CPSC 340 and 532M: Machine Learning and Data Mining

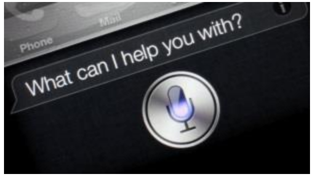
Andreas Lehrmann and Mark Schmidt
University of British Columbia, Fall 2022
https://www.students.cs.ubc.ca/~cs-340

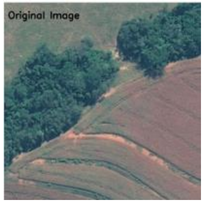
Held on the traditional, ancestral, and unceded territory of the Musqueam people

Some images from this lecture are taken from Google Image Search, contact me if you want the reference

Big Data Phenomenon

- We are collecting and storing data at an unprecedented rate.
- Examples:
  - YouTube, Facebook, MOOCs, news sites.
  - Credit cards transactions and Amazon purchases.
  - Transportation data (Google Maps, Waze, Uber)
  - Gene/protein sequencing/expression/structures.
  - Maps and satellite data.
  - Camera traps and conservation efforts.
  - Phone call records and speech recognition results.
  - Video game worlds and user actions.



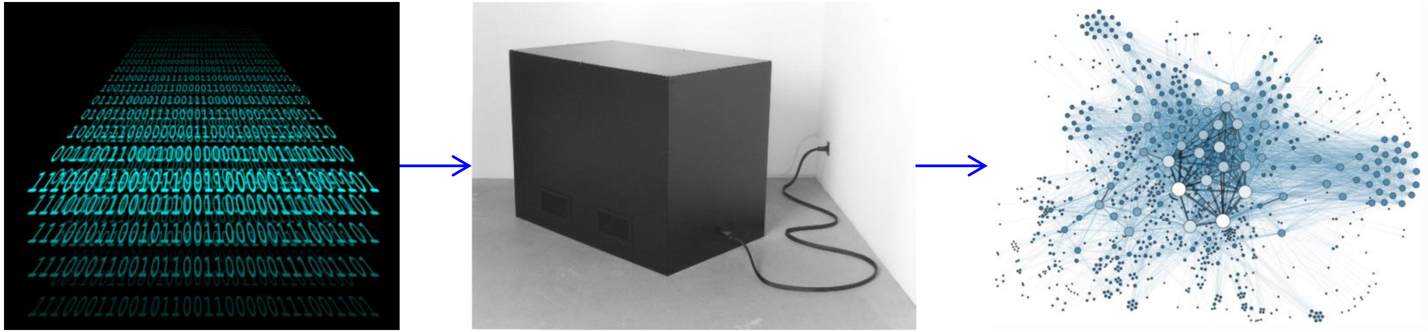


Big Data Phenomenon

- What do you do with all this data?
  - Too much data to search through it manually.
- But there is valuable information in the data.
  - How can we use it for fun, profit, and/or the greater good?
- Data mining and machine learning are key tools we use to make sense of large datasets.

Data Mining

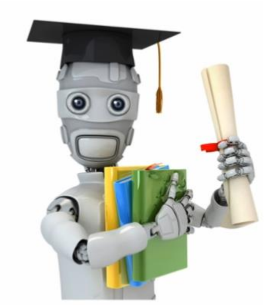
- Automatically extract useful knowledge from large datasets.



- Usually, to help with human decision making.

Machine Learning

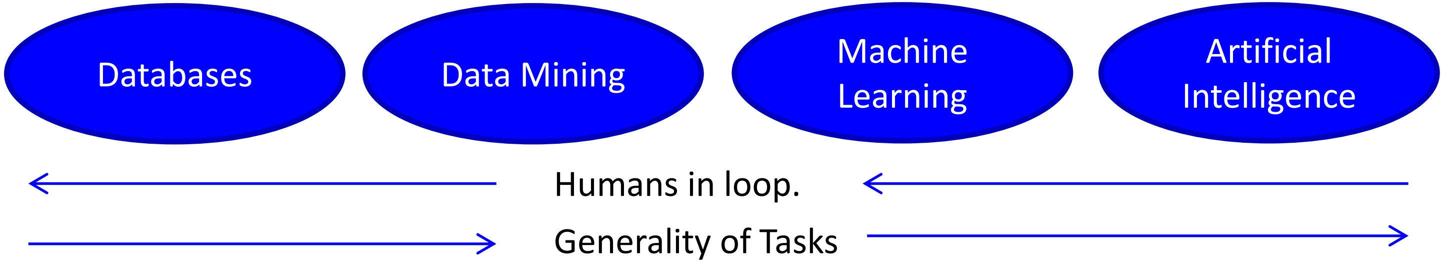
- Using computer to automatically detect patterns in data and use these to make predictions or decisions.



- Most useful when:
  - We want to automate something a human can do.
  - We want to do things a human can't do (look at 1 TB of data).

Data Mining vs. Machine Learning

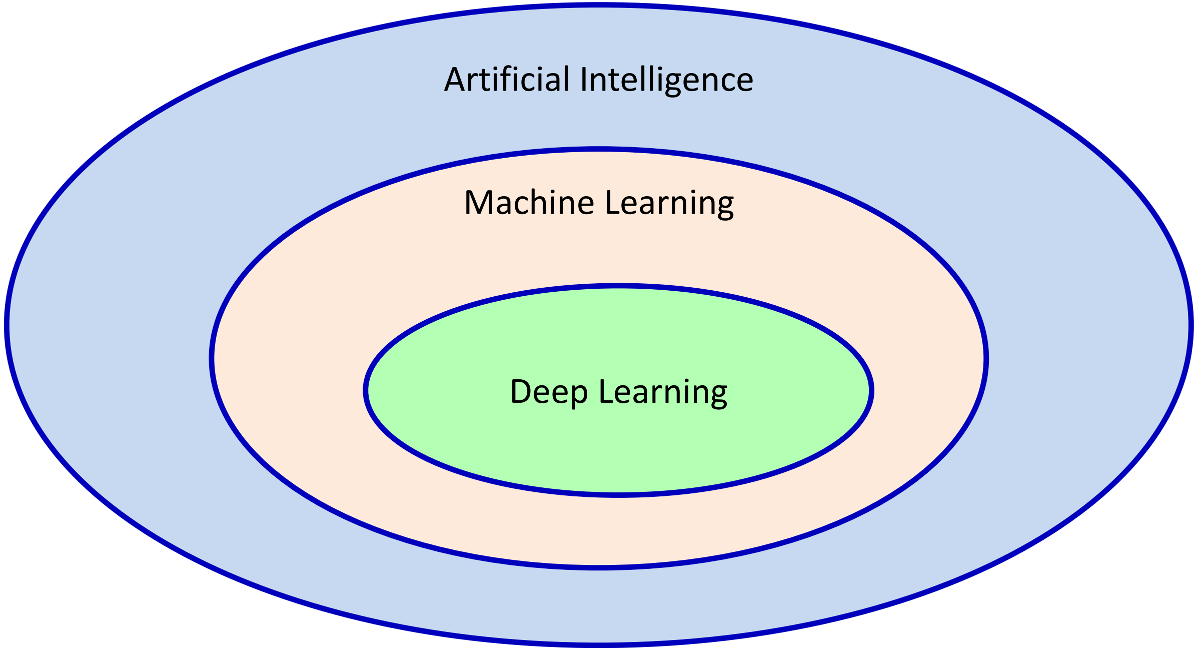
- Data mining and machine learning are very similar:
  - Data mining often viewed as closer to databases.
  - Machine learning often viewed as closer AI.



- Both are similar to statistics, but more emphasis on:
  - Large datasets and computation.
  - Predictions (instead of descriptions).
  - Flexible models (that work on many problems).

