

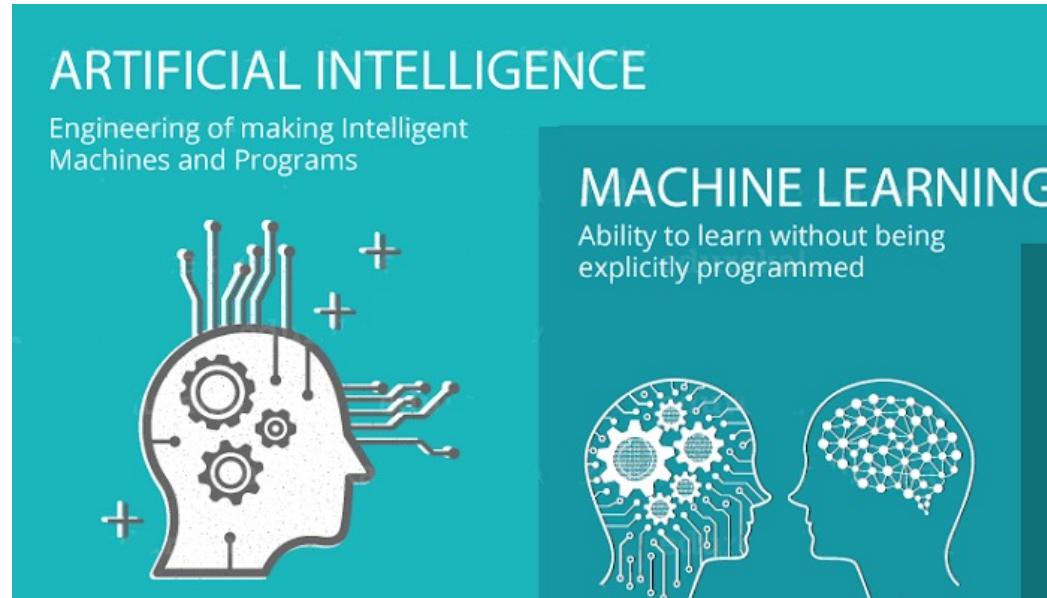
What is this course about?

Artificial Intelligence

The science and engineering of making intelligent machines, especially intelligent computer programs. (John McCarthy)

Machine Learning

- an application of artificial intelligence (AI) that provides systems the ability to automatically learn and improve from experience without being explicitly programmed
- **Learn from data!**



Learning outcomes

The objectives of this course are as follows:

1. Gain an appreciation of the role that Machine Learning plays in enhancing the decision-making process.
2. Gain an understanding of the fundamental concepts that underpin all Machine Learning techniques, namely, supervised learning, unsupervised learning.
3. Gain an understanding of the strengths and weaknesses of many popular machine learning approaches.
4. Be able to design and implement various machine learning algorithms in a range of real-world applications.
5. Gain knowledge about some best practices in innovation as it pertains to machine learning and AI.

Lecture 01

What is Machine Learning (ML)?

Making the computers perform the intelligent tasks you performed is

Artificial Intelligence

Learning to perform these tasks using existing data is called

Machine Learning

In short, Machine Learning is learning from **DATA**

What is ML?

Traditional Programming



Machine Learning



What is ML?



Apples



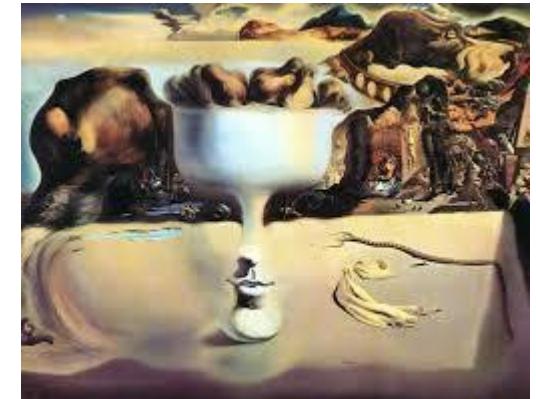
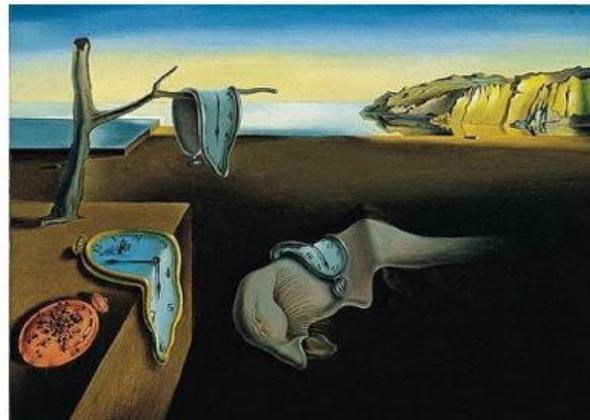
Pears

