

Statistics and Data Science 265

# **Introductory Machine Learning**

Thursday, September 1

**Yale**

# Outline

- Overview of course
- Perspectives on ML (and AI)
- Syllabus and logistics
- Questions

# **Course objectives**

Gain understanding of and experience with basic machine learning methodology

# Course objectives

- Gain some new perspective
- Appreciate some of the power and limitations of ML
- Have fun
- Want to learn more

## Related course

- This course introduced for Certificate in Data Science
- Intended to be accessible intro to ML for wide range of students
- S&DS 365 (grad number 665) will become a new course “Intermediate Machine Learning” last spring. Can be taken as a follow up course; more technical and in-depth
- Happy to chat if unclear this course is right for you

# Common questions

“What’s the difference between AI and Machine Learning?”

“Is Deep Learning the same as Machine Learning?”

“What’s the difference between Statistics and Machine Learning?”

August 31, 1955

John McCarthy, Marvin L. Minsky, Nathaniel Rochester,  
and Claude E. Shannon

A Proposal for the

DARTMOUTH SUMMER RESEARCH PROJECT ON ARTIFICIAL INTELLIGENCE

*June 17 - Aug. 16*

We propose that a 2 month, 10 man study of artificial intelligence be carried out during the summer of 1956 at Dartmouth College in Hanover, New Hampshire. The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it. An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves. We think that a significant advance can be made in one or more of these problems if a carefully selected group of scientists work on it together for a summer.

SUNDAY, OCTOBER 19, 1958

## MACHINE TO COPY BRAIN'S METHODS

Huge Computer in London  
to 'Think' Like a Person  
for Study of Learning

Special to The New York Times.

LONDON, Oct. 15—Investigators in neurology at University College here are building a massive automatic computer for the principal purpose of testing theories about the learning capacity of the brain.

The machine will "think"; that is, it will scan shapes such as the letters of the alphabet and simple words and after analyzing and absorbing this visual information it will "say" (through a loudspeaker) what it has seen at precisely the same rate as that of a fairly intelligent human subject.

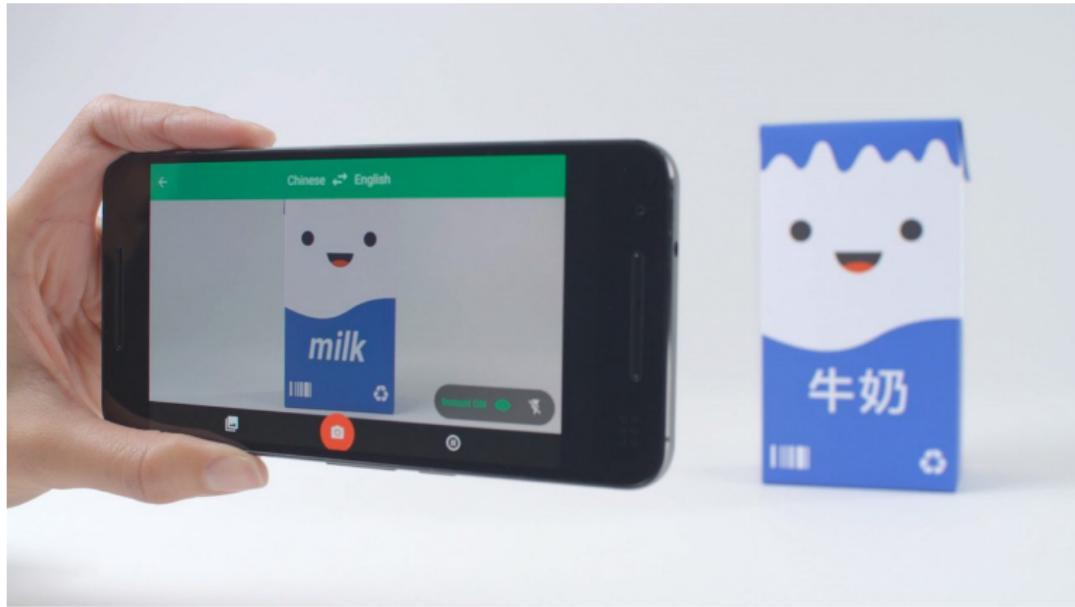
This is being achieved by



# Today: Home assistants



# Translation



<http://www.sciencemag.org/>

# Pricing and recommending homes

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CIO JOURNAL



## Zillow Develops Neural Network to 'See' Like a House Hunter

Granite or stainless steel countertops? Zillow's visual recognition effort can recognize the difference

By **SARA CASTELLANOS**

Nov 11, 2016 3:29 pm ET

Data scientists at Zillow Group are developing complex computer programs that detect specific attributes in photographs of homes, which could aid in estimating their value. Advances in deep learning, big data and cloud computing have converged to allow the online real estate database firm and others to develop technology that mimics how the human brain [...]

