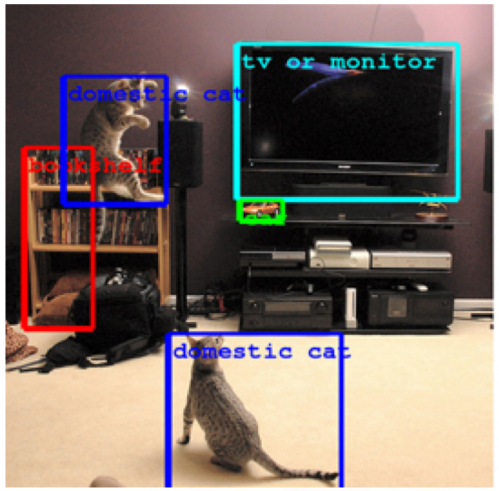
CS181: Introduction to Machine Learning

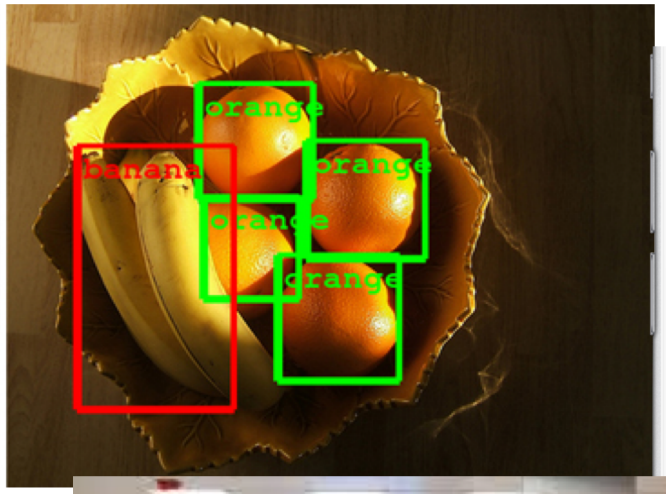
Spring 2021

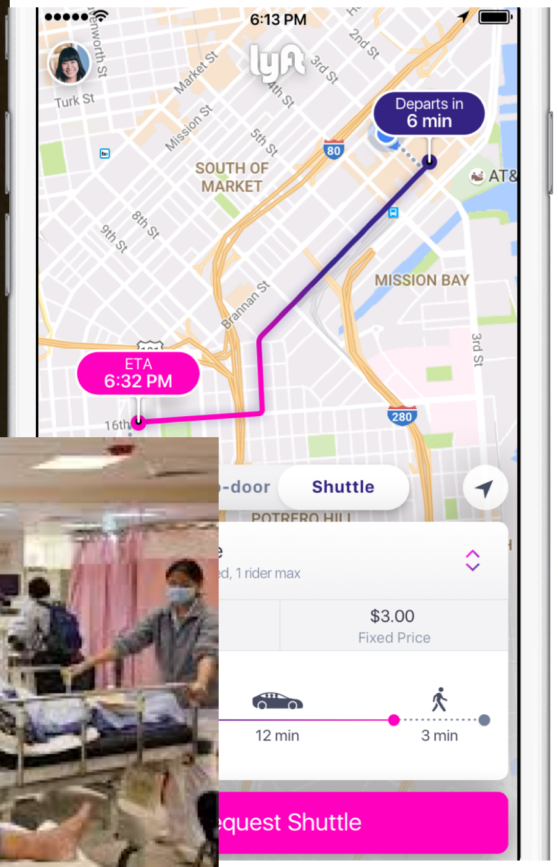
Finale Doshi-Velez and David C. Parkes
Harvard Computer Science

Staff: Nari Johnson (head TF), Prasidh Chhabria, Jonathan Chu, Andrew Kim, Dylan Li, Yash Nair, Sanjana Narayanan, Ife Omidiran, Karthik Rao, Rylan Schaeffer, Katherine Tian, and Bill Zhang

What this course is about







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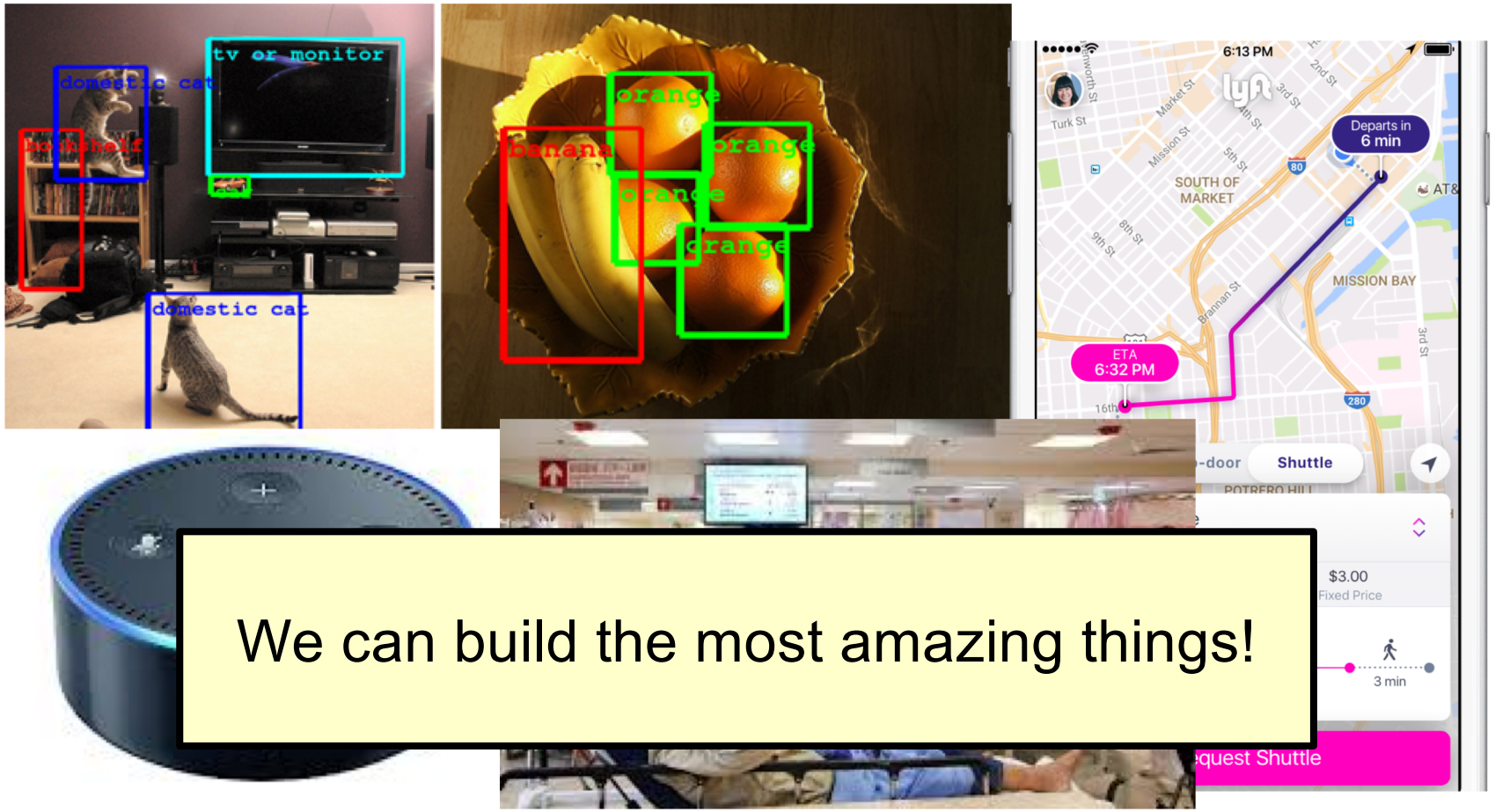

We can build the most amazing things!

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What this course is about

BUSINESS NEWS OCTOBER 9, 2018 / 11:12 PM / 2 MONTHS AGO

Amazon scraps secret AI recruiting tool that showed bias against women

HEALTH TECH

3 lessons from Stanford's Covid-19 vaccine algorithm debacle

By CASEY ROSS @caseymross *and* ERIN BRODWIN @erbrod / DECEMBER 21, 2020

https://twitter.com/geraldmellor/status/712880710328139776
https://www.statnews.com/2020/12/21/stanford-covid19-vaccine-algorithm/
https://www.theguardian.com/education/2020/aug/20/england-exams-row-timeline-was-ofqual-warned-of-algorithm-bias
https://www.propublica.org/article/machine-bias-risk-assessments-in-criminal-sentencing
https://www.reuters.com/article/us-amazon-com-jobs-automation-insight/amazon-scraps-secret-ai-recruiting-tool-that-showed-bias-against-women-idUSKCN1MK08G

What this course is about

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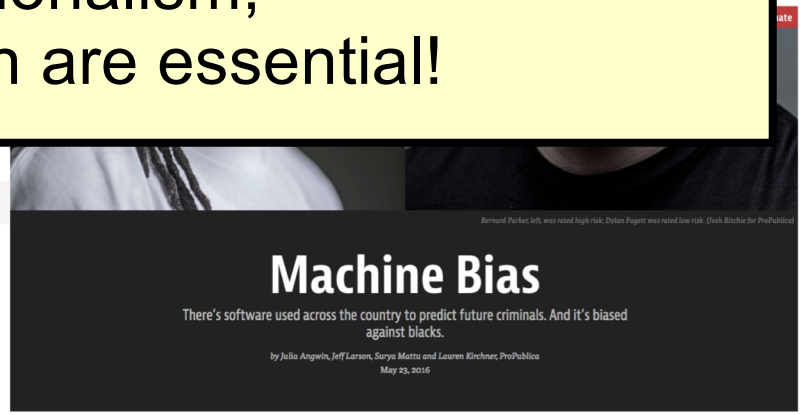
Amazon scraps secret AI recruiting tool that showed bias against women

Rigor, professionalism,
ethics, and inclusion are essential!