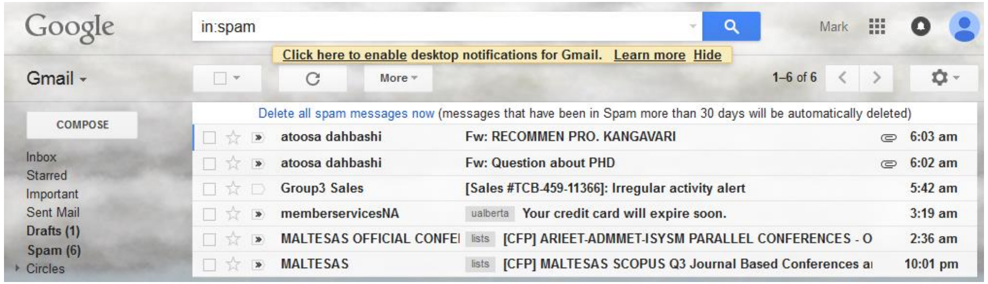
Deep Learning vs. Machine Learning vs. AI

- Traditional we’ve viewed ML as a subset of AI.
  - And “deep learning” as a subset of ML.



Applications

- Spam filtering:



Google in:spam Mark

Click here to enable desktop notifications for Gmail. Learn more Hide

Gmail More 1–6 of 6

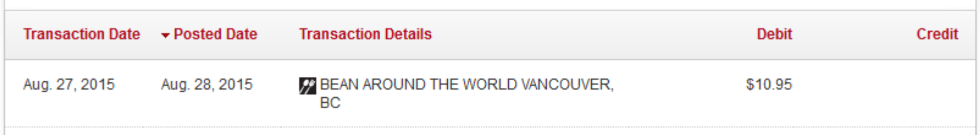
COMPOSE

Inbox
Starred
Important
Sent Mail
Drafts (1)
Spam (6)
Circles

Delete all spam messages now (messages that have been in Spam more than 30 days will be automatically deleted)

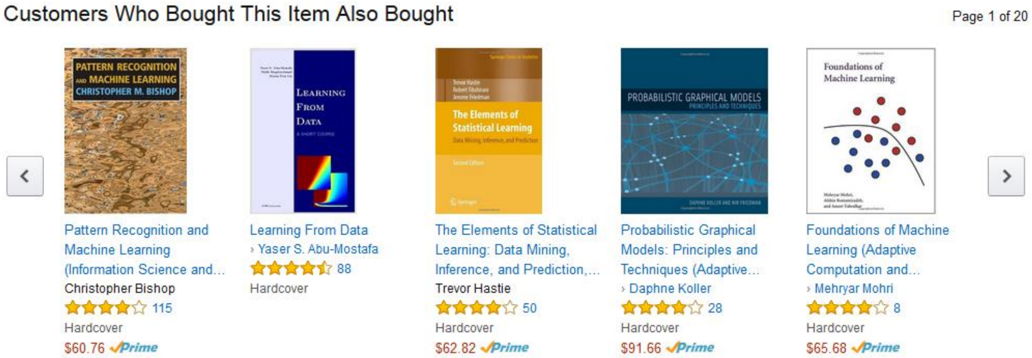
atoosa dahbashi	Fw: RECOMMEN PRO. KANGAVARI	6:03 am
atoosa dahbashi	Fw: Question about PHD	6:02 am
Group3 Sales	[Sales #TCB-459-11366]: Irregular activity alert	5:42 am
memberservicesNA	ualberta Your credit card will expire soon.	3:19 am
MALTESAS OFFICIAL CONFEI	lists [CFP] ARIEET-ADMMET-ISYSM PARALLEL CONFERENCES - O	2:36 am
MALTESAS	lists [CFP] MALTESAS SCOPUS Q3 Journal Based Conferences ai	10:01 pm

- Credit card fraud detection:



Transaction Date	Posted Date	Transaction Details	Debit	Credit
Aug. 27, 2015	Aug. 28, 2015	BEAN AROUND THE WORLD VANCOUVER, BC	$10.95	

- Product recommendation:



Customers Who Bought This Item Also Bought

Page 1 of 20

Pattern Recognition and Machine Learning (Information Science and...
Christopher Bishop
115
Hardcover
$60.76 Prime

Learning From Data
Yaser S. Abu-Mostafa
88
Hardcover

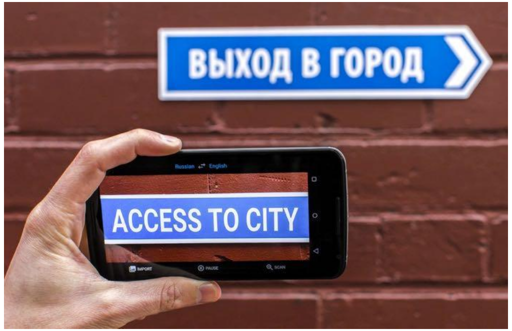
The Elements of Statistical Learning: Data Mining, Inference, and Prediction,...
Trevor Hastie
50
Hardcover
$62.82 Prime

Probabilistic Graphical Models: Principles and Techniques (Adaptive...
Daphne Koller
28
Hardcover
$91.66 Prime

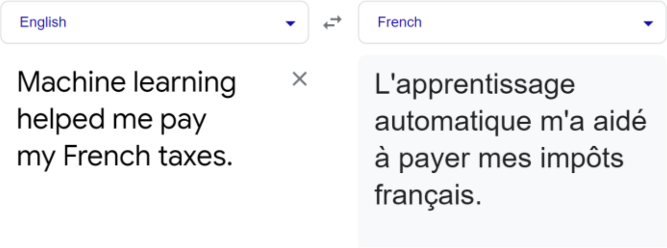
Foundations of Machine Learning (Adaptive Computation and...
Mehryar Mohri
8
Hardcover
$65.68 Prime

Applications

- Optical character recognition:



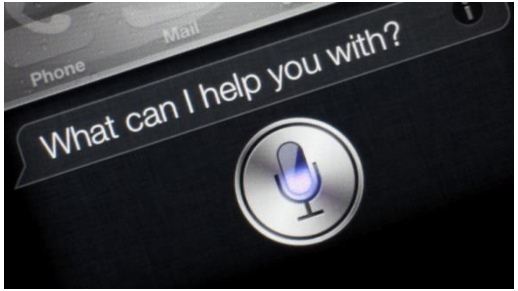
- Machine translation:



Machine learning helped me pay my French taxes.

L'apprentissage automatique m'a aidé à payer mes impôts français.

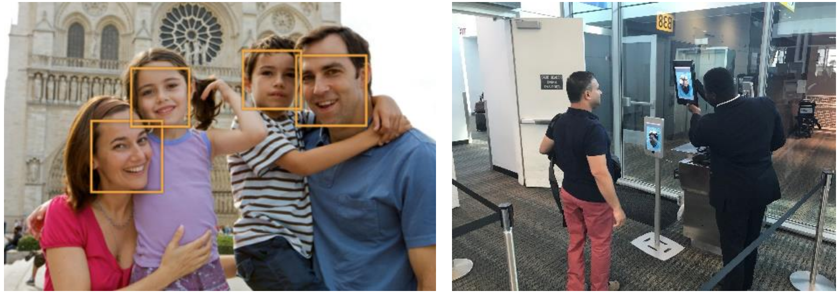
- Speech recognition:



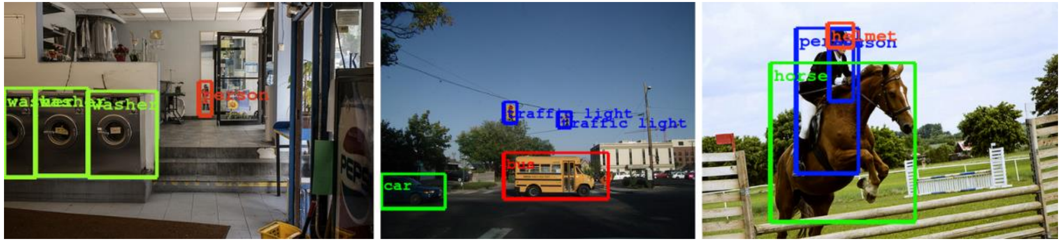
What can I help you with?