What is ML?

Apple or pear?



What is ML?



What is ML?

Who painted this?



What is ML?

Who painted this?



What is ML?

How many types of apples are there?



What is ML?

Pick the odd one out



What is ML?

Pick the odd one out



What is ML?

Predict the series

1, 1, 2, __, 5, 8, __, 21,

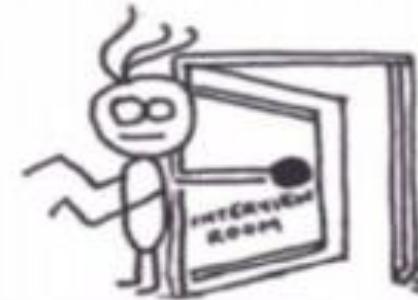
What is ML?

When you interview a data scientist...

WOW! YOU ANSWERED
EVERY QUESTION
PERFECTLY. HOW
DID YOU DO THAT?



WELL, I MET WITH EVERY
CANDIDATE YOU INTERVIEWED
IN LAST 5 YEARS AND
COLLECTED THE QUESTIONS &
CORRELATED IT TO INTERVIEW
PARAMETERS.



THEN I BUILT A SYSTEM THAT
PREDICTS THE EXACT QUESTION
YOU'RE GOING TO ASK WITH 85%
PRECISION



WOW! THAT IS
IMPRESSIVE
ENGINEERING BUT
I CAN'T HIRE YOU
ON ETHICAL
GROUNDS

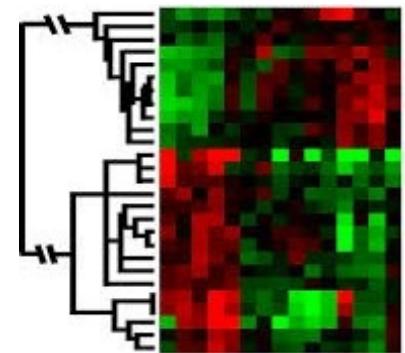
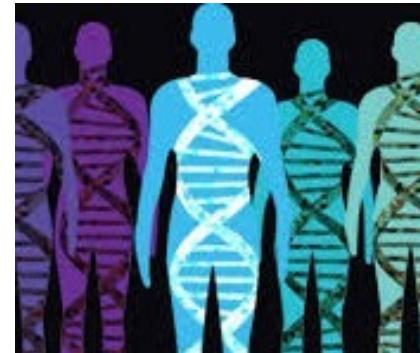
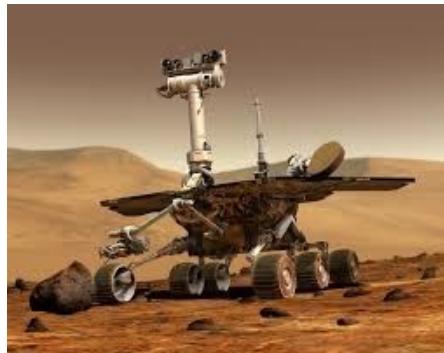


DON'T WORRY. I WAS
JUST FIELD TESTING MY
PREDICTION SYSTEM



When Do We Use ML?

