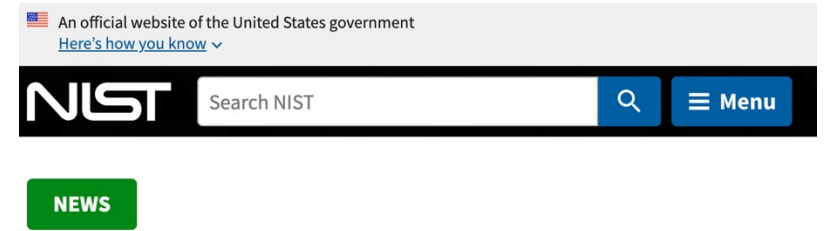
[Sweeney 2013, Miller 2015, Byrnes 2016, Rudin 2013, Barry-Jester et al. 2015]



Hiring

Lending

Policing/  
sentencing

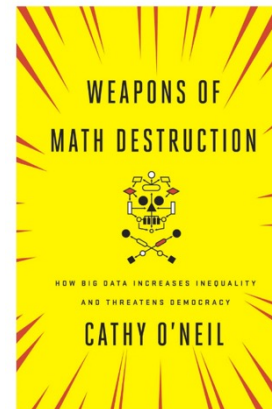


## NIST Proposes Approach for Reducing Risk of Bias in Artificial Intelligence

Comments are sought on the publication, which is part of NIST's effort to develop trustworthy AI.

Search for minority names →  
ads for DUI/arrest records

Female cookies →  