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### Recommended Videos

1. Film Clip: Pirates of the Caribbean: Dead Men Tell No Tales'



2. What to do in your 40s to retire a millionaire



<https://blogs.wsj.com/cio/2016/11/11/zillow-develops-neural-network-to-see-like-a-home-buyer/>

# Email suggestions

The screenshot shows a user interface for composing an email. A dark gray rectangular box is overlaid on the main content area, containing the text "Taco Tuesday". This box is positioned above a list of suggested subjects. The background shows a partially visible email message from Jacqueline Bruzek, which includes the subject "Taco Tuesday" and a greeting "Hey Jacqueline," followed by a message about not seeing her for a while.

Taco Tuesday

Jacqueline Bruzek x

Taco Tuesday

Hey Jacqueline,

Haven't seen you in a while and I hope you're doing well.

SUBSCRIBE

<https://www.youtube.com/watch?v=nZ-C8I-8BZw&t=0m16s>

# YouTube



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Amazing ways YouTube uses ML and AI: <https://www.forbes.com/sites/bernardmarr/2019/08/23/the-amazing-ways-youtube-uses-artificial-intelligence-and-machine-learning>

# YouTube

- Each month: 1.9 billion users
- Each day: 1 billion hours of video watched
- Each minute: 300 hours of video uploaded
- ML: Automatically remove objectionable content
- ML: “Up Next” feature

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Amazing ways YouTube uses ML and AI: <https://www.forbes.com/sites/bernardmarr/2019/08/23/the-amazing-ways-youtube-uses-artificial-intelligence-and-machine-learning>

# Translation

HOME > SPORTS

## A Belarusian Olympian who complained about her coaches used Google Translate to relay her plea for help to Japanese police

Lauren Fries Aug 5, 2021, 6:46 PM



Belarusian Olympic sprinter Krystsina Tsimanouskaya said she was taken to the airport against her wishes and would not return home. Reuters

With a zero trust strategy, C you're in the driver's seat

See how →

IBM

# More translation

A close-up photograph of a small, hairless naked mole rat being held gently by a person wearing a pair of blue nitrile gloves. The mole rat is positioned horizontally, facing towards the right. The background is a dark, textured surface, possibly a curtain or wall.

The New York Times

## *The Animal Translators*

Scientists are using machine learning to eavesdrop on naked mole rats, fruit bats, crows and whales — and to communicate back.

# More translation

## *The Animal Translators*

Scientists are using machine learning to eavesdrop on naked mole rats, fruit bats, crows and whales — and to communicate back.

# What is Machine Learning?

The study of algorithms and statistical models to develop computer programs that improve with experience.

# What is Machine Learning?

Machine Learning is closely aligned with Statistics, but with a focus on computation, scalability, prediction, representation, and complex problems

- Speech recognition
- Machine translation
- Object recognition and scene classification
- Autonomous driving...

Subproblems of these and other complex problems are concrete, statistical estimation and inference problems that can be studied in isolation.