- ML is used when:
- Human expertise does not exist (navigating on Mars)
- Humans can't explain their expertise (speech recognition)
- Models must be customized (personalized medicine)
- Models are based on huge amounts of data (genomics)

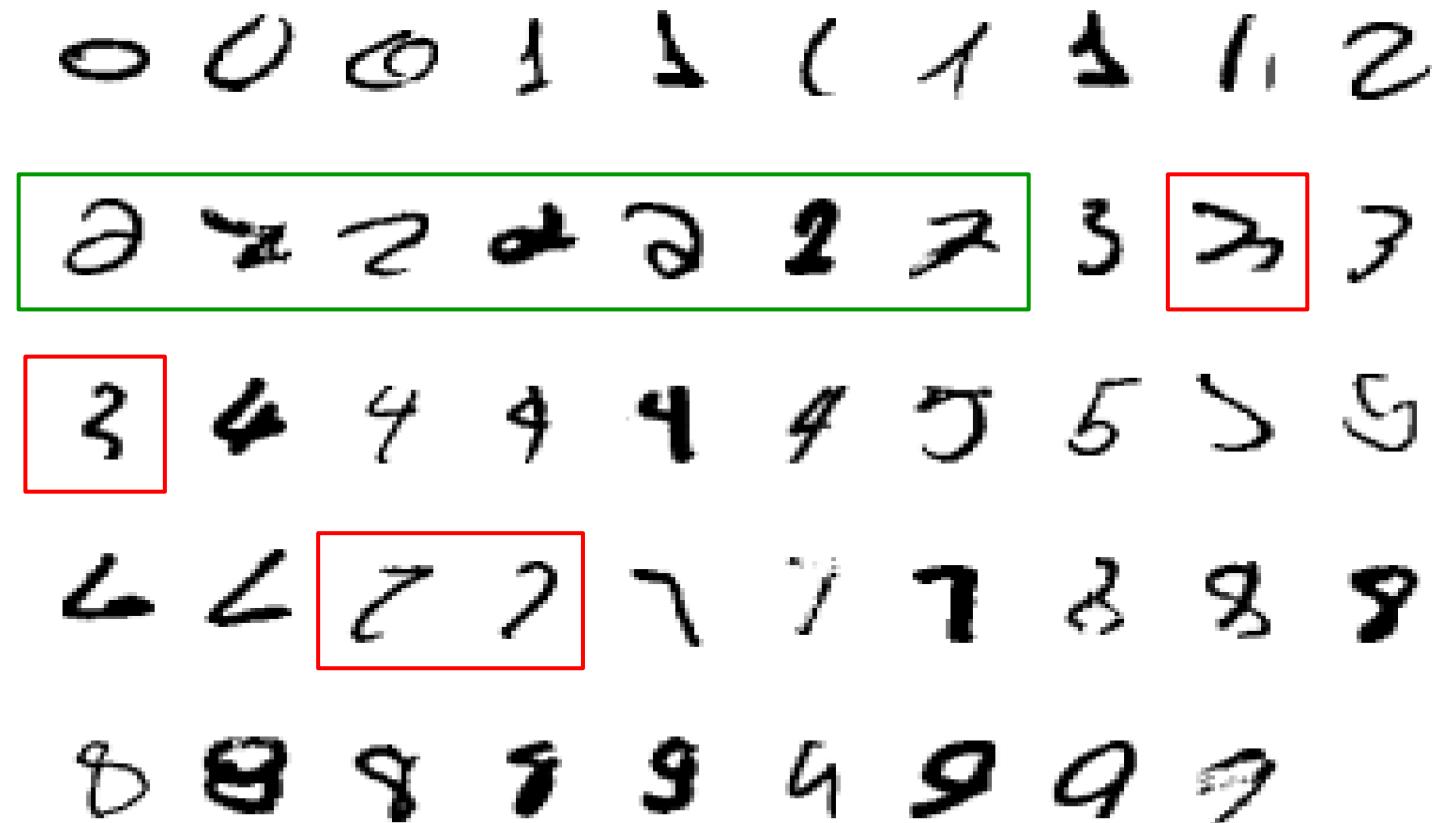


Learning isn't always useful:

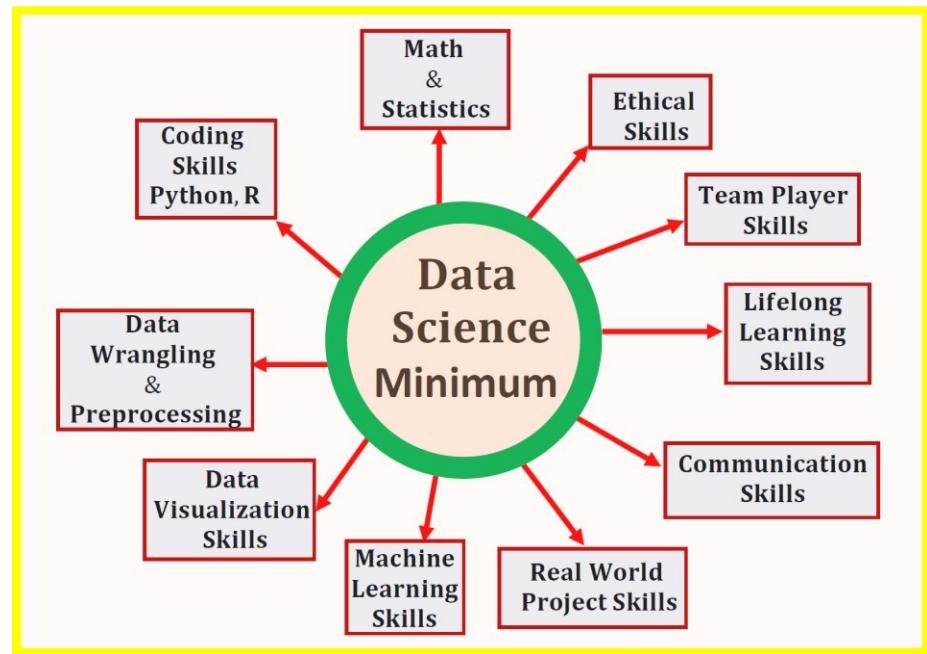
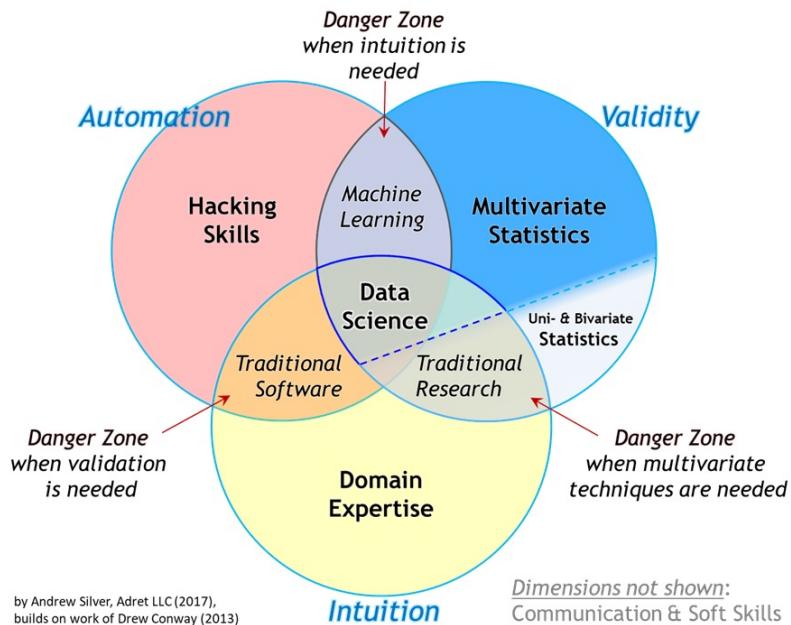
- There is no need to “learn” to calculate payroll

When Do We Use ML?

A classic example of a task that requires machine learning: It is very hard to say what makes a 2



Why do you have to study it?



The most important pillar of Data Science

<https://towardsdatascience.com/data-science-minimum-10-essential-skills-you-need-to->

Deep Learning in the Headlines

BUSINESS NEWS

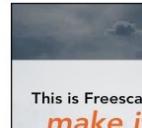
Is Google Cornering the Market on Deep Learning?

A cutting-edge corner of science is being wooed by Silicon Valley, to the dismay of some academics.

By Antonio Regalado on January 29, 2014



How much are a dozen deep-learning researchers worth? Apparently, more than \$400 million.