less freq. shown professional job opening ads



“... a lot remains unknown about how big data-driven decisions may or may not use factors that are proxies for race, sex, or other traits that U.S. laws generally prohibit from being used in a wide range of commercial decisions ... What can be done to make sure these products and services—and the companies that use them treat consumers fairly and ethically?”

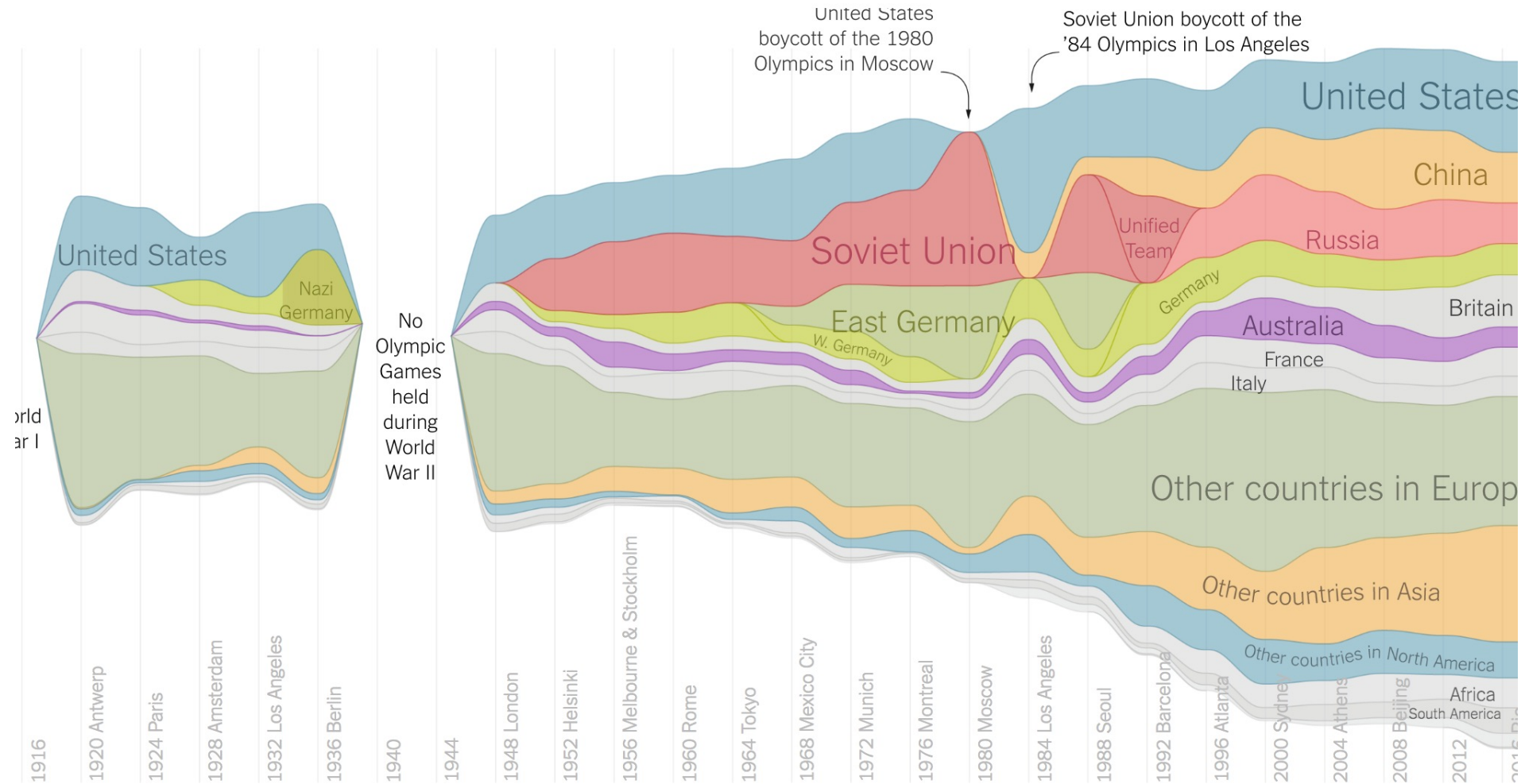
- FTC Commissioner Julie Brill [2015]