Applications

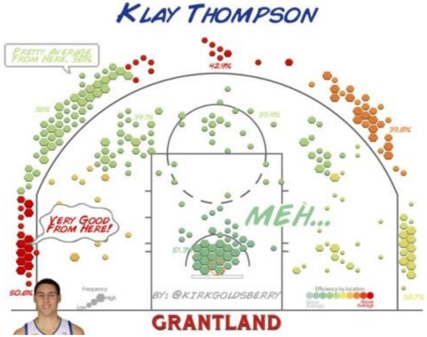
- Face detection/recognition:



- Object detection:

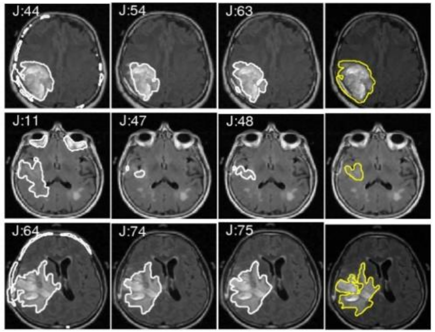


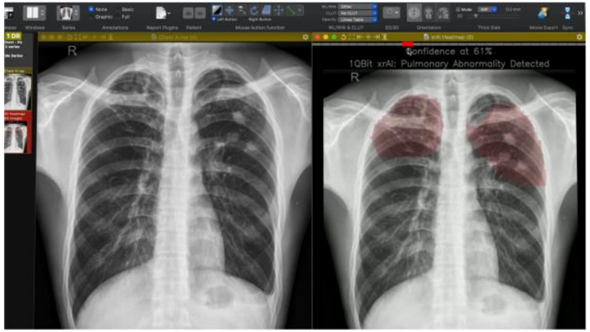
- Sports analytics:



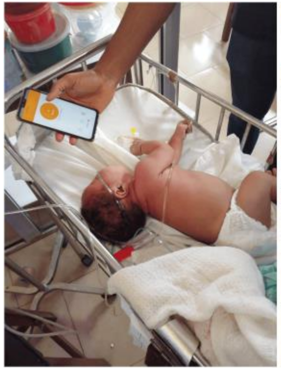
Applications

- Medical imaging:

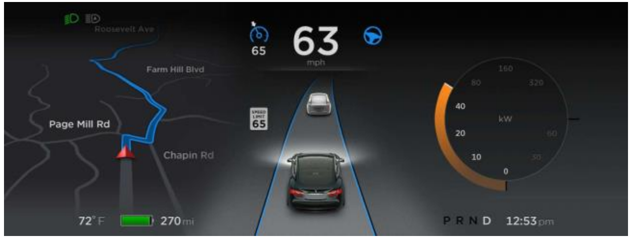




- Medical diagnostics:

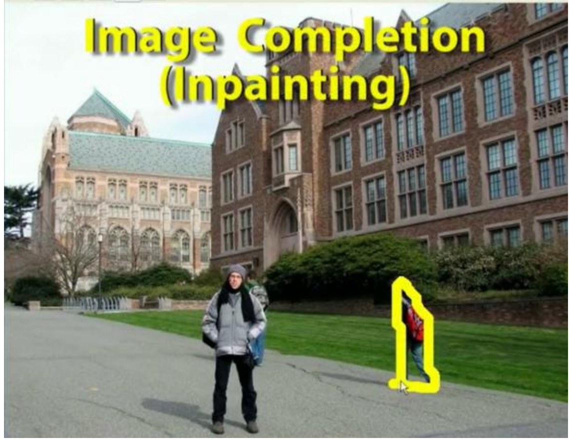


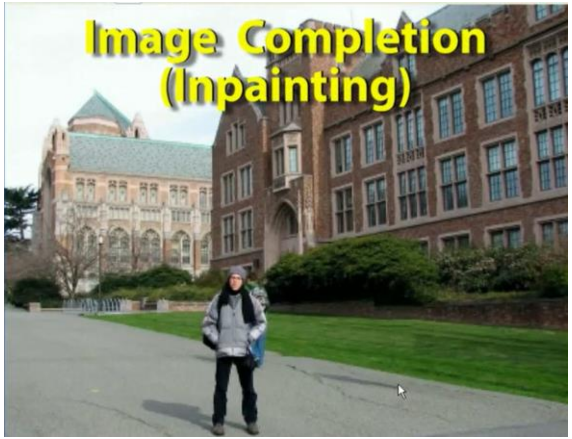
- Self-driving cars:



Applications

- Image completion:





- Image annotation:

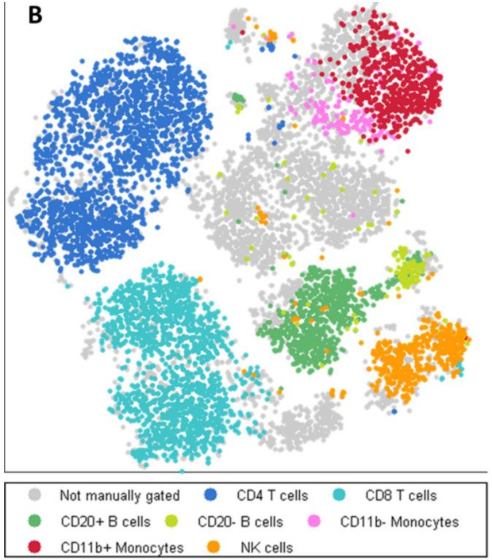
a cat is sitting on a toilet seat
logprob: -7.79

a display case filled with lots of different types of donuts
logprob: -7.78

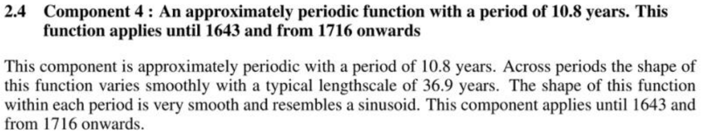
a group of people sitting at a table with wine glasses
logprob: -6.71

Applications

- Discovering new cancer subtypes:

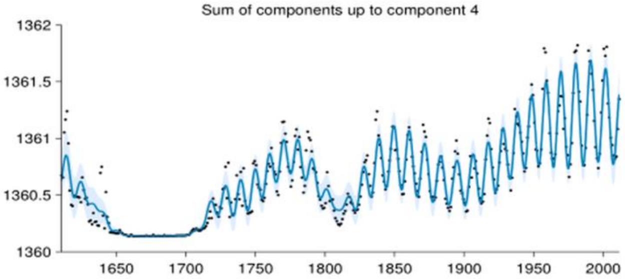


- Automated Statistician:



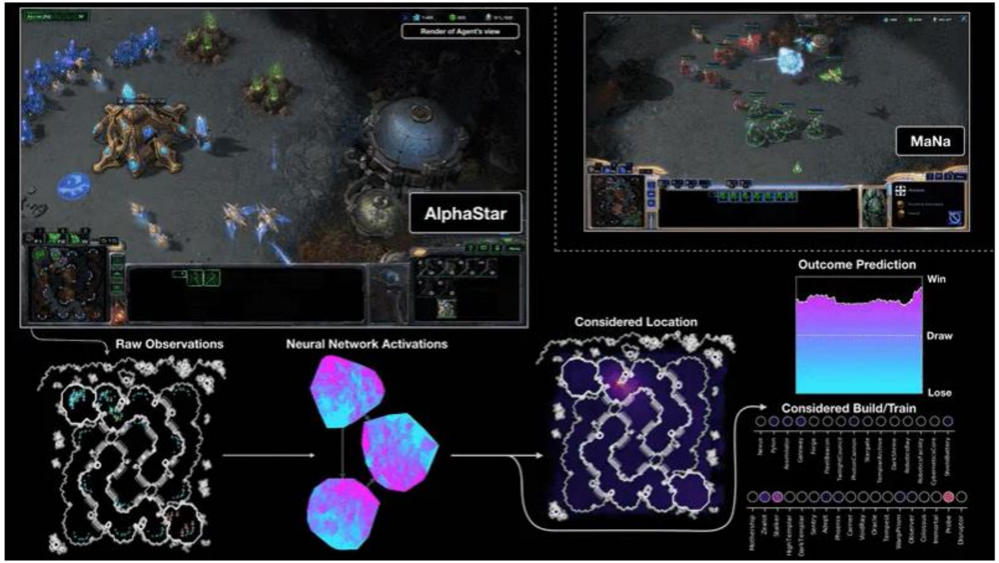
2.4 Component 4 : An approximately periodic function with a period of 10.8 years. This function applies until 1643 and from 1716 onwards

This component is approximately periodic with a period of 10.8 years. Across periods the shape of this function varies smoothly with a typical lengthscale of 36.9 years. The shape of this function within each period is very smooth and resembles a sinusoid. This component applies until 1643 and from 1716 onwards.