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https://www.theguardian.com/education/2020/aug/20/england-exams-row-timeline-was-ofqual-warned-of-algorithm-bias
https://www.propublica.org/article/machine-bias-risk-assessments-in-criminal-sentencing
https://www.reuters.com/article/us-amazon-com-jobs-automation-insight/amazon-scraps-secret-ai-recruiting-tool-that-showed-bias-against-women-idUSKCN1MK08G

David and Finale chat about machine learning in real life, in our work

Your Turn: Detecting Fake Videos

Obama: https://www.youtube.com/watch?v=AmUC4m6w1wo&feature=youtu.be

Nixon: https://www.youtube.com/watch?time_continue=2&v=yaq4sWFvnAY&feature=emb_logo

Ethics Question: Why might we care about deepfakes, when Impersonation is nothing new?

SNL: https://www.youtube.com/watch?v=BG-_ZDrypec

Russian Robot: https://www.youtube.com/watch?v=om5z3Uck9IY

How we will get there: Zen and Hard Work

Zen

- Make appropriate model choices
- Have sufficient understanding to learn and apply the new techniques
- Identify sources of error
- Evaluate carefully

Zen and Hard Work

- Make appropriate model choices
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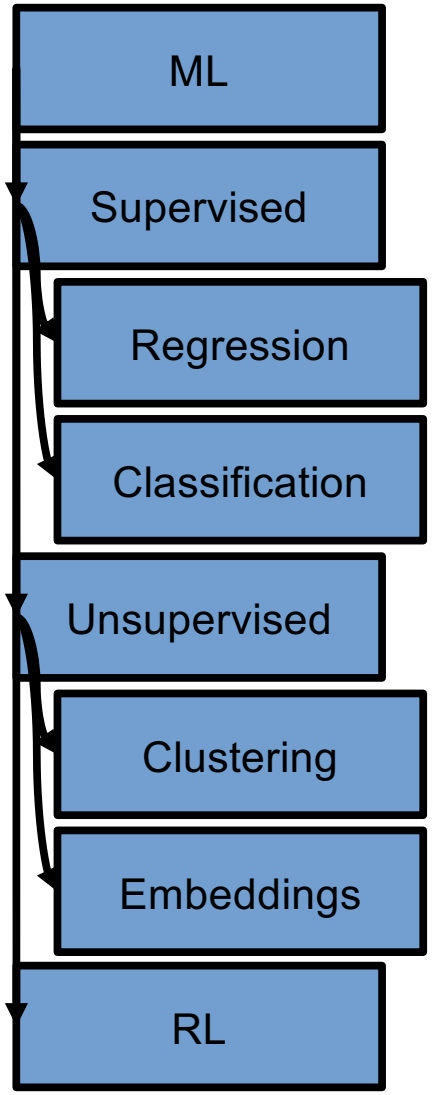
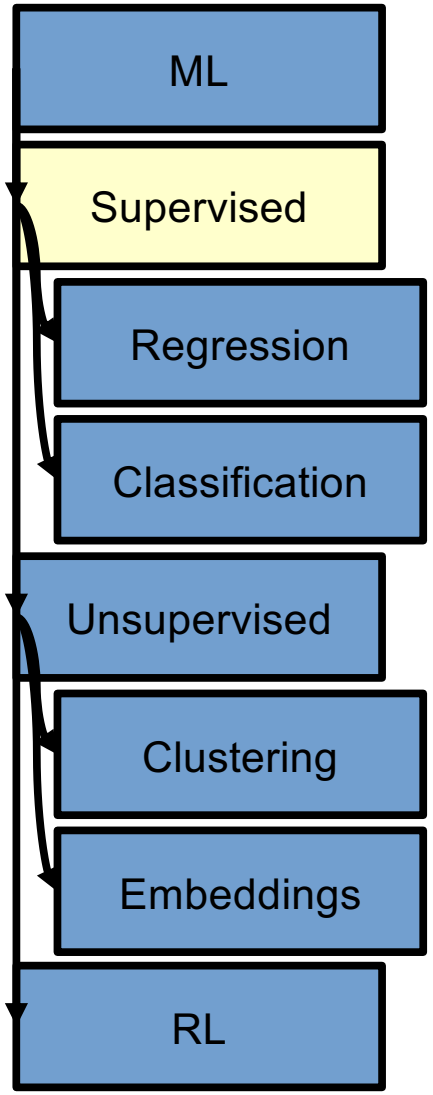
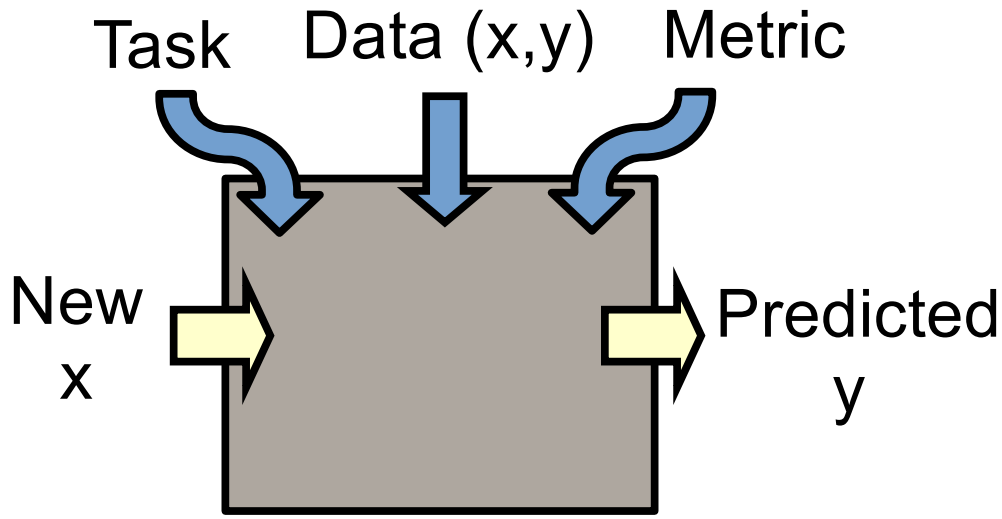
How we will get there: Taxonomy of Problems