# AI vs. ML

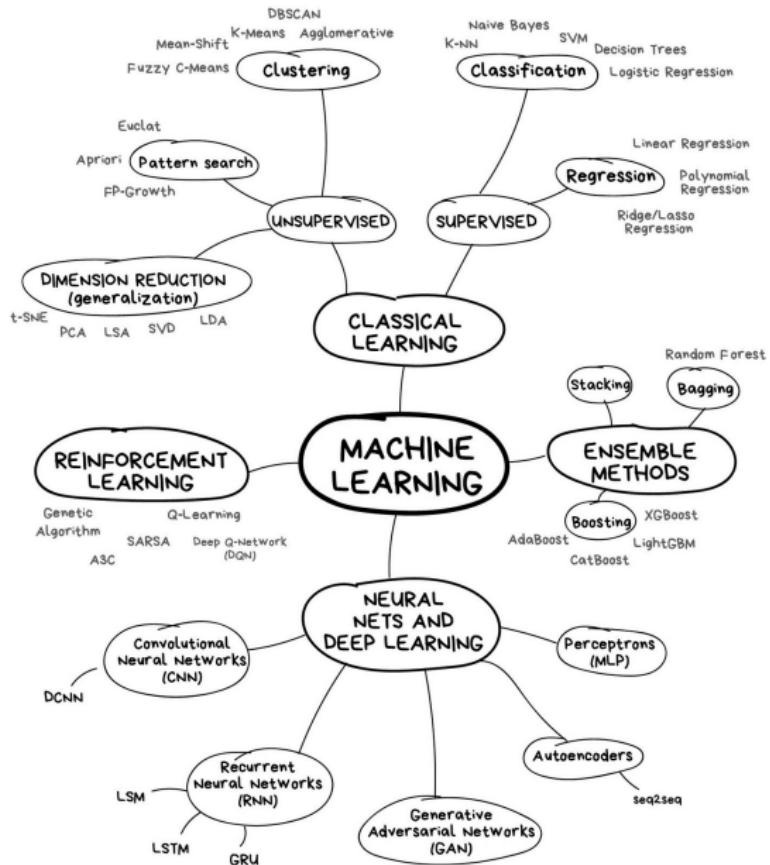
Machine learning focuses on making predictions and inferences from data.

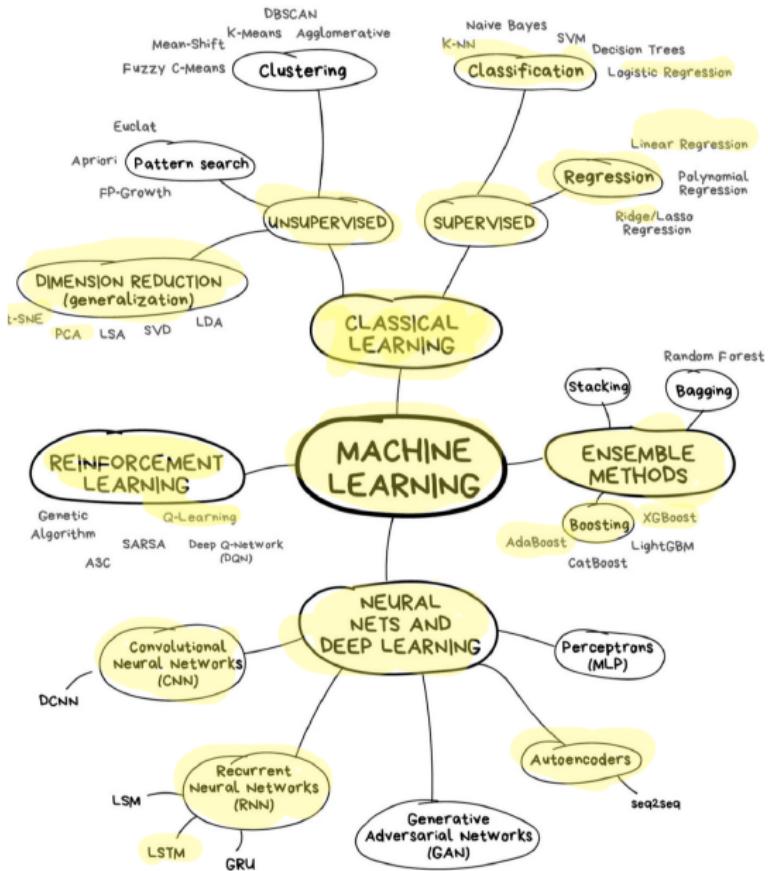
AI combines machine learning components into a larger system that includes a decision making component.