Sum of components up to component 4

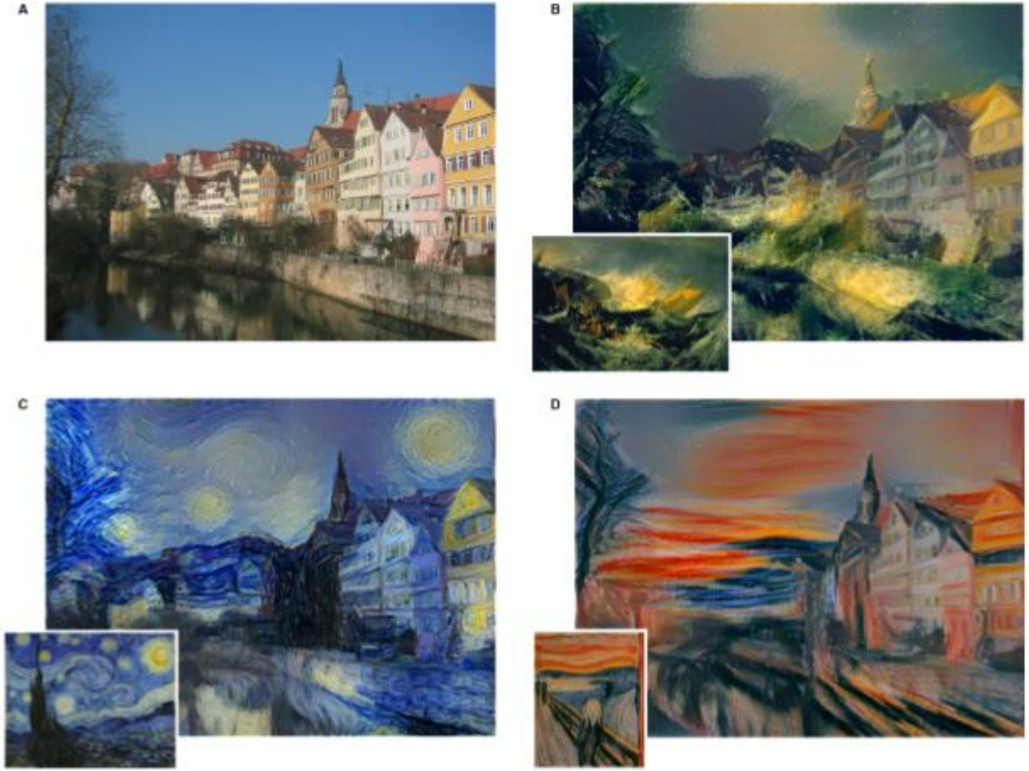
Applications

- Beating humans in Go and Starcraft:



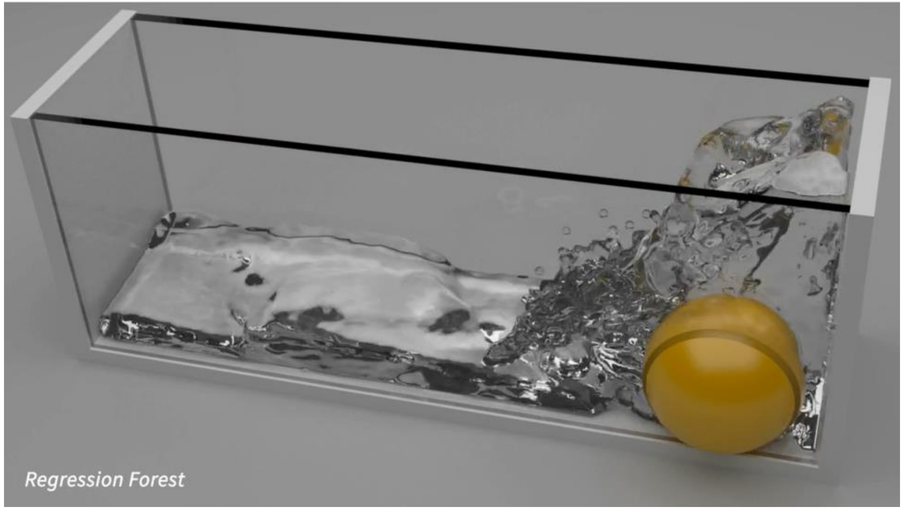
Applications

- Mimicking artistic styles (video).



Applications

- Fast physics-based animation:

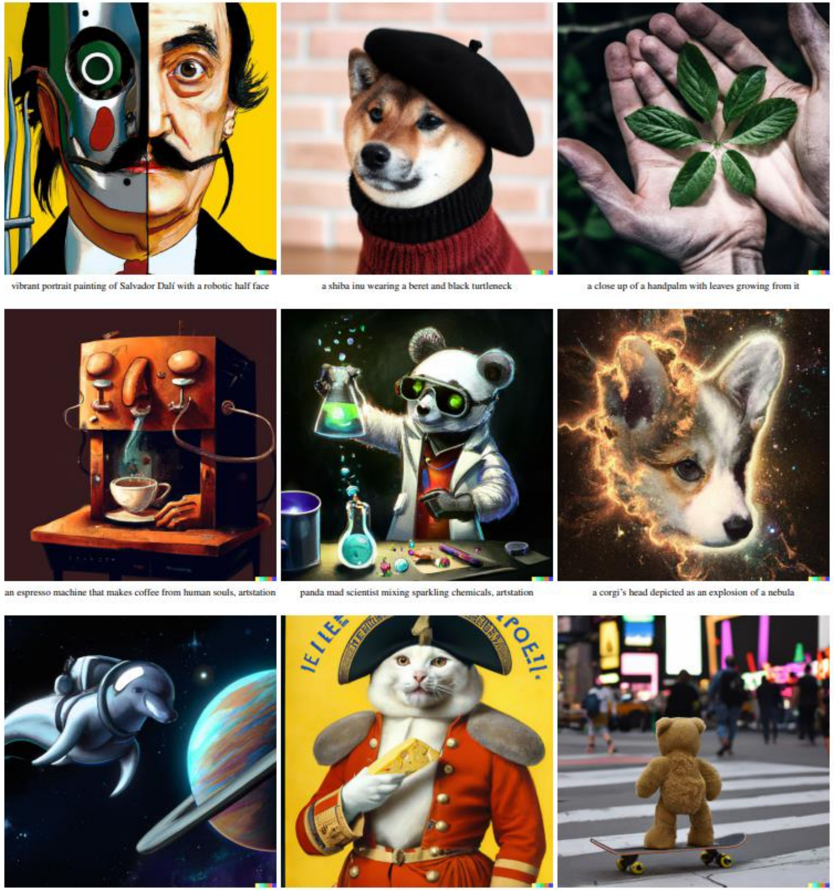


- Character animation (video):

- Recent work on generating text/music/voice/poetry/dance.