Machine Learning Taxonomy

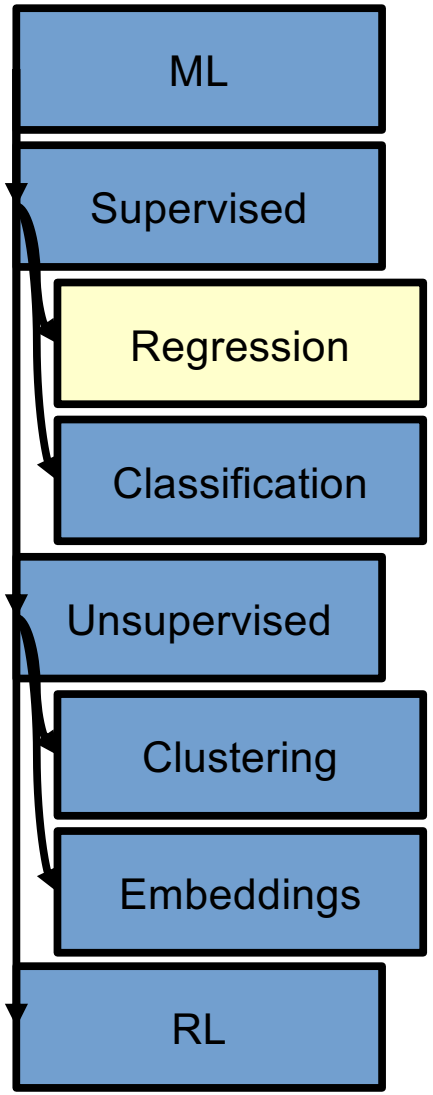


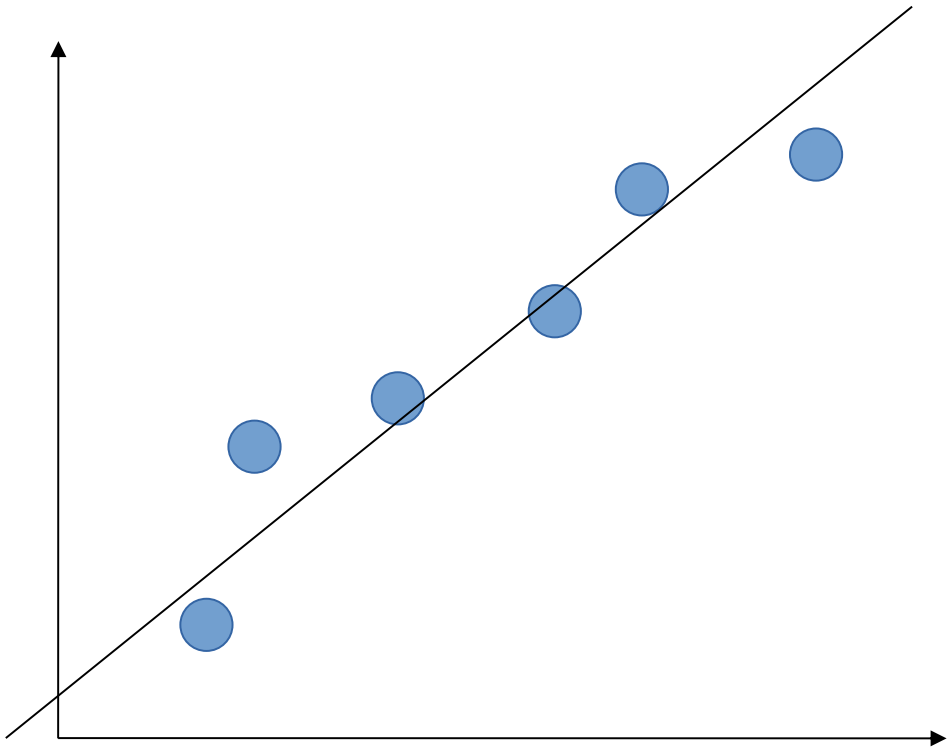
Machine Learning Taxonomy





Terminology: Regression



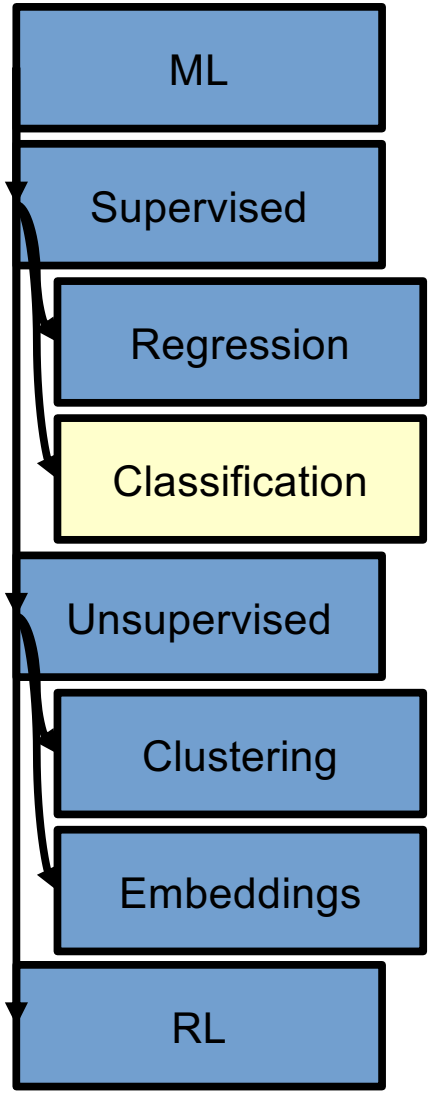


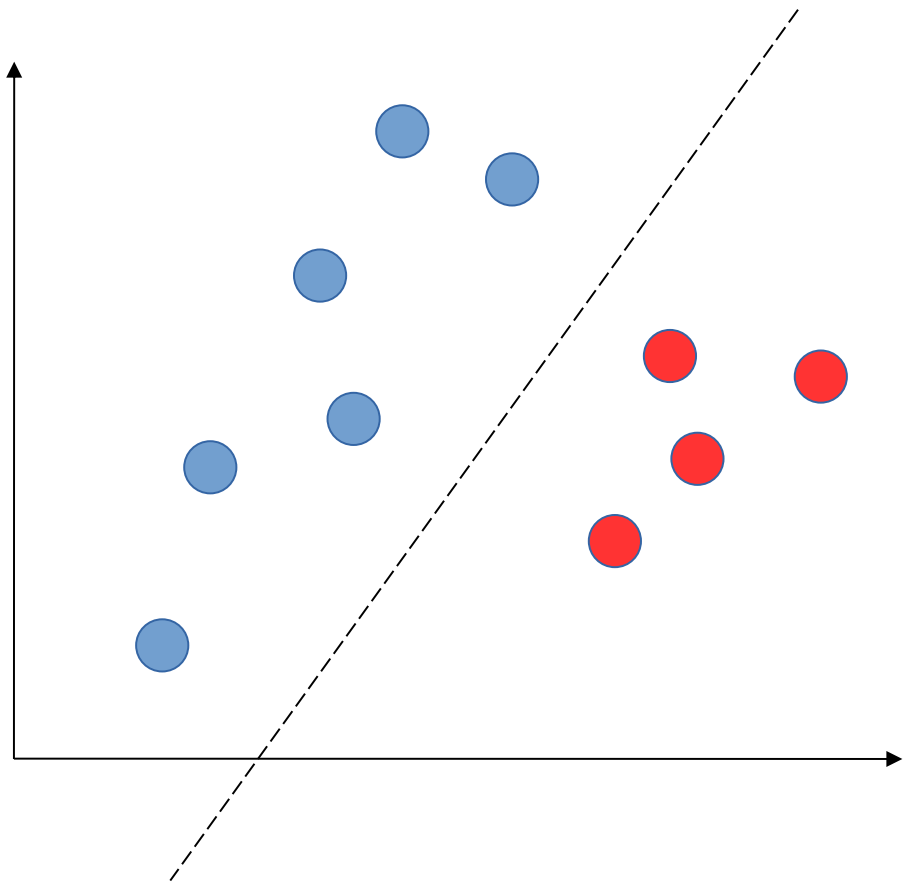
Example: Virtu Financial

Core technology: regression model to predict stock price, often in the very short-term

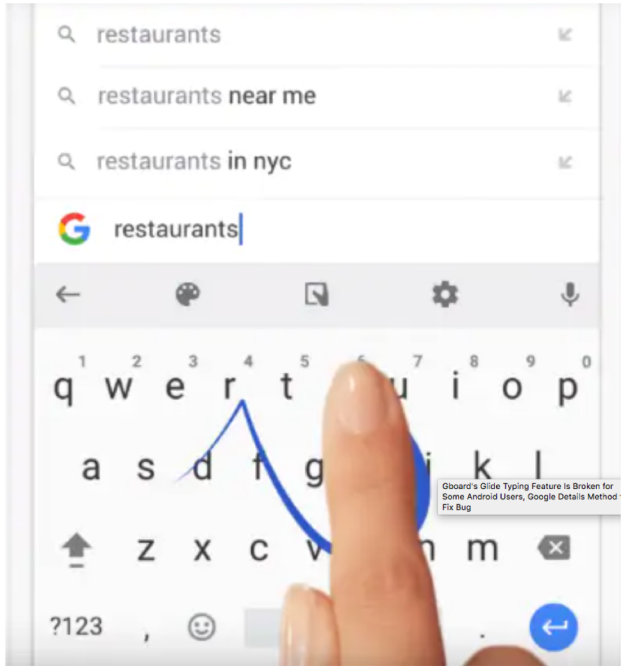
https://fortune.com/2015/04/16/how-virtu-financial-went-from-pr-pariah-to-ipo-idol/
https://www.virtu.com/

Terminology: Classification

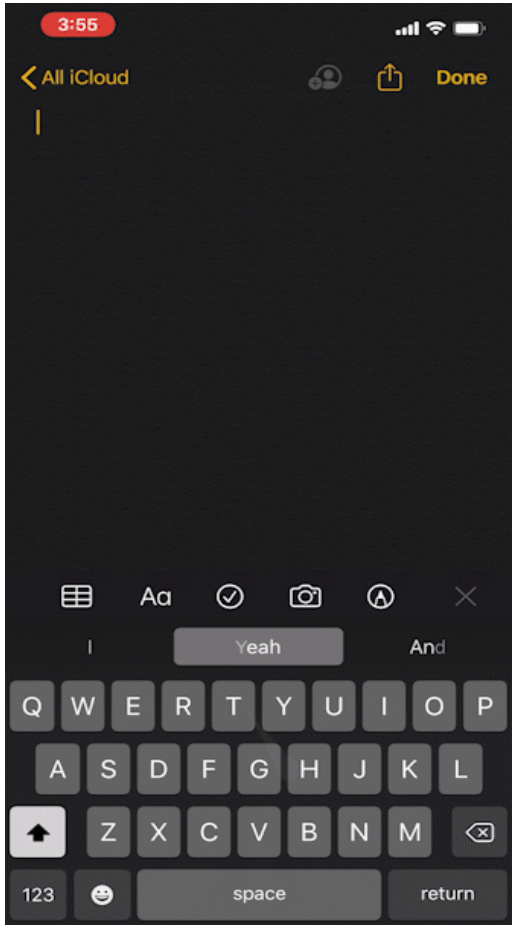




Example: “Swipe typing”