**“Hold yourself accountable – or be ready for the FTC to do it for you.** As we’ve noted, it’s important to hold yourself accountable for your algorithm’s performance. ... keep in mind that if you don’t hold yourself accountable, the FTC may do it for you.”

- FTC official blog post, “Aiming for truth, fairness, and equity in your company’s use of AI”, written by Elisa Jillson [2021]



# OLYMPIC MEDALS



# NETFLIX PRIZE I



Recommender systems: predict a user's rating of an item

	Twilight	Wall-E	Twilight II	Furious 7
User 1	+1	-1	+1	?
User 2	+1	-1	?	?
User 3	-1	+1	-1	+1

Netflix Prize: \$1MM to the first team that beats our in-house engine by 10%

- Happened after about three years
- Model was **never used** by Netflix for a variety of reasons
  - Out of date (DVDs vs streaming)
  - Too complicated / not interpretable

# NETFLIX PRIZE II

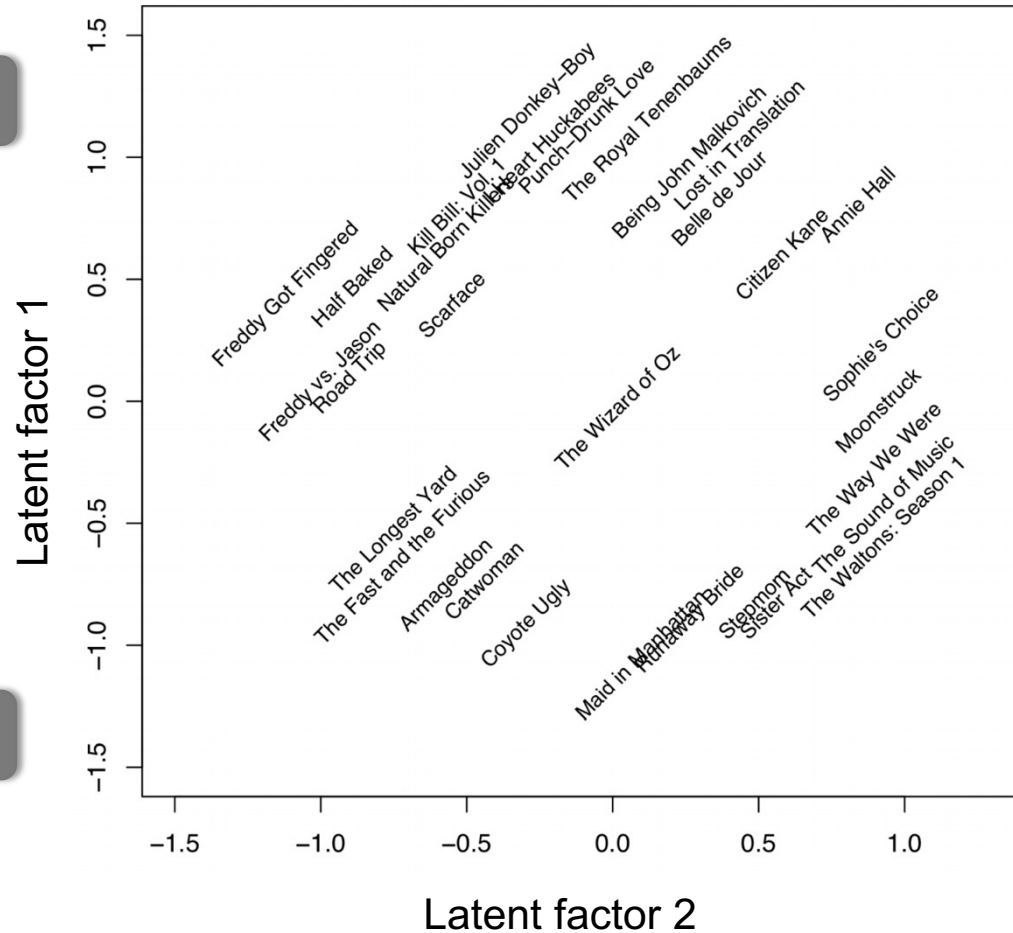


Frat/Gross-Out Comedy

Critically-Acclaimed/Strong Female Lead

Artsy

BB



Latent factors model:  
Identify factors with max discrimination between movies

Image courtesy of Christopher Volinsky



# NETFLIX PRIZE III

Netflix initially planned a follow-up competition

In 2007, UT Austin managed to deanonymize portions of the original released (anonymized) Netflix dataset:

- ??????????????
- Matched rating against those made publicly on IMDb

Why could this be bad?