Applications

- Generating images from text:



vibrant portrait painting of Salvador Dalí with a robotic half face

a shiba inu wearing a beret and black turtleneck

a close up of a handpalm with leaves growing from it

an espresso machine that makes coffee from human souls, artstation

panda mad scientist mixing sparkling chemicals, artstation

a corgi's head depicted as an explosion of a nebula

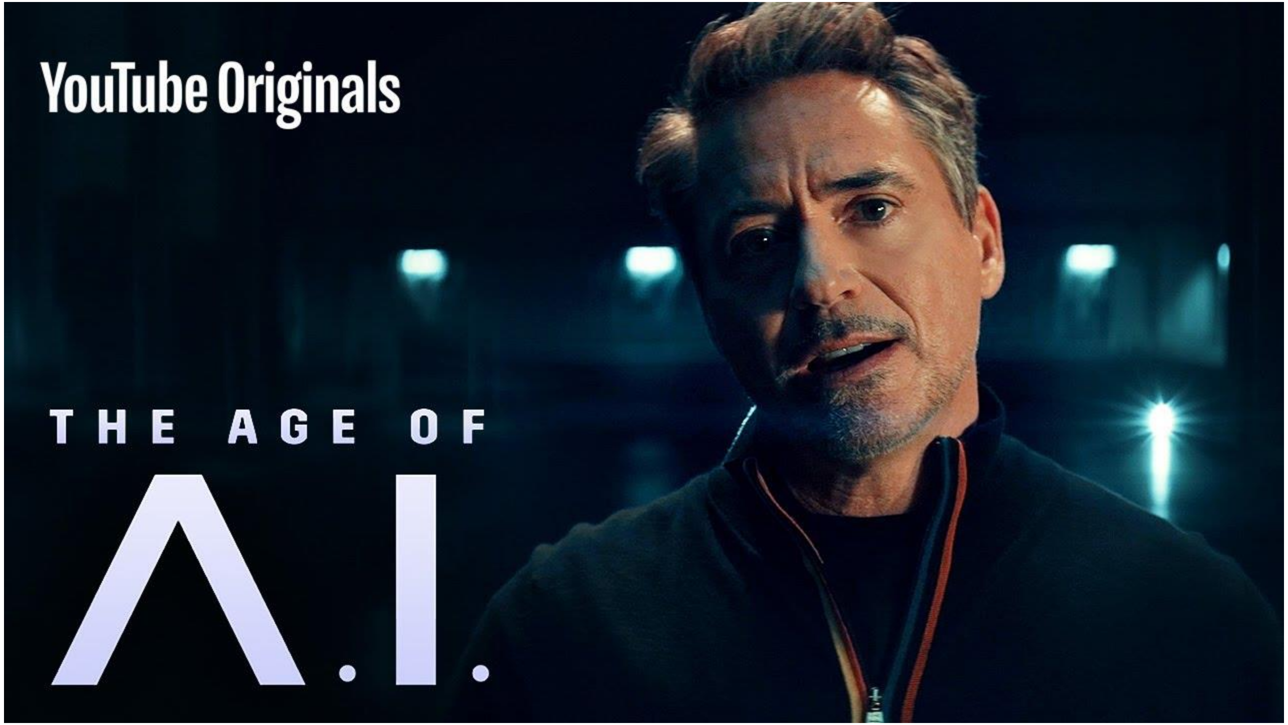
a dolphin in an astronaut suit on saturn, artstation

a propaganda poster depicting a cat dressed as french emperor napoleon holding a piece of cheese

a teddy bear on a skateboard in times square

Applications

- “Age of AI” YouTube series:

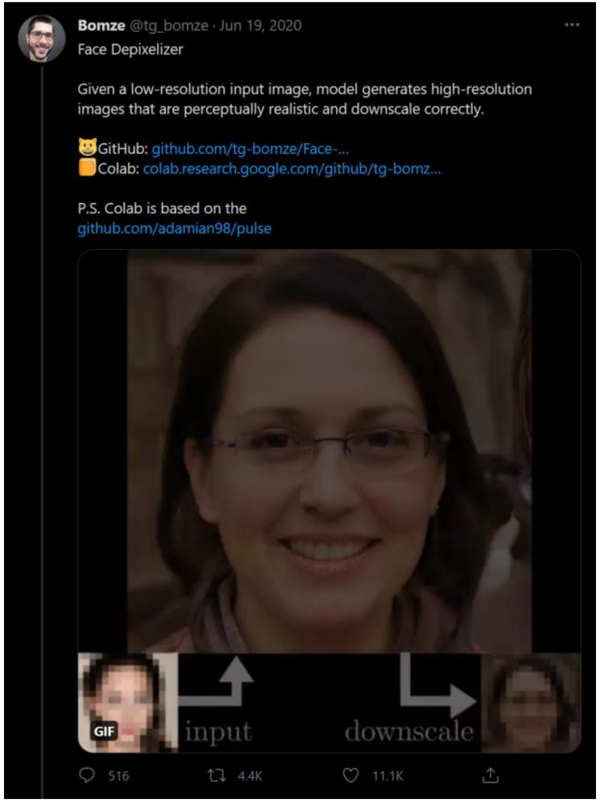


- Summary:
  - There is a lot you can do with a bit of statistics and a lot data/computation.

- We are in exciting times.
  - Major recent progress in many fields:
    - Speech recognitio, computer vision, natural language processing, iamge generation.
  - Things are changing a lot on the timescale of 3-5 years.
  - NeurIPS conference sold out in ~11 minutes in 2019 (switched to lottery).
  - A bubble in ML investments (most “AI” companies are just doing ML).

- But it is important to know the limitations of what you are doing.
  - A huge number of people applying ML are just “overfitting”.
    - Their methods do not work when they are released “into the wild”.

Failures of Machine Learning



Bomze @tg_bomze · Jun 19, 2020

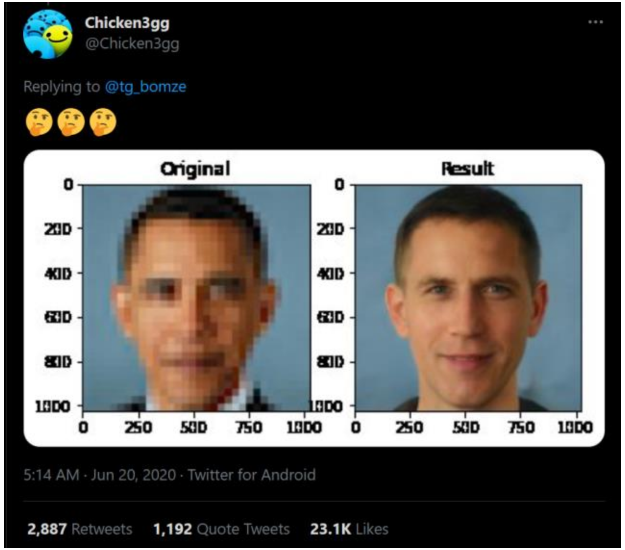
Face Depixelizer

Given a low-resolution input image, model generates high-resolution images that are perceptually realistic and downscale correctly.

😺GitHub: github.com/tg-bomze/Face-...
🟧Colab: colab.research.google.com/github/tg-bomz...

P.S. Colab is based on the
github.com/adamian98/pulse

516 4.4K 11.1K



Chicken3gg
@Chicken3gg

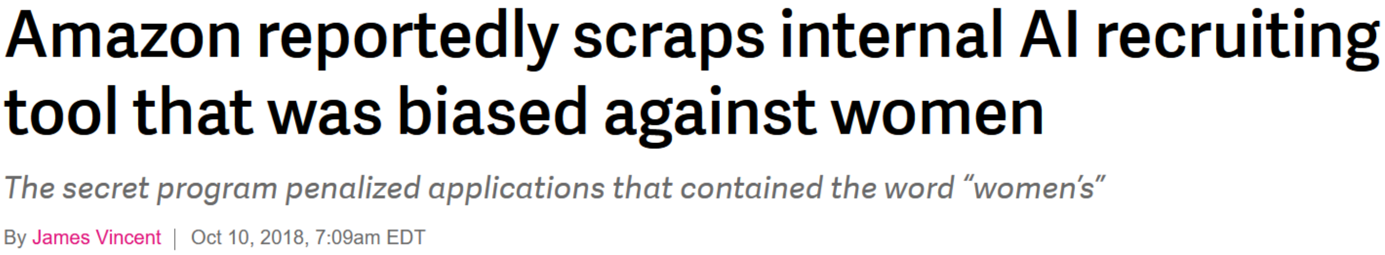
Replying to @tg_bomze

🤔🤔🤔

5:14 AM · Jun 20, 2020 · Twitter for Android

2,887 Retweets **1,192** Quote Tweets **23.1K** Likes

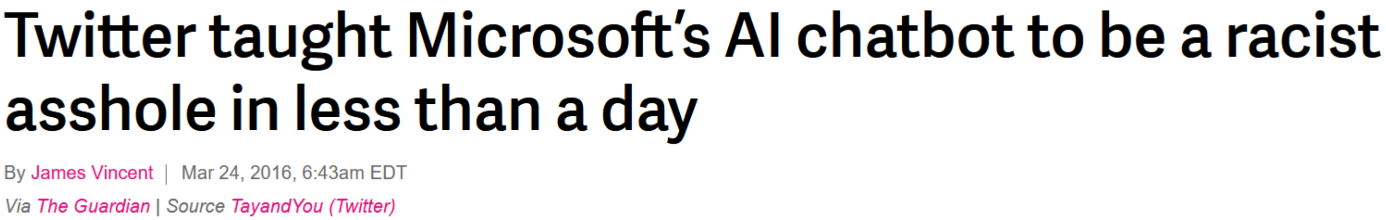
Failures of Machine Learning



Amazon reportedly scraps internal AI recruiting tool that was biased against women