Android Glide Typing

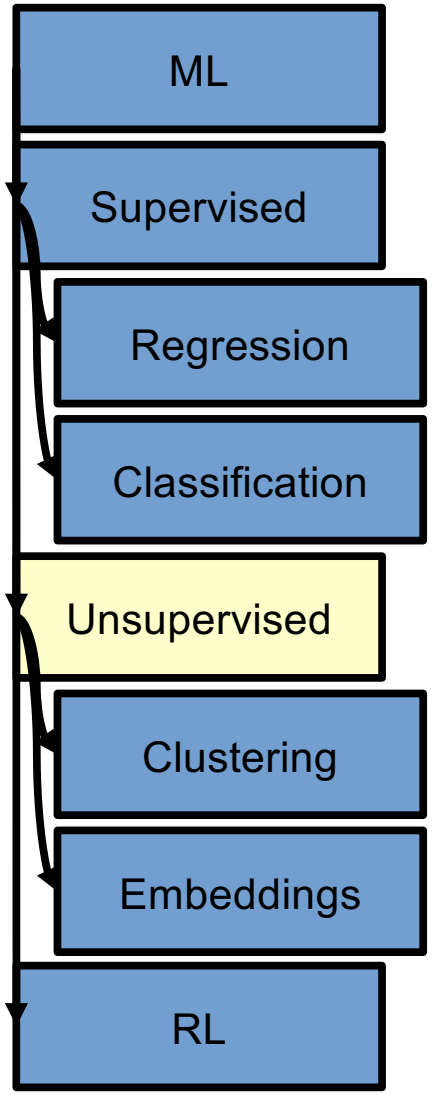


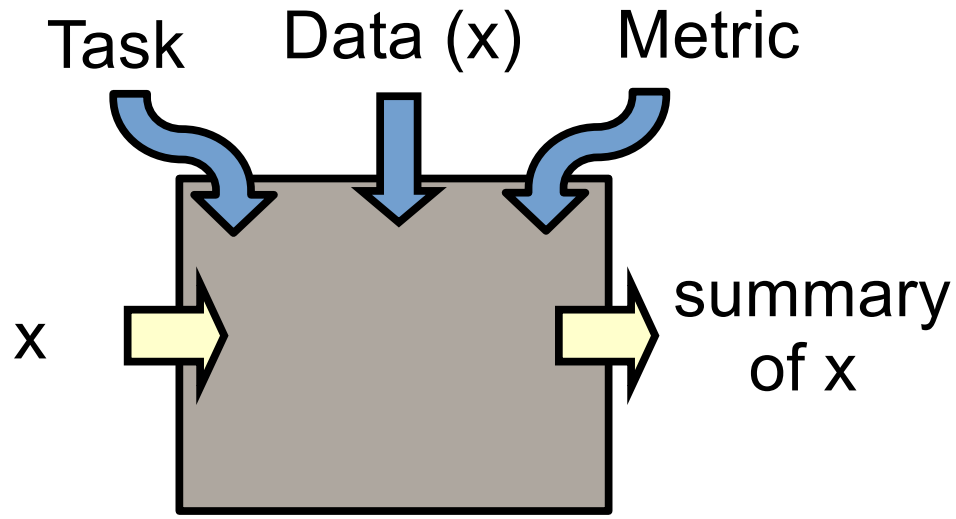
iOS QuickPath

Core technology: language model to predict which word is intended

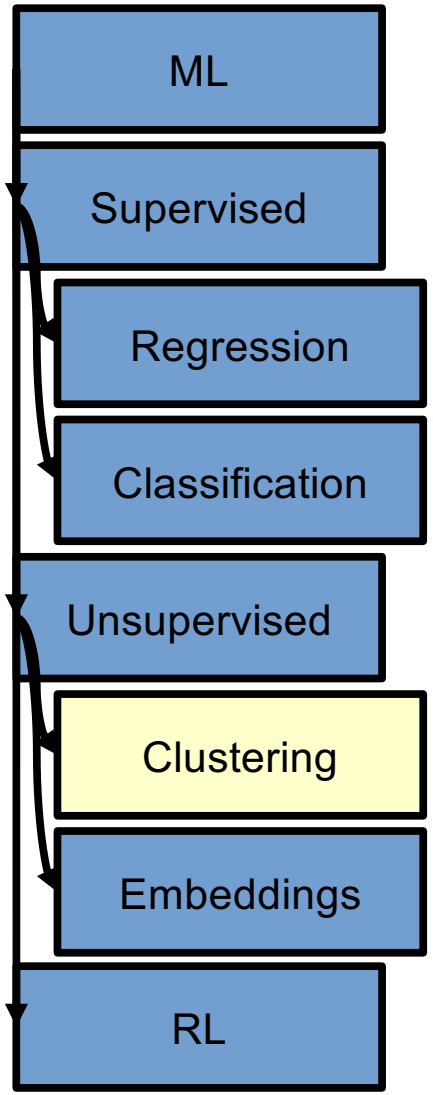
https://www.macworld.com/article/3432168/how-to-use-the-quickpath-swipe-keyboard.html
https://en.wikipedia.org/wiki/Swype
https://gadgets.ndtv.com/apps/news/gboard-for-android-glide-typing-bug-fix-google-1917639