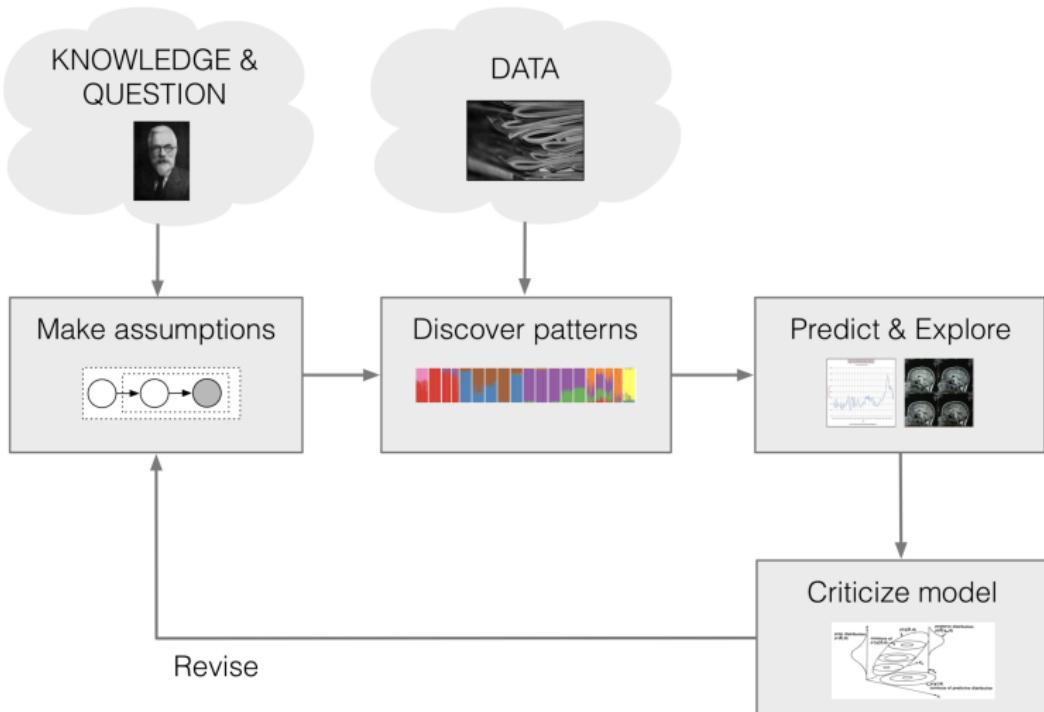
*An AI system exhibits a behavior, resulting from the collective decisions that are made.*

# Machine learning frameworks

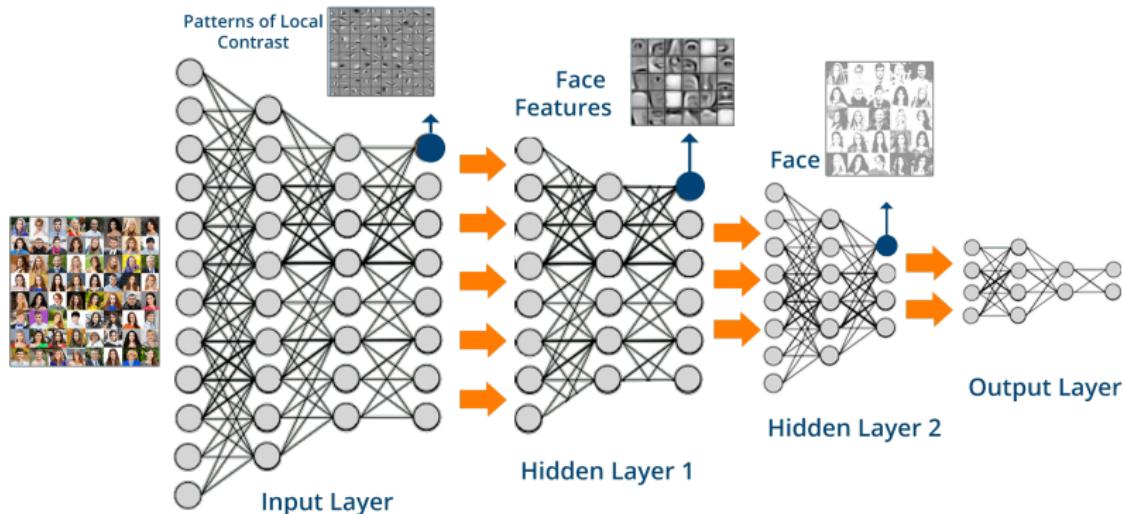
- Supervised, unsupervised, semi-supervised
- Reinforcement learning
- Generative vs. discriminative models
- Representation learning







# Deep learning is a type of machine learning



- Heuristics motivated from simplified view of the brain
- A particular form of nonlinear classification/regression
- Not well-suited to latent variables

# Culture of Code

- Great deal of current AI/ML work is purely engineering based
- Informal input/output reasoning

*“that program gave this output...  
maybe this program will give that output”*

- Deep learning software engineers develop sophisticated intuitions
- The code is the product

THIS IS YOUR MACHINE LEARNING SYSTEM?