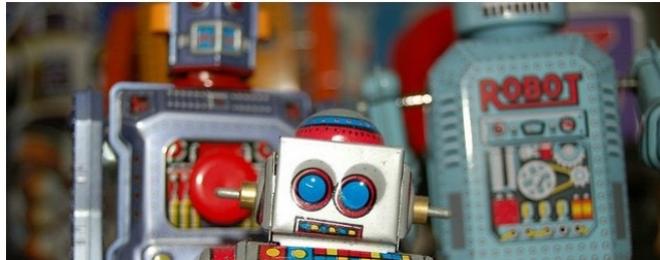
This week, Google reportedly paid that much to acquire DeepMind Technologies, a startup based in

MIT
Technology
Review

WIRED GEAR SCIENCE ENTERTAINMENT BUSINESS SECURITY DESIGN
INNOVATION INSIGHTS | **community content** | ▾ featured

Deep Learning's Role in the Age of Robots

BY JULIAN GREEN, JETPAC 05.02.14 2:56 PM



Bloomberg Businessweek
Technology

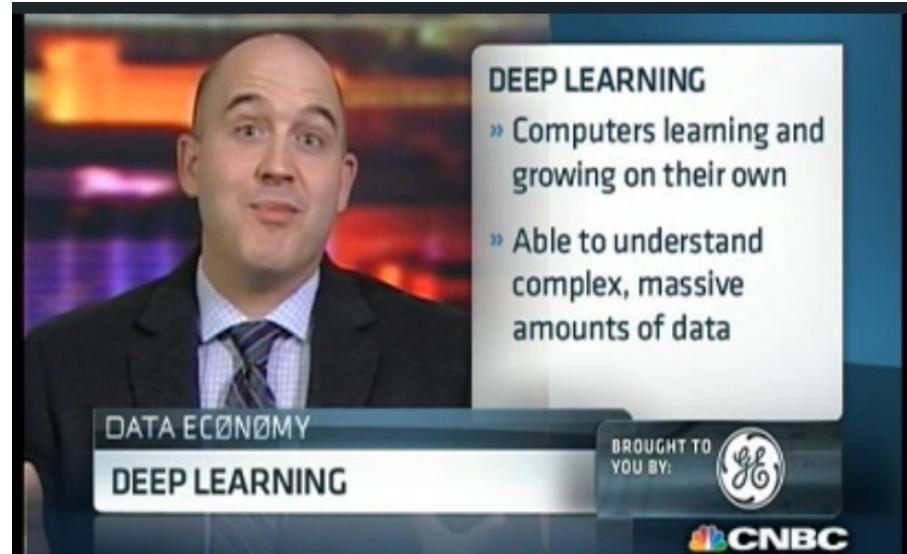
Acquisitions

The Race to Buy the Human Brains Behind Deep Learning Machines

By Ashlee Vance [Twitter](#) | January 27, 2014

intelligence projects. "DeepMind is bona fide in terms of its research capabilities and depth," says Peter Lee, who heads Microsoft Research.

According to Lee, Microsoft, Facebook ([FB](#)), and Google find themselves in a battle for deep learning talent. Microsoft has gone from four full-time deep learning experts to 70 in the past three years. "We would have more if the talent was there to



DATA ECONOMY
DEEP LEARNING

DEEP LEARNING

- » Computers learning and growing on their own
- » Able to understand complex, massive amounts of data