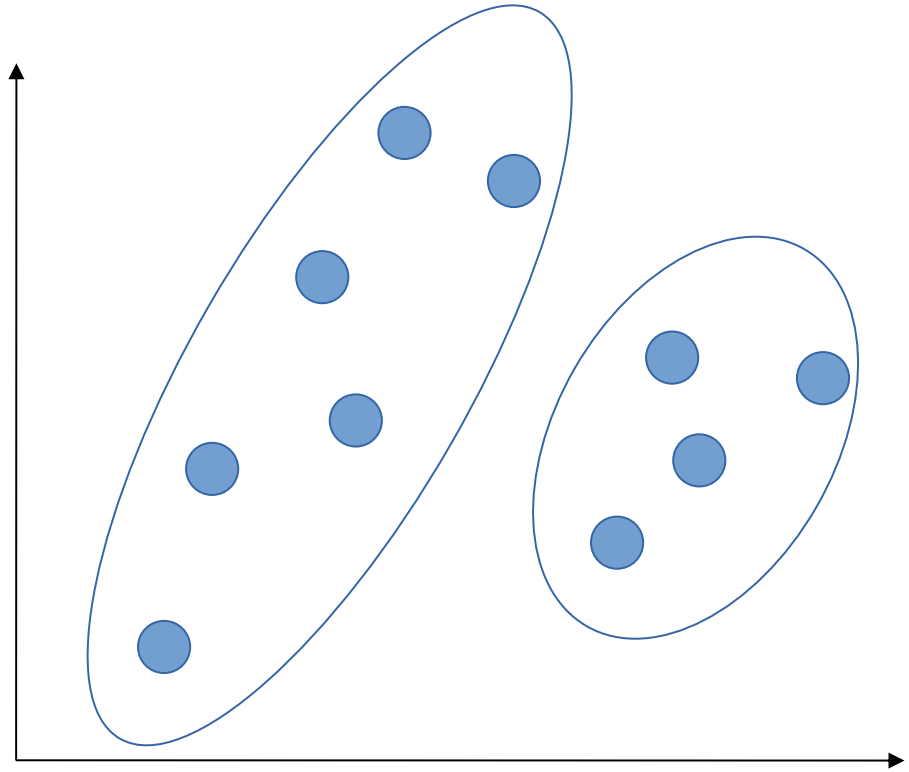
Machine Learning Taxonomy



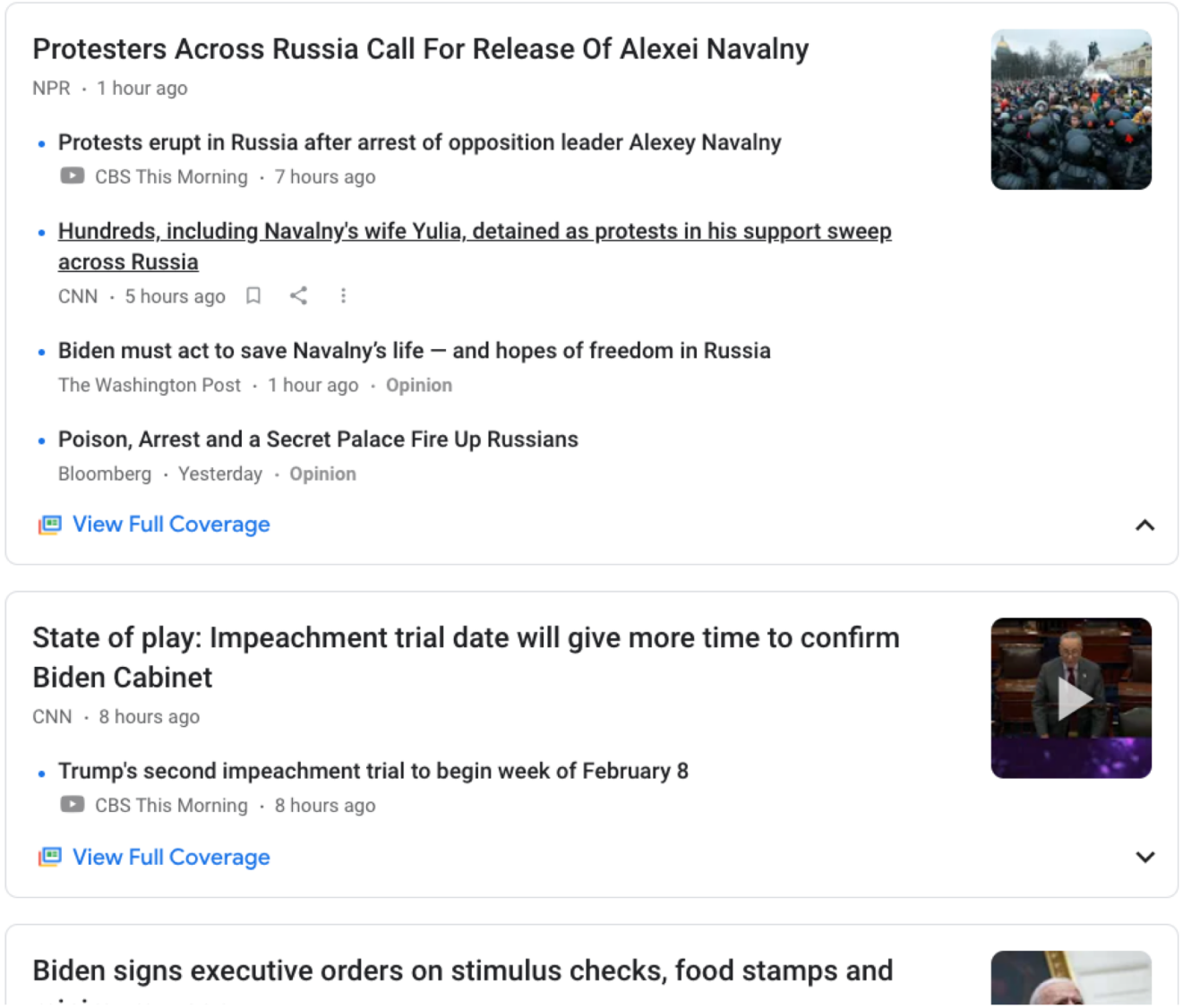


Terminology: Clustering





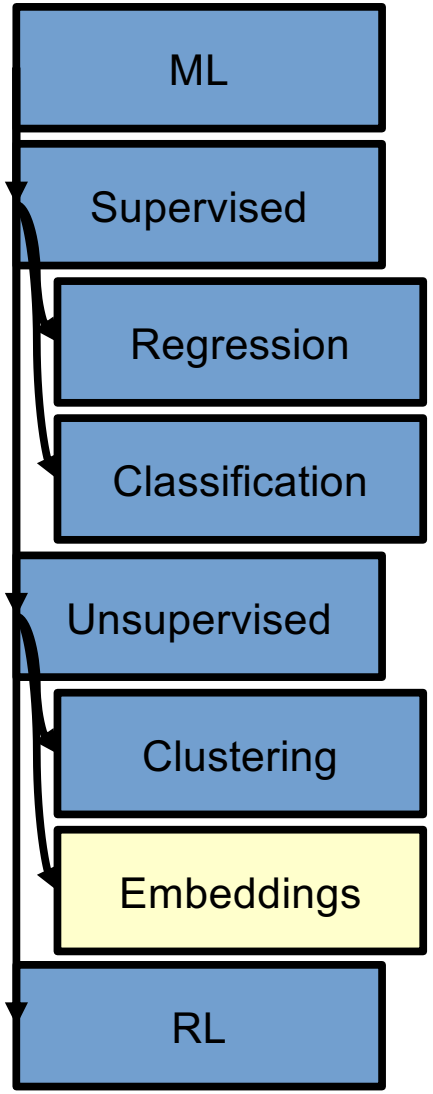
Example: Google News

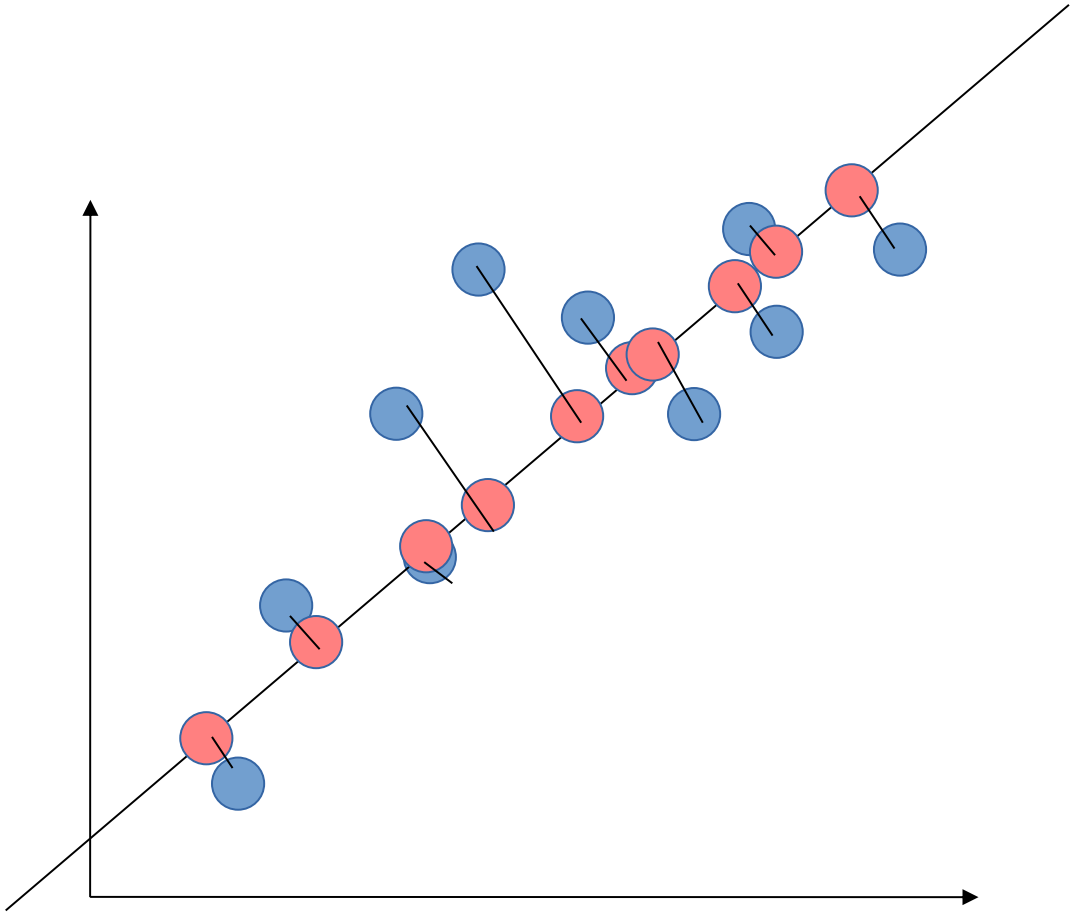


https://news.google.com/topstories?hl=en-US&gl=US&ceid=US:en

Core technology: clustering based on language and links to understand which stories are related

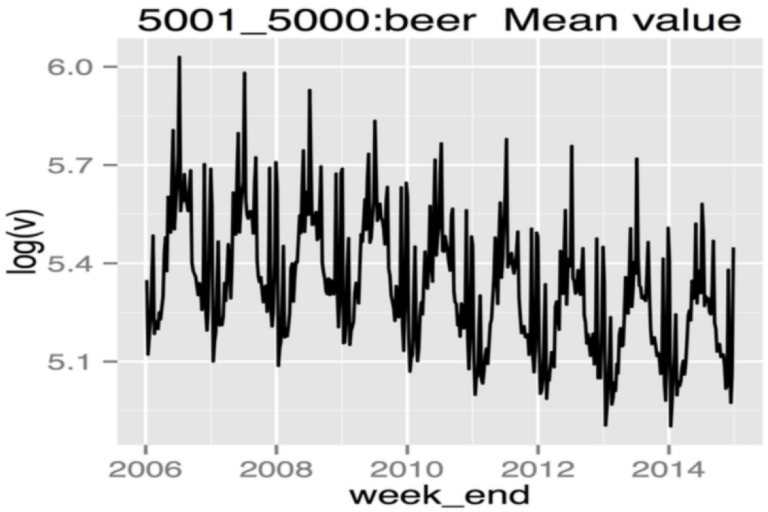
Terminology: Embedding

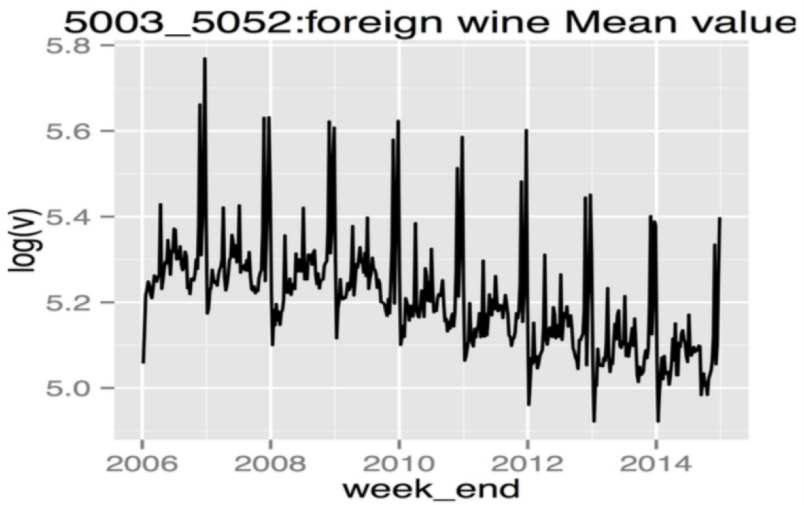


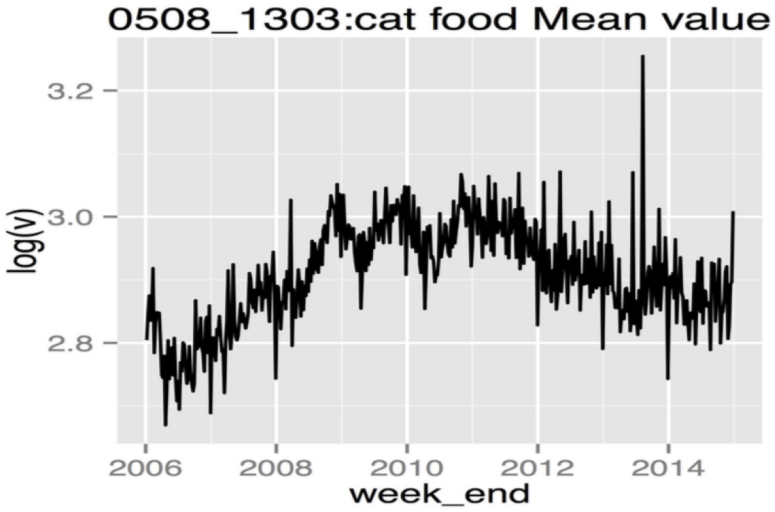


Example: Point-of-Sales Data

(S. Ng 2016)