YUP! YOU POUR THE DATA INTO THIS BIG  
PILE OF LINEAR ALGEBRA, THEN COLLECT  
THE ANSWERS ON THE OTHER SIDE.

WHAT IF THE ANSWERS ARE WRONG?

JUST STIR THE PILE UNTIL  
THEY START LOOKING RIGHT.



xkcd.com/1838

# Latent variables: The elephants in the room



# DALL·E 2



DALL·E 2 is a new AI system that can create realistic images and art from a description in natural language.



- [▶ JOIN WAITLIST](#)
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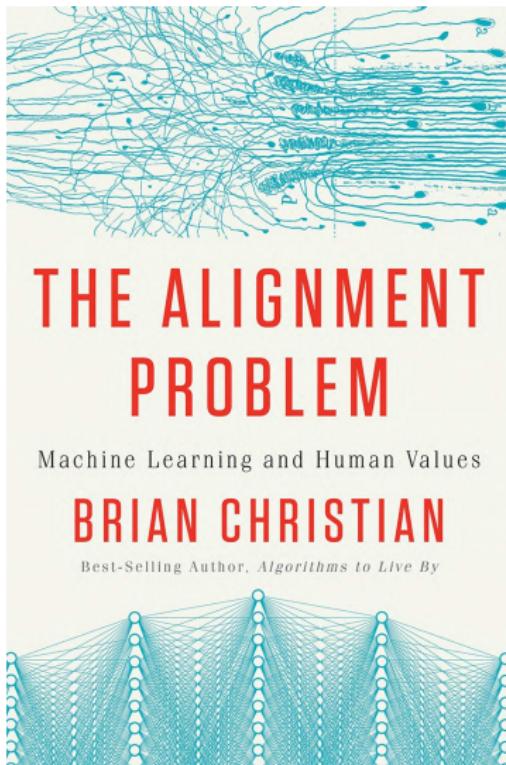
## DALL·E Now Available in Beta

We'll invite 1 million people from our waitlist over the coming weeks. Users can create with DALL·E using free credits that refill every month, and buy additional credits in 115-generation increments for \$15.

[JOIN DALL·E 2 WAITLIST ➞](#)

July 20, 2022  
3 minute read





# **Example of representation learning: Word embeddings**

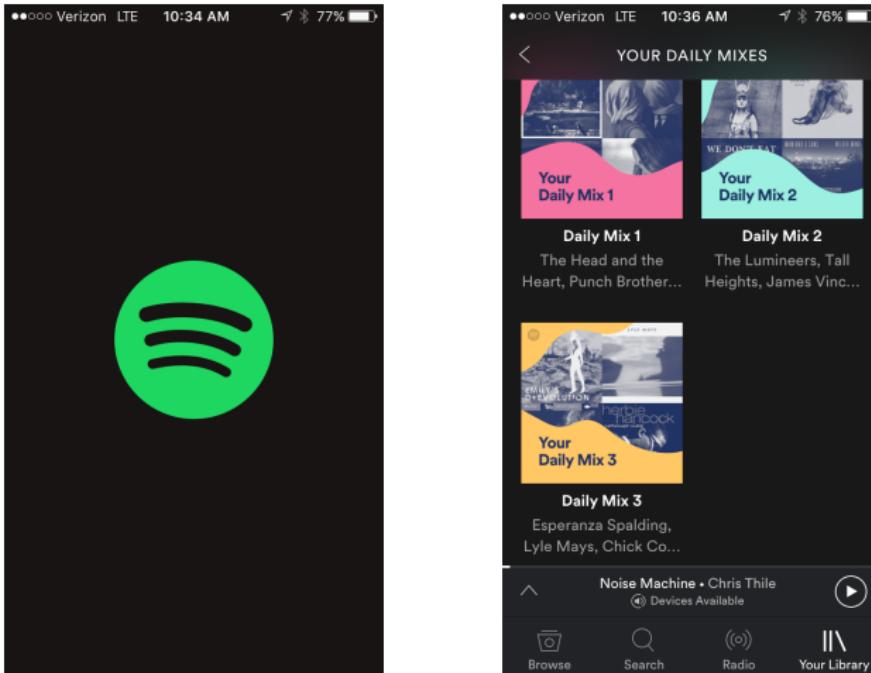
- Each word in vocab is mapped to 100 or 500 dimensional vector
- Based solely on co-occurrence statistics in corpus of text