2009—2010, four Netflix users filed a class-action lawsuit against Netflix over





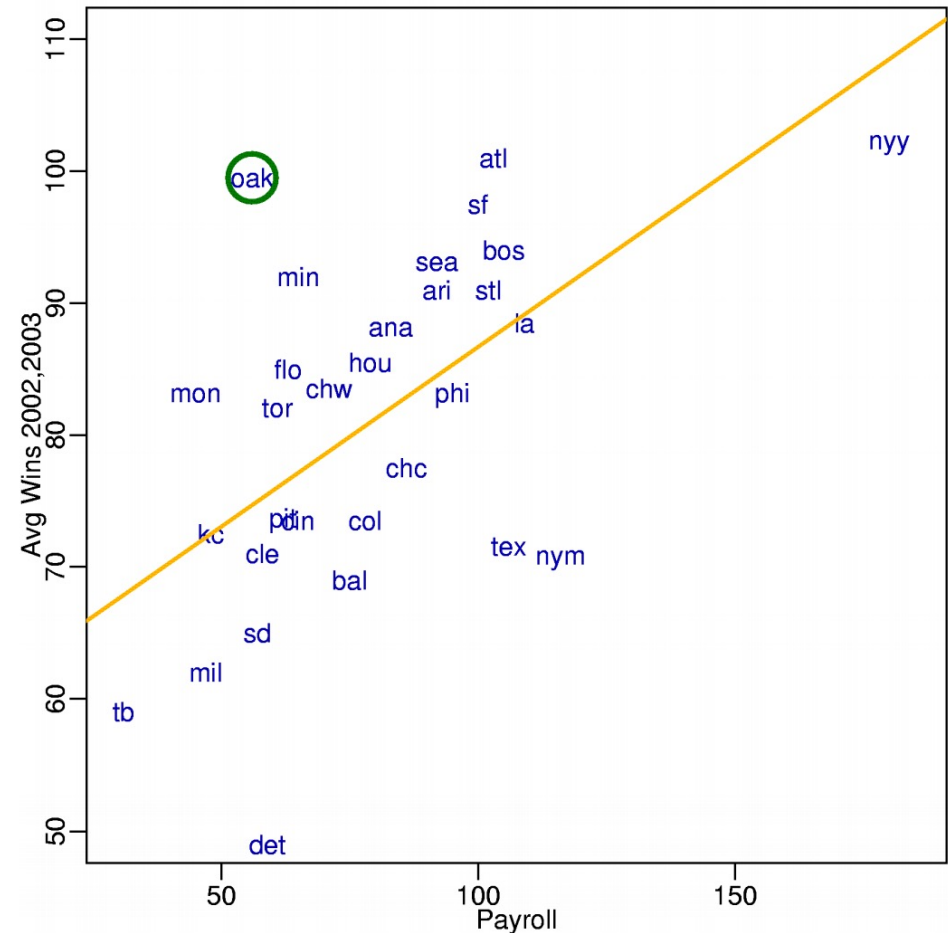
# MONEYBALL

Baseball teams drafted rookie players primarily based on human scouts' opinions of their talents

**Paul DePodesta**, data scientist *du jour*, convinces the {bad, poor} Oakland Athletics to use a **quantitative** aka sabermetric approach to hiring

(Spoiler: Red Sox offer Brand a job, he says no, they take a sabermetric approach and win the World Series.)

(Spoiler #2: DePodesta is now Chief Strategy Officer for the Browns, and they extended his contract in 2021, so we'll see what happens!)



## 1. Data scientist



Shutterstock

Overall job score (out of 5.0): 4.8

Job satisfaction rating (out of 5.0): 4.4

Number of job openings: 4,184

Median base pay: \$110,000

<http://www.businessinsider.com/best-jobs-in-america-in-2017-2017-1/>

# WRAP-UP FOR TODAY

Register on Piazza using your UMD address:

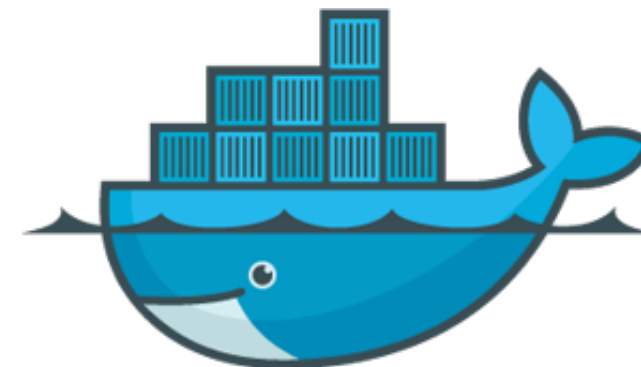
[piazza.com/umd/fall2021/cmssc320](https://piazza.com/umd/fall2021/cmssc320)

Please get in touch with me if you're unsure of whether or not you're at the right {programming, math} level for this course:

- My guess is that you are!
- This is a young class, so we're quite flexible

**Tonight, read about Docker & Jupyter!**

- Works on \*nix, OSX, Windows
- <https://www.docker.com/>
- (We'll post a small project shortly.)



docker



***NEXT CLASS:***  
**SCRAPING DATA WITH PYTHON**