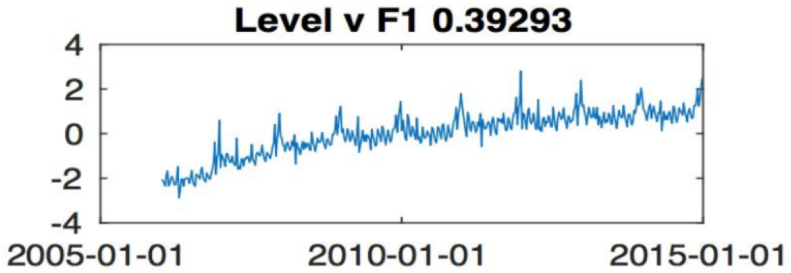


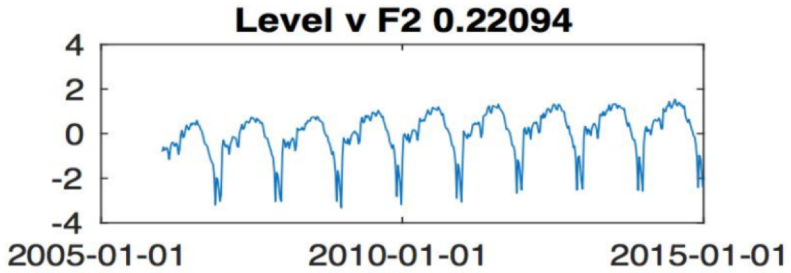
Nielsen scanner data, 2006-2014 on 1073 products in different locations ~6 TB

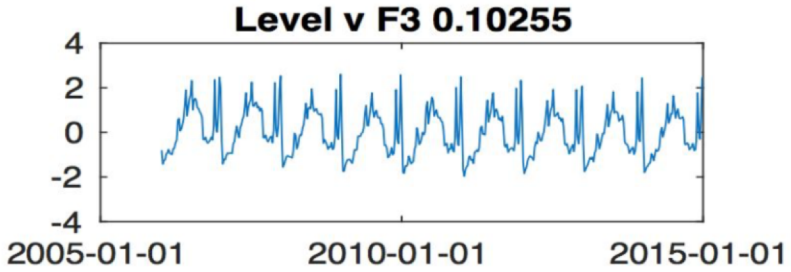
Can we see the effect on demand of the 2008-09 financial crisis?

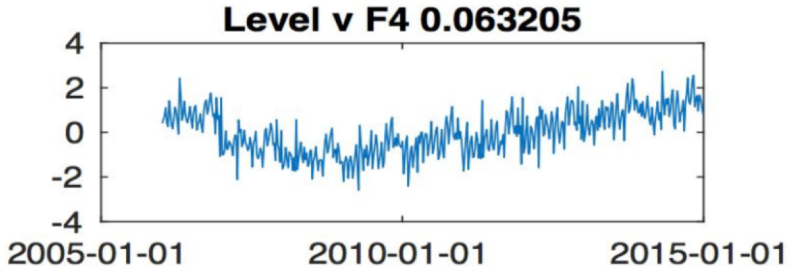
Eight Components (PCA)

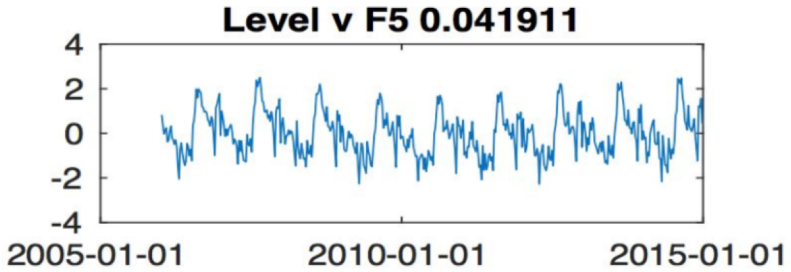
(S. Ng 2016)