# Example of representation learning: Word embeddings

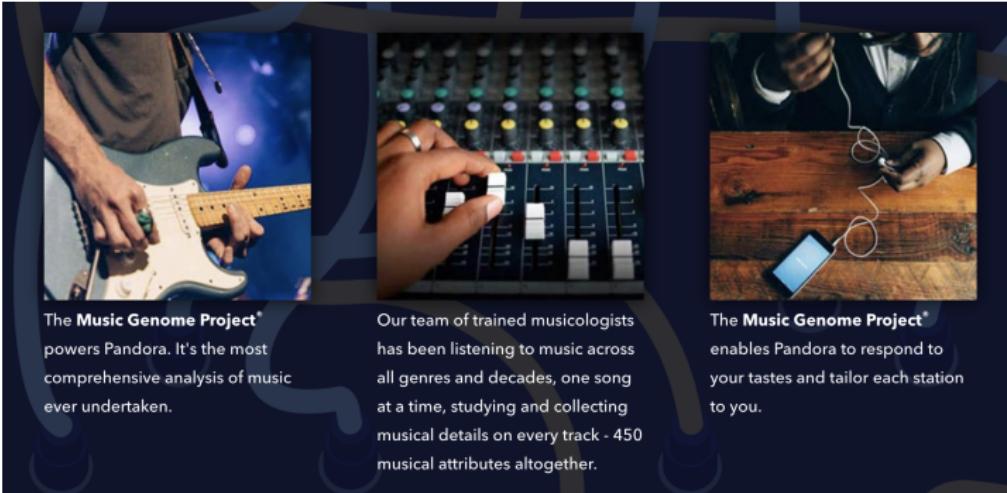
Yale:

```
[ 0.78310001, 0.51717001, -0.38207 , -0.23722 , -0.31615999, 0.30805001, 0.76389998, 0.064106 , -0.74913001,  
 0.60585999, -0.23871 , -0.16876 , -0.25634 , 1.07270002, -0.29967999, 0.020095 , 0.54500997, -0.17847 , -0.26675999,  
 -0.11798 , -0.48692 , 0.22712 , 0.017473 , -0.4747 , 0.44861001, -0.084281 , -0.30412999, -1.13510001, -0.14869 , -0.11182 ,  
 -0.32530001, 1.0029 , -0.35742 , 0.35148999, -1.10679996, -0.064142 , -0.72284001, 0.14114 , -0.41247001, -0.16184001,  
 -0.54576999, -0.12958001, -0.88356 , -0.089722 , 0.10555 , -0.12288 , 0.92851001, 0.50032002, 0.1349 , 0.21457 ,  
 0.35073999, -0.73132998, 0.39633 , -0.43239999, -0.38815999, -1.34669995, 0.37463999, -0.79386002, 0.11185 , 0.18007 ,  
 -0.75142998, 0.24975 , -0.094948 , -0.36341 , 0.24869999, -0.22667 , 0.32289001, 1.29489994, 0.42658001, 1.29120004,  
 -0.13954 , 0.68976003, 0.21586999, 0.13715 , -1.00919998, 0.028827 , 0.11011 , -0.1912 , -0.073198 , -0.52449 , 0.49199 ,  
 0.14463 , -0.18844 , -0.75536001, -0.28704 , 0.019113 , 0.30349001, -0.74425 , -0.072221 , -0.40647 , 0.26899001, -0.28318  
, 0.72409999, 0.50796002, -0.37845999, -0.13008 , -0.13808 , 0.098928 , 0.16215999, 0.16293 ]
```

# Embeddings for music recommendations



# Experts vs. Data: The case of Pandora vs. Spotify



The Music Genome Project\* powers Pandora. It's the most comprehensive analysis of music ever undertaken.

Our team of trained musicologists has been listening to music across all genres and decades, one song at a time, studying and collecting musical details on every track - 450 musical attributes altogether.

The Music Genome Project\* enables Pandora to respond to your tastes and tailor each station to you.

- Pandora's "Music genome": Over 450 musical attributes
- Melody, harmony, rhythm, form, composition, lyrics...