BROUGHT TO YOU BY:
GE

CNBC

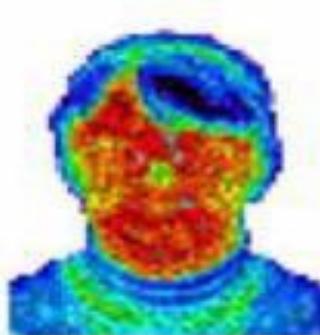
Application of Machine Learning

**Can you think of any
applications of ML around you?**

Biometric



face



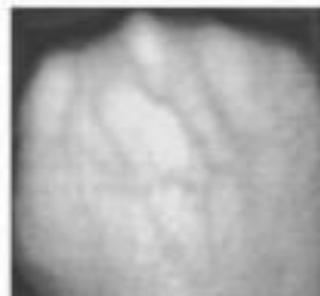
facial thermogram



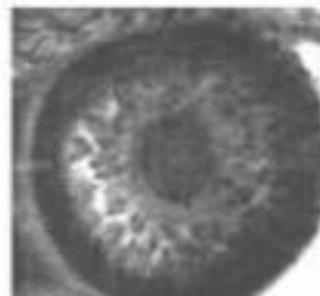
fingerprint



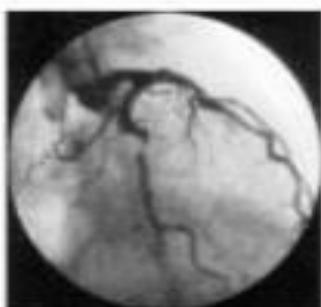
hand geometry



hand vein



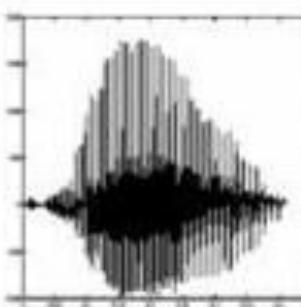
iris



retinal scan

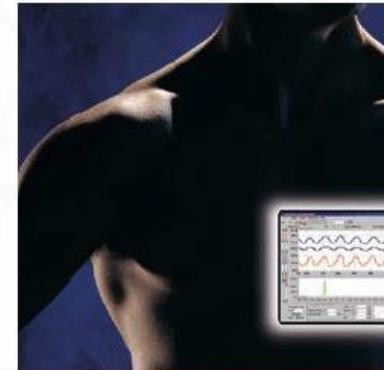


signature



voice print

Autonomous Driving/Flying



STANFORD UNIVERSITY AUTONOMOUS HELICOPTER

Overview

The goal of this project is to push the state-of-the-art in autonomous helicopter flight: extreme aerobatics under computer control.

Featured Videos

<http://heli.stanford.edu/>



OCR

From
Jim Elder
829 Loop Street, Apt 300
Allentown, New York 14707

Nov 10, 1999

To
Dr. Bob Grant
602 Queensberry Parkway
Omar, West Virginia 25638

We were referred to you by Xena Cohen at the University Medical Center. This is regarding my friend, Kate Zack.

It all started around six months ago while attending the "Rubeq" Jazz Concert. Organizing such an event is no picnic, and as President of the Alumni Association, a co-sponsor of the event, Kate was overworked. But she enjoyed her job, and did what was required of her with great zeal and enthusiasm.

However, the extra hours affected her health; halfway through the show she passed out. We rushed her to the hospital, and several questions, x-rays and blood tests later, were told it was just exhaustion.

Kate's been in very bad health since. Could you kindly take a look at the results and give us your opinion?