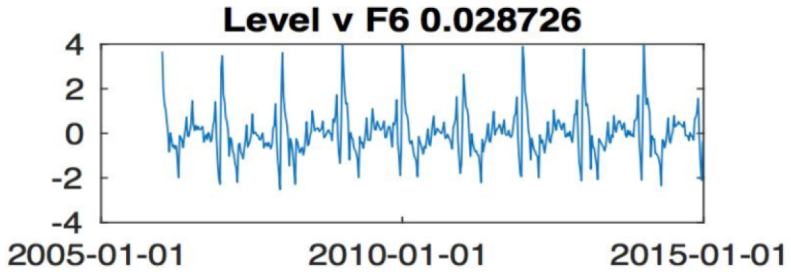


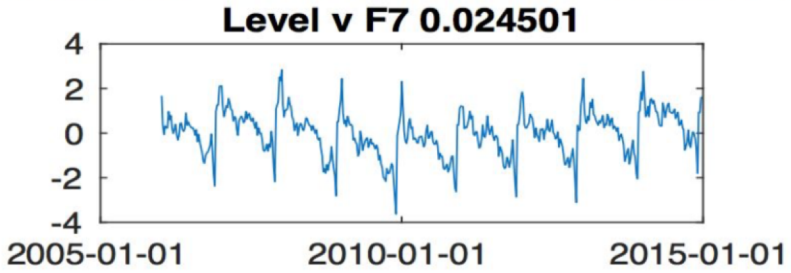


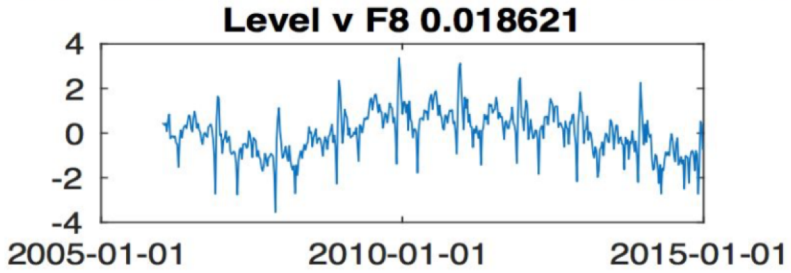




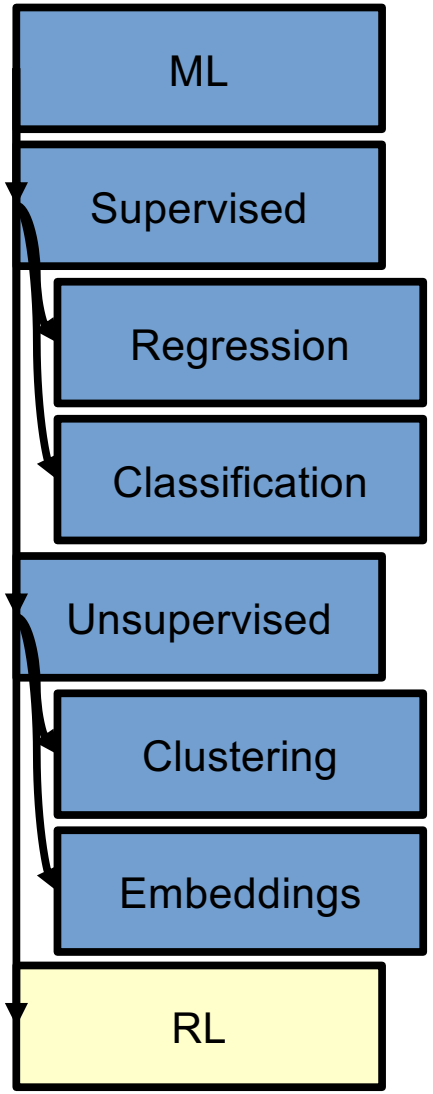


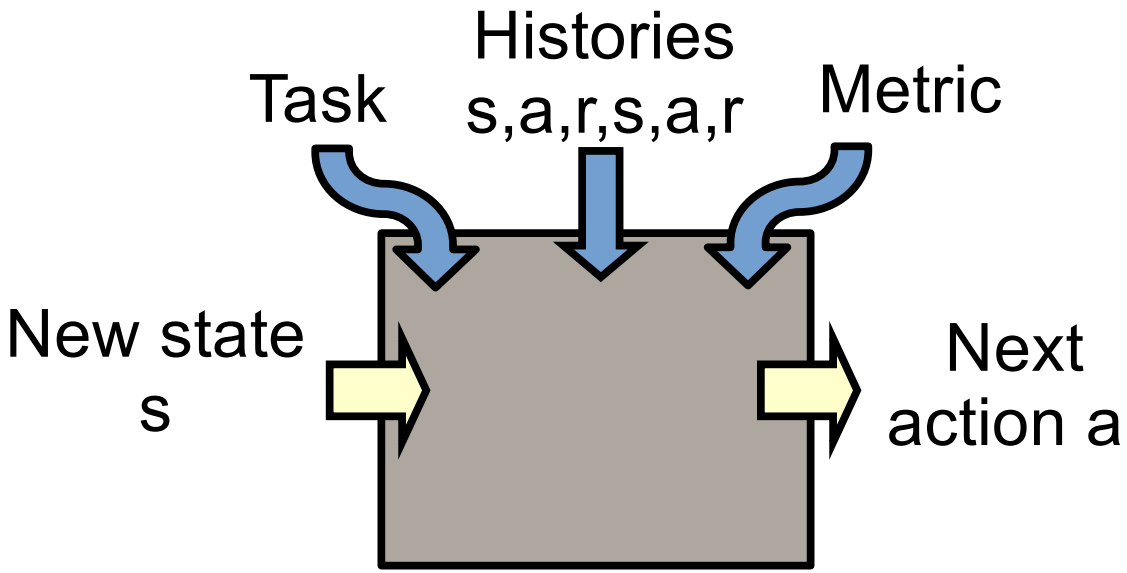






Terminology: Reinforcement Learning





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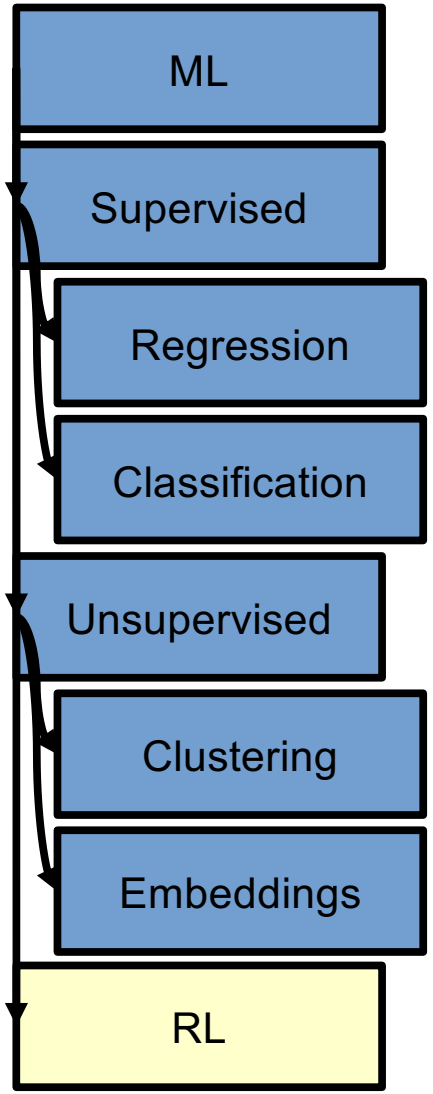
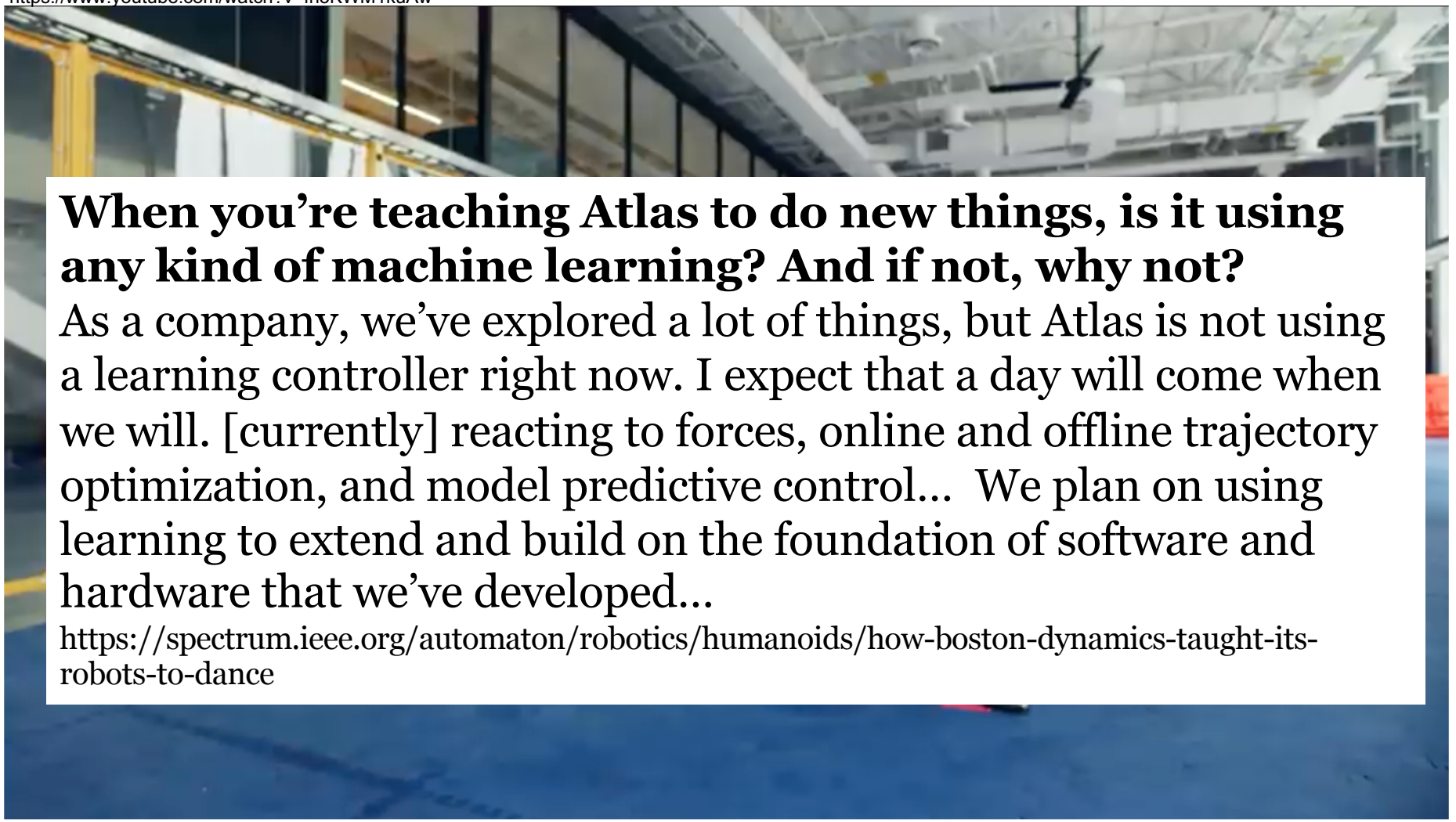


Kormushev et al., 2010
https://www.youtube.com/watch?v=W_gxLKSsSIE

2016

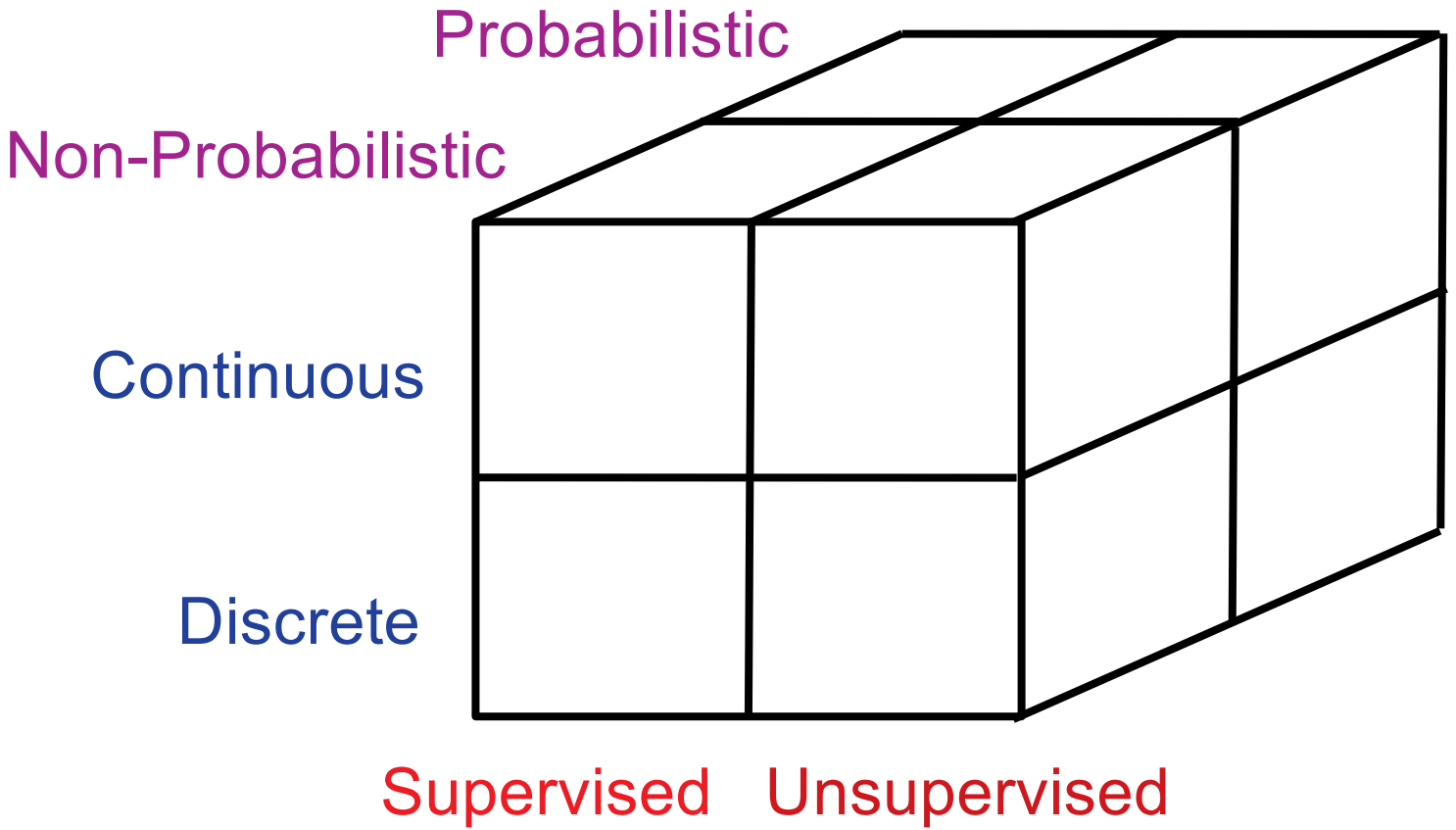
https://www.youtube.com/watch?v=fn3KWM1kuAw



When you're teaching Atlas to do new things, is it using any kind of machine learning? And if not, why not?

As a company, we've explored a lot of things, but Atlas is not using a learning controller right now. I expect that a day will come when we will. [currently] reacting to forces, online and offline trajectory optimization, and model predictive control… We plan on using learning to extend and build on the foundation of software and hardware that we've developed…

https://spectrum.ieee.org/automaton/robotics/humanoids/how-boston-dynamics-taught-its-robots-to-dance



+ graphical models, reinforcement learning

How we will get there: Course Structure

Structure of the Course

- Follow the “cube”++
  - Supervised: regression, classification
  - Unsupervised: clustering, embeddings
  - Graphical Models, Reinforcement Learning
- Excursions to discuss model classes, model selection, evaluation...