<https://arstechnica.com/tech-policy/2011/01/digging-into-pandoras-music-genome-with-musicologist-nolan-gasser/>

# Experts vs. Data: The case of Pandora vs. Spotify

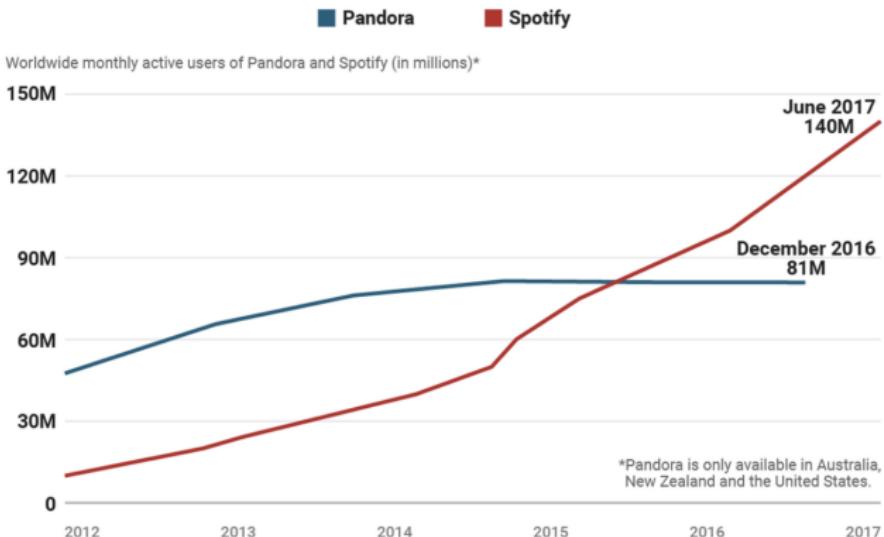


*Spotify: Word embeddings trained from playlists*

# Experts vs. Data: The case of Pandora vs. Spotify

TECH ■ CHART OF THE DAY

## PANDORA'S GROWTH STALLS AS SPOTIFY PULLS AHEAD



SOURCE: Company filings/announcements

BUSINESS INSIDER

# Hacking ML Systems

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TESLA AUTOPILOT —

## Researchers trick Tesla Autopilot into steering into oncoming traffic

Stickers that are invisible to drivers and fool autopilot.

DAN GOODIN - 4/1/2019, 8:50 PM

Keen Security Lab



# Machine learning at a large Internet company

- Typical project lifetime: 6 months to 1 year
- Ads projects involve thousands of software engineers
- Often adding new “feature” to existing black box model
- No single person understands entire model
- Not interpretable
- Users are hashed; employees don’t have access to friends’ data

# Reasons for optimism

- Increasingly part of academic research across disciplines
- Engaging a broad community
- We're still in very early stages

**Questions or discussion?**

# Team

- Instructor  
John Lafferty
- Teaching Fellows  
Zhehao Xu (PhD student in S&DS)  
Hannah Wang (Graduate student, School of the Environment)  
Wendy Luo (Graduate student, Biomedical Engineering)
- ULAs  
Yuxuan Geng, Lucas Zheng, Jacob Alvarado, Edward Hu, Kaitlin Flores, Mofeed Nagib, Teckhua Chiang
- Course manager  
Hanwen Gu

# Course materials

Materials posted to <http://introml.ydata123.org>; sometimes to Canvas

Please use Ed Discussion for any questions about lectures, homework, etc. first, before email!

## For email

- For logistical issues (e.g. adding to Canvas): E-mail Hanwen Gu; copy me and TAs
- All other: E-mail me, copy TAs

# Syllabus

*Introductory Machine Learning* covers the key ideas and techniques in machine learning without the use of advanced mathematics. Basic methodology and relevant concepts are presented in lectures, including the intuition behind the methods and a more formal understanding of how and why they work. Assignments give students hands-on experience with the methods on different types of data.

# Syllabus

Topics include linear regression and classification, tree-based methods, topic models, word embeddings, recurrent neural networks, deep learning and reinforcement learning. Examples come from a variety of sources including political speeches, archives of scientific articles, real estate listings, natural images, and several others. Programming is central to the course, and is based on the Python programming language.

# Prerequisites

- At least two of the following courses: S&DS 230, 238, 240, 241 and 242
- Previous programming experience (e.g., R, Matlab, Python, C++), Python preferred. The course will make extensive use of Python programming, using Jupyter notebooks.