The secret program penalized applications that contained the word "women's"

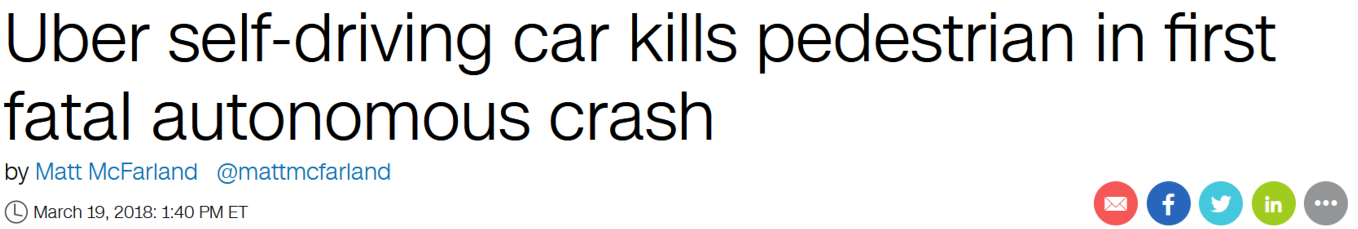
By James Vincent | Oct 10, 2018, 7:09am EDT



Twitter taught Microsoft's AI chatbot to be a racist asshole in less than a day

By James Vincent | Mar 24, 2016, 6:43am EDT

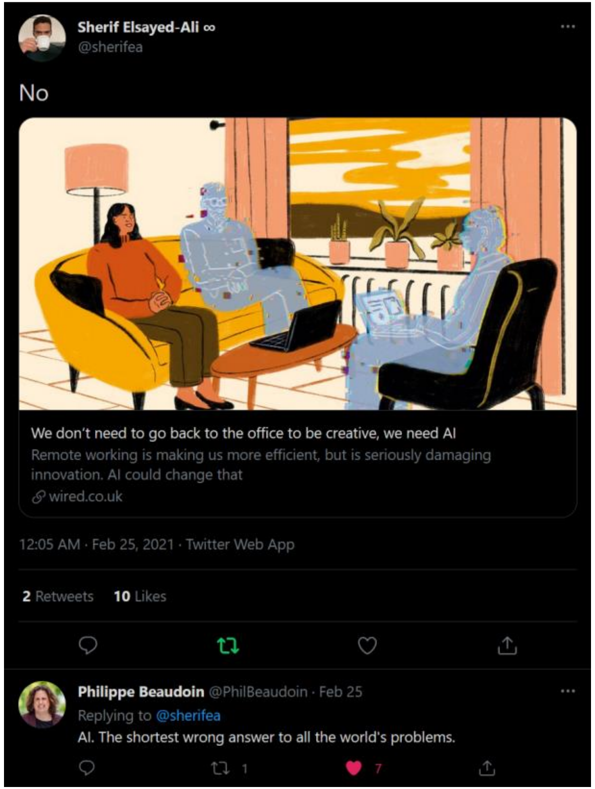
Via The Guardian | Source TayandYou (Twitter)



Uber self-driving car kills pedestrian in first fatal autonomous crash

by Matt McFarland @mattmcfarland

March 19, 2018: 1:40 PM ET



Sherif Elsayed-Ali ∞
@sherifea

No

We don't need to go back to the office to be creative, we need AI
Remote working is making us more efficient, but is seriously damaging innovation. AI could change that
wired.co.uk

12:05 AM · Feb 25, 2021 · Twitter Web App

2 Retweets **10** Likes

Philippe Beaudoin @PhilBeaudoin · Feb 25
Replying to @sherifea
AI. The shortest wrong answer to all the world's problems.

1 7

- ML/AI worship is not healthy.
- Learn how things work "under the hood", and have a healthy dose of skepticism!

Next Topic: Course Syllabus

Lectures

- All slides will be posted online (before lecture, and final version after).

- Please ask questions: you probably have similar questions to others.
  - I may deflect to the next lecture or Piazza for certain questions.

- Be warned that the course we will move fast and cover a lot of topics:
  - Big ideas will be covered slowly and carefully.
  - But a bunch of other topics won’t be covered in a lot of detail.

- Is it wrong to have only have shallow knowledge?
  - In this field, it’s better to know many methods than to know 5 in detail.
    - Different problems need different solutions.

Bonus Slides

- I will include a lot of "bonus slides".
  - May mention advanced variations of methods from lecture.
  - May overview big topics that we don't have time for.
  - May go over technical details that would derail class.

- You are not expected to learn the material on these slides.
  - But they are useful if you want to take 440 or work in this area.

- I will use this colour of background on bonus slides.

Essential Links

- Please bookmark the course webpage:
  - https://www.students.cs.ubc.ca/~cs-340/
  - Contains lecture slides, assignments, optional readings, additional notes.
- You should sign up for Piazza:
  - http://piazza.com/ubc.ca/winterterm12019/cpsc340/home.
  - Can be used to ask questions about lectures/assignments/exams.
  - May occasionally be used for course announcements.
  - Most questions should be "public" and not "private",
    I will switch viewability of generally-relevant questions to "public".
- Use Piazza instead of e-mail for questions:
  - I can take a long time to respond e-mails.
  - Please direct administrative questions and questions regarding assignment/exam accommodations to cpsc340-admin@cs.ubc.ca

Different Sections of CPSC 340

- Andreas and I are jointly teaching both sections of 340 this term.
  - Both sections have the same webpage, assignments, and exams.

- You are free to attend the lectures of the other section.
  - But do not take a seat if you are not registered and people are standing.

- We are planning to alternate weeks.
  - I am giving all lectures this week, Andreas will give all lectures next week, I will do the week after, and so on.

- We expect the AM and PM lectures to cover roughly the same set of topics.
  - At the start of the term, both sections will cover the exact same topics.
  - Later in the term, we might lecture on different topics in the AM and PM sections.
    - But you will only be tested on material that appears in both sections.

- Not that I am a research faculty and this is Andreas' first time teaching.
  - We will do our best, but may not be as effective as experienced teaching faculty.

- Next term CPSC 340 will be taught by others (probably in Python).

Videos from Previous Offering

- Following department recommendations, lectures are in-person.
  - We do not plan to record lectures or broadcast via Zoom.
- If you are sick, videos from a previous offering are available here:
  - https://www.youtube.com/playlist?list=PLWmXHcz_53Q02ZLeAxigki1JZFfCO6M-b
  - From Mike Gelbart, who is a more experience teacher we are.
  - Material is almost identical, particularly for the “testable” concepts.

CPSC 340 vs. 532M

- One section of CPSC 340 is also cross-listed as CPSC 532M.
  - For graduate students who want/need graduate credit.
- Students in CPSC 532M must do a small research project.
  - Literature survey on an ML topic not covered in class.
  - Must be done in groups of 2-3.
  - More details later.
- Grading will be slightly different:

Number	Assignments	Midterm	Final Exam	Survey
340	30	20	50	0
532M	25	15	40	20

Assignments

- There will be 6 Assignments worth 30% of final grade (for 340):
  - Usually a combination of math, programming, and very-short answer.