Lecture Structure

- Chit chat
- Session one
- Break
- Session two
- Concept checks

Please join us!

Lectures will include real world examples and concept exercises; we'll also discuss ethics

Logistics

- Attend ≥7 live lectures (exemptions!), lectures recorded
- Regular homeworks: biweekly (8p Friday), done individually, theoretical and some programming elements (LaTex, Python)
- Practical: groups of 2-3 people, 1 week, working on a real-world problem
- Six late days, at most two per problem set
- Two timed, closed-book midterms proctored over Zoom
- Sections: section zero with math preliminary material this week, then weekly sections on content; new “Beyond CS 181” sections
- Lots of office hours (almost all on *Collaborate*)
- Ed: for all discussion and questions on course content (content, clarification, private message)
- And more: concept checks, lecture recaps, CS 181 “textbook”

This week only

Office hours
All on **Congregate** except for Finale's

Finale Tuesday 3.30-4.30p (today!)
David Friday 2.30-4p

Nari + Sanjana Weds 8-9:30PM
Kat + Yash Tue 10:30pm-12am (today!)
Andrew + Ife Fri 6-7:30PM
Dylan + Rylan Sunday 1-2:30pm
Jonathan + Karthik Saturday 1-2:30pm

Prasidh Thurs 10:15am-11:45am

Section 0

All on **Zoom** (will be recorded)

- Andrew + Jonathan. Thurs 7-8pm. Probability
- Kat + Yash Wed 8-9pm Lin Alg
- Dylan + Rylan Friday 1-2 pm Coding Numpy
- Sanjana + Prasidh. Wed 9-10 am Hw 0

Collaboration Policy

- You may work with others, but your write-up must be entirely written by yourself in your own words. You may help each other debug code, but again, the code must be written by you.
- *Include the names of anyone you worked with in your write-up.*
- Do not copy parts of another person's assignment or jointly type up an assignment.
- You can make use of textbooks and online sources to help in answering questions, but you must cite your sources (and you should be ready to explain your answer to a member of the teaching staff)
- Do not look up solutions to specific questions from the internet or other sources (e.g. friends from previous years)

FAQ: Is this the right course?

- CS181: Rigorous conceptual grounding of a broad range of machine learning ideas with math and code
- Goal: Reason about when ML algorithms work, and why
- Alternatives:
  - For mostly theory: Stat195, etc.
  - For mostly practice: CS109, etc.
  - For depth rather than breadth: CS282, etc.

FAQ: Can I sit in/audit/simultaneouly enroll/take CS181?

Yes!

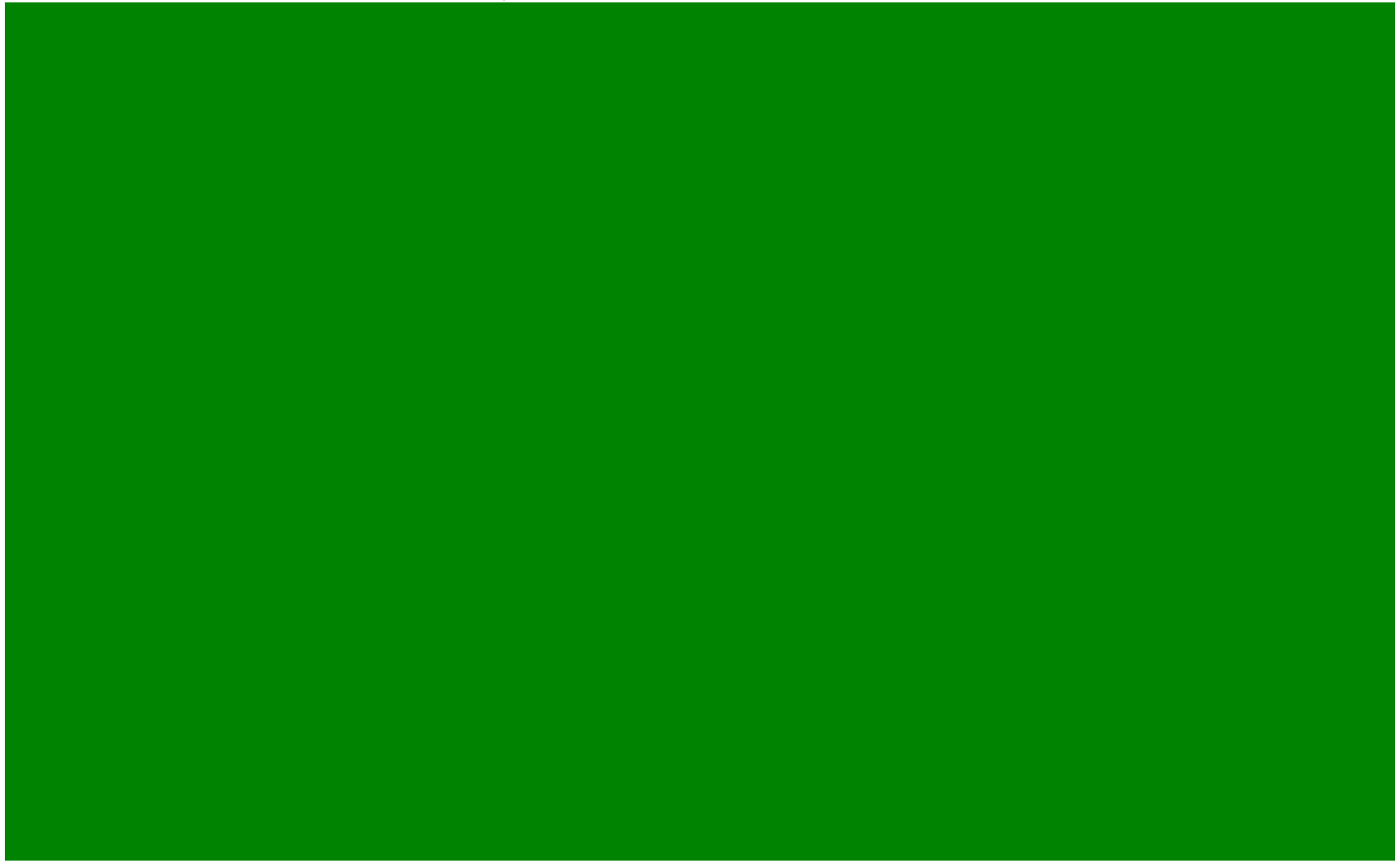
FAQ: Do I need the Prereqs?

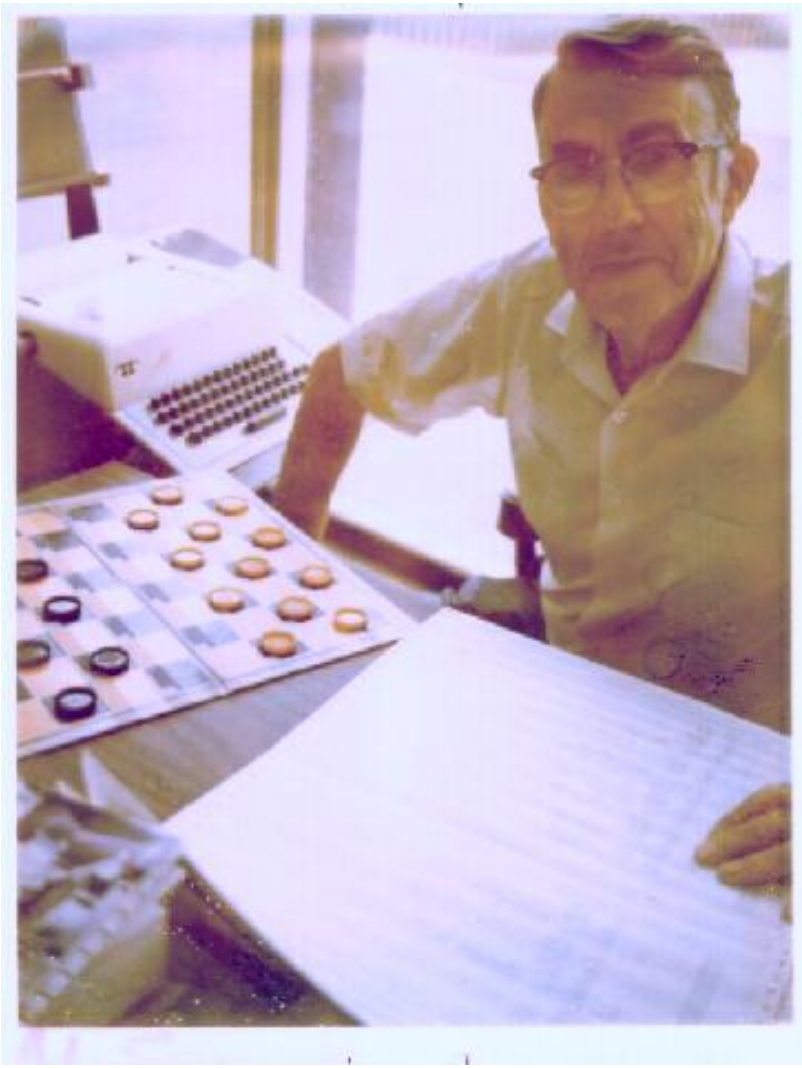
- What you need: programming, probability, calculus, and linear algebra
- See our section zero “Math review” resource (use this as a reference)
- See Math for ML resource https://mml-book.com/

Problem 1.1:
Take the gradient of training loss with respect to the vector of weights *w*
...

The Thinking Machine (CBS, 1961)

https://techtv.mit.edu/videos/10268-the-thinking-machine-1961---mit-centennial-film





Arthur Samuel (1952): Learning to play checkers through self play

A Short Break (and then, … nonparametric regression)