Thank you!
Jim

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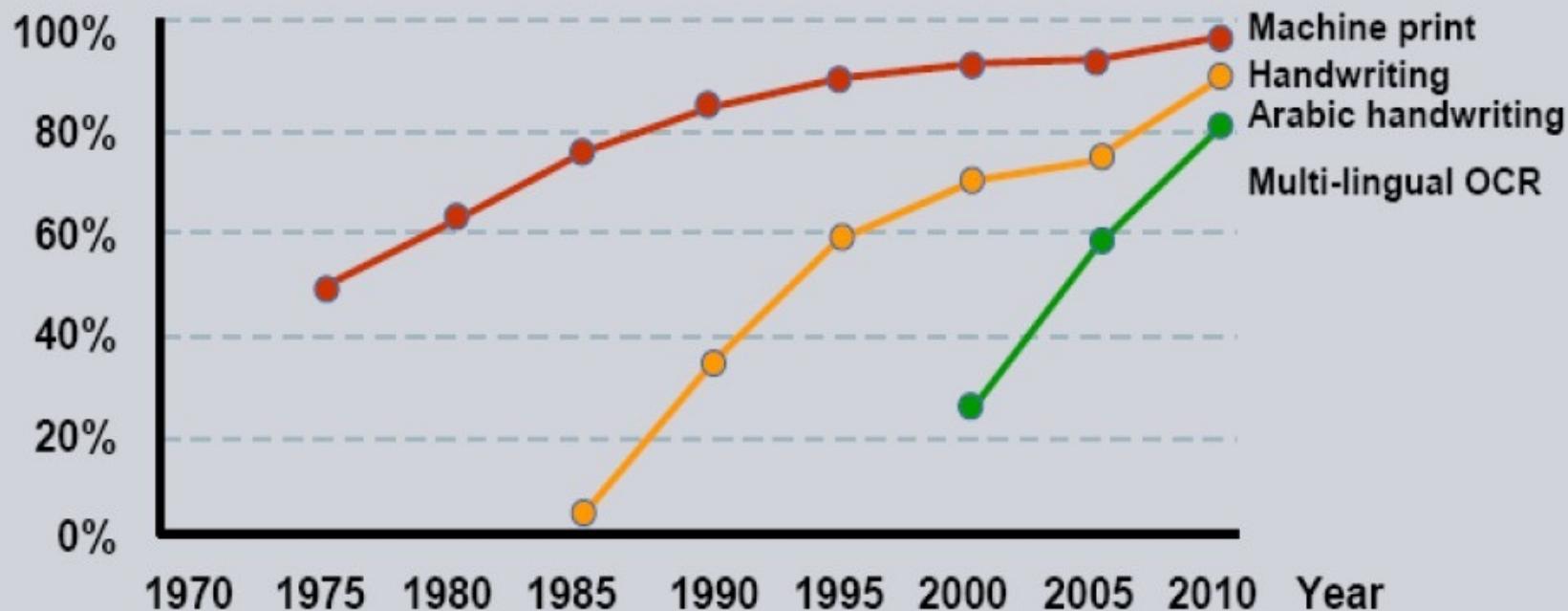
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Thank you!
Jim

OCR

Read rate



OCR Benchmarks

- NIST'93 Test Award
- ISRI'95 Award
- ICDAR'07 Arabic Award

Spam Filtering

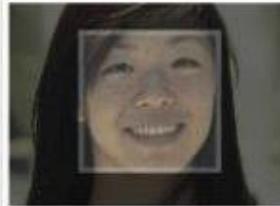


As the amount of spam has increased, Gmail users have received less of it in their inboxes, reporting a rate less than 1%.

Facebook

Tag Your Friends

This will quickly label your photos and notify the friends you tag. Learn more



Who is this? Who is this? Who is this?



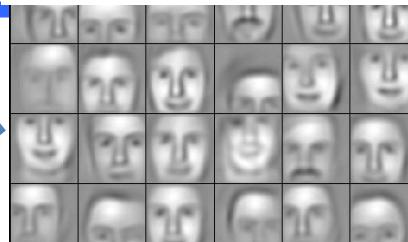
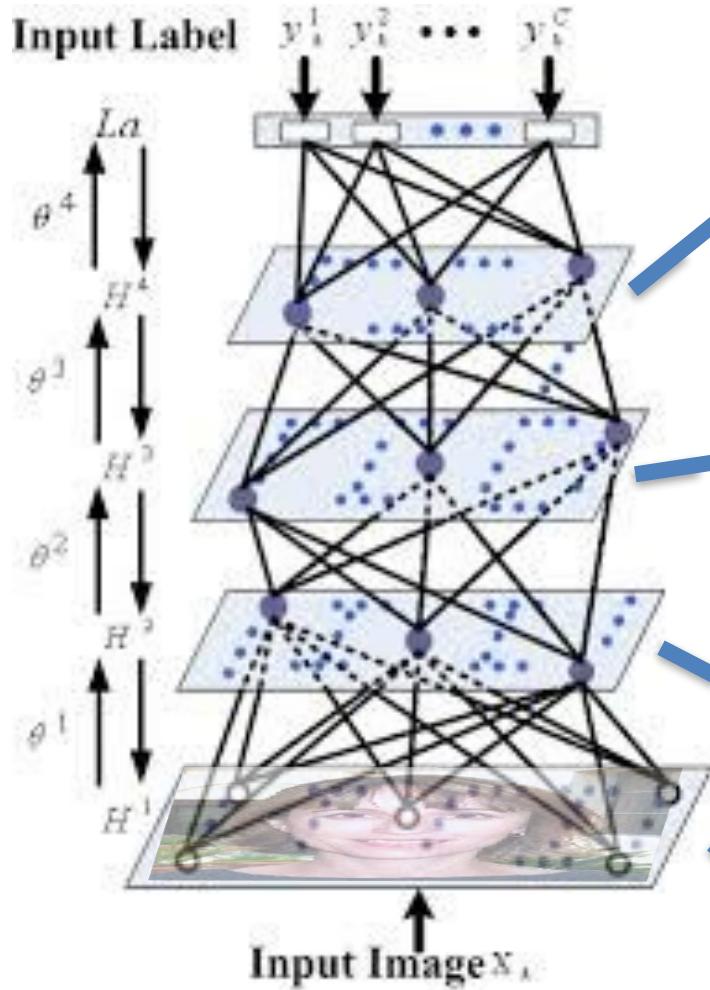
Who is this? Who is this? Who is this?