- Assignment 1 will be on webpage soon, and is due next Friday.
  - Submission instructions will posted on webpage/Piazza.
  - The assignment should give you an idea of expected background.
  - Make sure to submit before the deadline and check your submission.

- Start early, there is a lot there.
  - Don’t wait to see you if get off the waiting list to start.
  - You should be able to do the first few questions already.

Working in Teams for Assignments

- Assignment 1 must be done individually.

- Assignments 2-6 can optionally be done in pairs.
  - You do not need to use the same pairing for all assignments.
  - But the midterm/final will ultimately be individual.

- All the various permutations of partners are allowed:
  - Partners can be from different sections of 340.
  - One of you can be in 340 and one can be in 532M.
  - Partnering with an auditor is ok.

Programming Language: Julia

- 3 most-used languages in these areas: Python, Matlab, and R.

- We will be using Julia which is free, highly-level (like above), and fast.
  - See the list of common Julia commands on the course webpage.
  - Expected to be able to learn a programming language on your own.

- No, you cannot use Matlab/R/TensorFlow/Python/etc.
  - Assignments have prepared code: we won't translate to many languages.
  - TAs shouldn't have to know many languages to grade.

- "Is Julia Set to Take Over Python the Same Way Python Took Over JAVA?"
  - I doubt it, but languages change over time and it's useful to know several.

Late “Class” Policy for Assignments

- Assignments will be due 5 minutes before midnight on the due date.

- If you can’t make it, you can use “late classes”:
  - For example, if assignment is due on a Friday:
    - Handing it in Monday is 1 late class.
    - Handing it in Wednesday is 2 late classes.
  - There is no penalty for using “late classes”,
    but you will get a mark of 0 on an assignment if you:
    - Use more than 2 late classes on the assignment.
    - Use more than 4 late classes across all assignments.
  - If you are working in a pair, you both must have late classes remaining.

- We will try to put up grades within 10 days of final late class.
  - You see the solutions by coming to TA/instructor office hours.
  - We are not releasing solutions anymore (too much time spent taking them down).

Midterm and Final

- Midterm worth 20% and a (cumulative) final worth 50%
  - Closed-book.
  - One doubled-sided 'cheat sheet' for midterm, two doubled-sided pages for final.
  - No need to pass the final to pass the course (but recommended).

- Midterm is scheduled for 6:30pm October 24th in IRC 2.
  - Let us know if you have a conflict that cannot be resolved.
- I don't control when the final is, don't make travel plans before December 22nd.
  - If it's scheduled early, we may restrict the number "late classes" for the last assignment.

- There will be two types of questions:
  - 'Technical' questions requiring things like pseudo-code or derivations.
    - Similar to assignment questions, and will only be related topics covered in assignments.
  - 'Conceptual' questions testing understanding of key concepts.
    - All lecture slide material except "bonus slides" is fair game here.

Reasons NOT to take this class

- Compared to typical CS classes, there is a lot more math:
  - Requires linear algebra, probability, and multivariate calculus (at once).
  - "the prerequisites for this course should require that students have obtained at least 75% (or around there) in the required math courses … I felt severely under prepared and struggled immensely in this course, especially seeing that I have taken CPSC courses in the past with similar math requirements"
- If you've only taken a few math courses (or have low math grades), this course will ruin your life for the next 4 months.
- It's better to improve your math, then take this course later.
  - A good reference covering the relevant math is here (Chapters 1-3 and 5-6).

Reasons NOT to take this class

- This is not a class on “how to use scikit-learn or TensorFlow or PyTorch”.
  - You will need to implement things from scratch, and modify existing code.
- Instead, this is a 300-level computer science course:
  - You are expected to be able to quickly understand and write code.
  - You are expected to be able to analyze algorithms in big-O notation.
- If you only have limited programming experience,
  this course will ruin your life for the next 4 months.
- It’s better to get programming experience, then take this course later.
  - Take CPSC 310 and/or 320 instead, then take this course later.

Reasons NOT to take this class

- Do NOT take this course expecting a high grade with low effort.

- Many people find the assignments very long and very difficult.
  - You will need to put time and effort into learning new/difficult skills.
  - If you aren’t strong at math and CS, they may take all of your time.

- From “Rate My Professors”:
  - “Lectures were dull, dry, and glossed over the material skipping over the theoretical details. Ironically, assignments were detail-heavy and LONG. Doesn't seem to care about students because some of us have 4 other classes and well, if they're all like this course, my girlfriend would have broken up with me two months ago.”

CPSC 330 vs. CPSC 340

- There is a less-advanced ML course, CPSC 330:
  - "Applied Machine Learning".
  - 330 emphasizes "when to use" tools, 340 emphasizes "how they work".
    - 330 is more like the Coursera course and online courses.

  - Fewer prerequisites and more emphasis "learning by doing".
    - 330 spends more time on low-level coding details and has basically no equations.
    - 330 spends more time on data cleaning, communicating results, and so on.

  - You can take both for credit (better to take 330 first or at same time).

CPSC 340 vs. CPSC 440

- There is also a more-advanced ML course, CPSC 440:
  - “Advanced machine Learning”: starts where this course ends.
  - More focus on theory/implementation, less focus on applications.
  - More prerequisites and higher workload (330 cannot be used as a prereq).

- For almost all students, take CPSC 340 first:
  - CPSC 330/340 focus on the most widely-used methods in practice.
    - It covers much more material than standard ML classes like Coursera.
  - CPSC 440 focuses on less widely-used methods and research topics.
    - It is intended as a continuation of CPSC 340.
    - You will miss important topics if you skip CPSC 340.
      - “I am familiar with ML from my research/company so I can skip CPSC 340” – someone who is wrong.

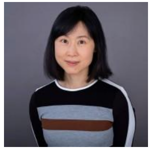
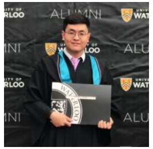
Waiting List and Auditing

- Right now only CS students can register directly.
  - All other students need to sign up for the waiting list to enroll.
- We're going to start registering people from the waiting list.
  - Being on the waiting list is the only way to get registered:
    - https://www.cs.ubc.ca/students/undergrad/courses/waitlists
  - You might be registered without being notified, be sure to check!
    - They might also ask to submit a prereq form, let me know if you have issues.
- Because the room is full, we may not have seats for auditors.
  - If there is space, I'll describe (light) auditing requirements then.

Getting Help

- There are many sources of help:
  - TA office hours and instructor office hours.
    - Starting in the second week of class.
    - Times will be posted on the course webpage.
  - Piazza (for general questions).
  - Weekly tutorials (optional).
    - Starting in second week of class.
    - Will go through provided code, review background material, review big concepts, and/or do exercises.
  - Other students (ask your neighbor for their e-mail).
  - The web (almost all topics are covered in many places).

TA Cheat Sheet

- Daniel Alisafe
- Curtis Fox
- Ruiyu Gou
- Lironne Kurzman
- Frederik Kunstner
- Alan Miligan
- Justin Rahardjo
- Betty Shea 
- Xin Ping Shi
- Chenwei Zhang 
- Tianyue Zhang

Cheating and Plagiarism

- Read about UBC’s policy on “academic misconduct” (cheating):
  - http://www.calendar.ubc.ca/Vancouver/index.cfm?tree=3,54,111,959

- When submitting assignments, acknowledge all sources:
  - Put “I had help from Sally on this question” on your submission.
  - Put “I got this from another course’s answer key” on your submission.
  - Put “I copied this from the Coursera website” on your submission.
  - Otherwise, this is plagiarism (course material/textbooks are ok with me).

- At Canadian schools, this is taken very seriously.
  - Automatic grade of zero on the assignment.
  - Could receive 0 in course, be expelled from UBC, or have degree revoked.
  - We have actually given 0 to people before.