# Installing Jupyter

- See installation guide on course Canvas site: Files > Getting started
- Use Python 3.x version

# Course goals

Gain understanding of and experience with basic machine learning methodology

# Course goals

- Gain some new perspective
- Appreciate some of the power and limitations of ML
- Have fun
- Want to learn more

# Evaluation

- Six assignments (50%)
- Mid-semester exam (20%)
- Six quizzes (10%)
- Final exam: 20%

Lowest assignment score will be dropped. Late assignments not accepted.

# Assignments

- Roughly every two weeks
- Due at midnight (11:59pm), typically Thursdays
- Submitted using Gradescope
- Mix of problem solving and data analysis
- Prepared using Python notebooks

# Collaboration

Collaboration on homework assignments with fellow students is encouraged. However, such collaboration should be clearly acknowledged, by listing the names of the students with whom you have had any discussions concerning the problem. You may *not* share written work or code—after discussing a problem with others, the solution must be written by yourself.

Week	Dates	Topics	Demos & Tutorials	Lecture Slides	Readings and Notes	Assignments & Exams
1	Sept 1	Course overview		Sept 1: Course overview		
2	Sept 6, 8	Python and background concepts	CO Python elements CO Covid trends	Sept 6: Python elements Sept 8: Pandas and linear regression	Data8 Chapters 3, 4, 5	Thu: Quiz 1
3	Sept 13, 15	Linear regression and classification	CO Covid trends (revisited) CO Classification examples	Sept 13: Regression concepts Notes on regression Sept 15: Classification	Notes on classification	Thu: CO Assn1 out
4	Sept 20, 22	Stochastic gradient descent	CO SGD examples	Sept 20: Classification (continued) Sept 22: Stochastic gradient descent		Thu: Quiz 2
5	Sept 27, 29	Bias and variance, cross-validation	CO Bias-variance tradeoff CO Covid trends (revisited) CO California housing	Sept 27: Bias and variance Sept 29: Cross-validation		Thu: Assn 1 in CO Assn2 out
6	Oct 4, 6	Tree-based methods	CO Trees and forests Visualizing trees	Oct 4: Trees Oct 6: Forests		Thu: Quiz 3
7	Oct 11, 13	PCA and dimension reduction	CO PCA examples CO PCA revisited CO Used for regression	Oct 11: PCA Oct 13: PCA and review		Thu: Assn 2 in CO Assn3 out

9	Oct 25, 27	Language models, word embeddings	<a href="#">Word embeddings</a>	Oct 25: Language models Oct 27: Word embeddings		Thu: Assn 3 in <a href="#">Assn4 out</a>
10	Nov 1, 3	Bayesian inference, topic models	<a href="#">Mixtures</a> <a href="#">Bayesian inference</a> <a href="#">Topic models</a>	Nov 1: Bayesian inference Nov 3: Bayes and topic models	<a href="#">Notes on Bayesian inference</a> <a href="#">Notes on simulation</a>	Thu: Quiz 4
11	Nov 8, 10	Introduction to neural networks	<a href="#">Minimal neural network</a> <a href="#">Regression examples</a>	Nov 8: Topic models Nov 10: Neural networks		Thu: Assn 4 in <a href="#">Assn5 out</a>
12	Nov 15, 17	Deep neural networks	<a href="#">Tensorflow playground</a> <a href="#">Autoencoder examples</a>	Nov 15: Neural networks (continued) Nov 17: Autoencoders	<a href="#">Notes on backpropagation</a>	Thu: Quiz 5
13	Nov 22, 24	No class, Thanksgiving break				
14	Nov 29, Dec 1	Reinforcement learning	<a href="#">Q-learning</a>	Nov 29: Reinforcement learning Dec 1: Deep reinforcement learning		Thu: Assn 5 in <a href="#">Assn 6 out</a>
15	Dec 6, 8	Societal issues for machine learning		Dec 6: Societal issues Dec 8: Course wrap up		Thu: Quiz 6
16	Dec 15					Thu: Assn 6 in
		Mon, Dec 19, 7pm	Final exam		<a href="#">Registrar: Final exam schedule</a> <a href="#">Practice final, sample solution</a>	

# Auditing

- Auditors are welcome!
- Full access to Canvas
- Just expected to regularly attend class

# **Questions?**