Code of Conduct

- Do not post offensive or disrespectful content on Piazza.
- If you have a problem or complaint, let me know.
  - Maybe we can fix it.
- Do not distribute any course materials without permission.
  - For example, do not post your solutions to the internet.
- Do not record lectures without permission.

- Think about how/when to ask for help:
  - Don't ask for help after being stuck for 10 seconds. Make a reasonable effort to solve your problem (check instructions, Piazza, and Google).
  - But do not wait until the 10th hour of debugging before asking for help.
    - If you do, the assignments could take all of your time.

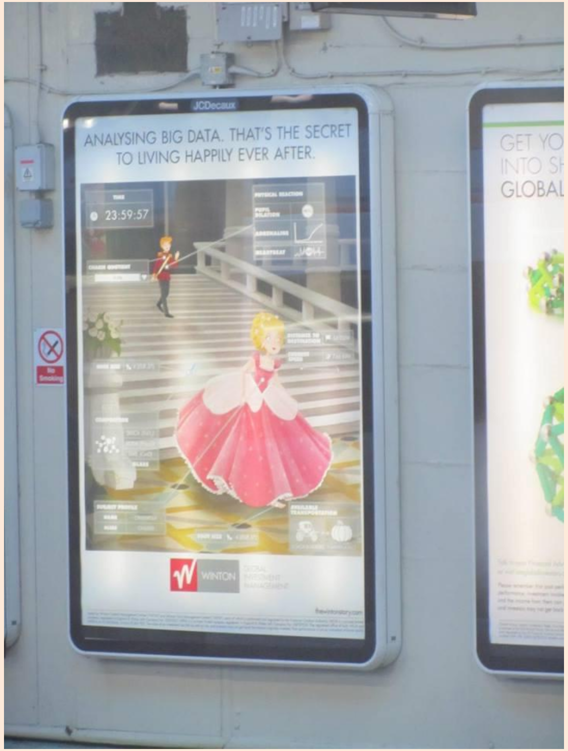
Course Outline

- Next class discusses “exploratory data analysis”.

- After that, the remaining lectures focus on five topics:
  1) Supervised Learning.
  2) Unsupervised learning.
  3) Linear prediction.
  4) Latent-factor models.
  5) Deep learning.

- “What is Machine Learning?” (overview of many class topics)

Photo I took in the UK on the way home from the “Optimization and Big Data” workshop:


JCDecaux
ANALYSING BIG DATA. THAT'S THE SECRET TO LIVING HAPPILY EVER AFTER.
23:59:57
WINTON
GLOBAL INVESTMENT MANAGEMENT
thewintonstory.com
No Smoking
GET YO
INTO SH
GLOBAL

Less-inspirational quote: “Without data you're just another person with an opinion.” W.E. Deming

This is the end of the lecture.
(Future lectures will end on a “Summary” slide.)

The slides after the “Summary” slide are typically “bonus” material related to the topics of the lecture.

Bonus Slide: “Machine Learning” vs. “Data Minig”

- Machine learning and data mining have many similarities (as do other fields like statistics and signal processing), and the similarity is increasing due to the 'arXiv' effect (people from both fields can now easily read each other's papers and are using standard notation).
- However, as a subjective answer I would say that the focuses are different. Data mining is broader in scope and includes things like how to organize data, models that simply look up answers or are based on counting (KNN and naive Bayes are also often covered in data mining, and in data mining there is a greater focus on interpretable models), and tasks like information visualization. Machine learning is more narrow, focusing largely on the modeling aspect, generalization error, and using methods that rely on numerical optimization or high-dimensional integration (that may not necessarily be interpretable).
- Another subjective comment would be that data mining often focuses on tools that help professionals analyze their data, while machine learning often focuses on automating data analysis. For example, here is a recent very-interesting project by some machine learning folks from Cambridge and MIT:
  - http://www.automaticstatistician.com

Textbooks

- No required textbook.

- I’ll post relevant sections out of these books as optional readings:
  - Artificial Intelligence: A Modern Approach (Rusell & Norvig).
  - Introduction to Data Mining (Tan et al.).
  - The Elements of Statistical Learning (Hastie et al.).
  - Mining Massive Datasets (Leskovec et al.)
  - Machine Learning: A Probabilistic Perspective (Murphy).
- Most of these are on reserve in the ICICS reading room.
- List of related courses on the webpage, or you can use Google.

Assignment Issues

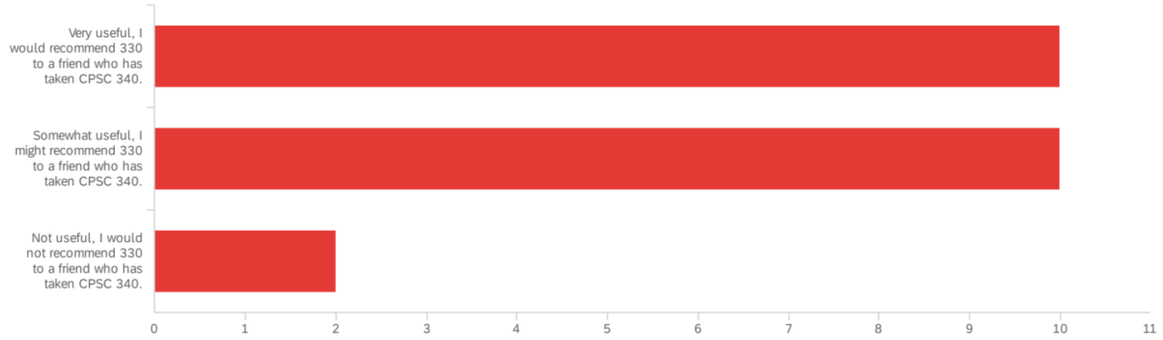
- No extensions will be considered beyond the late days.
  - Also, since you can submit more than once, you have no excuse not to submit something preliminary by the deadline.

- Further, due to grouchiness, these issues are a 50% penalty:
  - Missing names or student IDs on assignments.
  - Submitting the wrong assignment or corrupted files.
  - Not including answers in the correct location in the .pdf file.

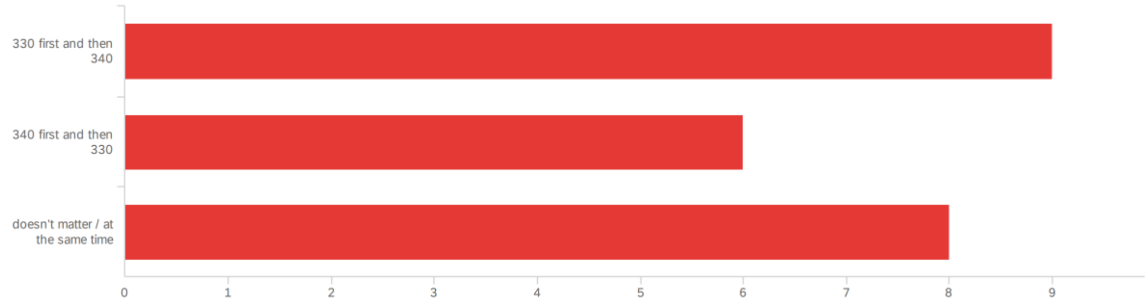
Tentative Course Schedule

- First class: Sep 7
- Assignment 1 due: Sep 16 (Friday of week 2)
- Drop deadline: Sept 19 (Monday of week 3)
- Assignment 2 due: Sep 30 (Friday of week 4)
- Assignment 3 due: Oct 14 (Friday of week 6)
- Midterm: Oct 24 (Monday of week 8)
- Assignment 4 due: Nov 7 (Monday of week 10)
- Assignment 5 due: Nov 23 (Wednesday of week 12)
- Assignment 6 due: Dec 7 (Wednesday of week 14, last day of class)
- Final: random day decided by UBC, sometime between Dec 11 and 22

Q4 - Please rate how useful CPSC 330 was to you as someone who has taken CPSC 340.



Q5 - Which order of the courses do you think makes more sense for a student who ultimately takes both courses?


330 first and then 340
340 first and then 330
doesn't matter / at the same time