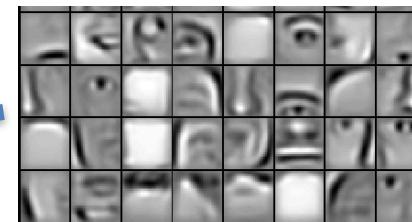
Francis Luu X

Skip Tagging Friends Save Tags

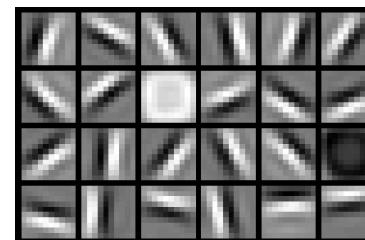
Face Recognition



object models



object parts
(combination
of edges)



edges



pixels



Face Recognition

Generating posterior samples from faces by “filling in” experiments (cf. Lee and Mumford, 2003). Combine bottom-up and top-down inference.

Input images



Samples
from
feedforward
Inference
(control)

Samples
from Full
posterior
inference

Scene Labeling



[Farabet et al. ICML 2012, PAMI 2013]

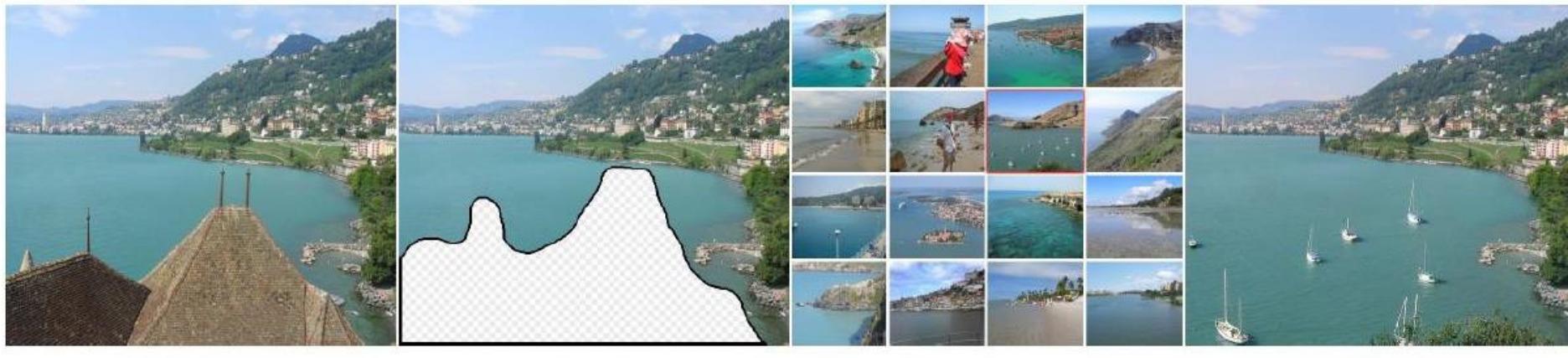
Scene Completion

Scene Completion Using Millions of Photographs

James Hays

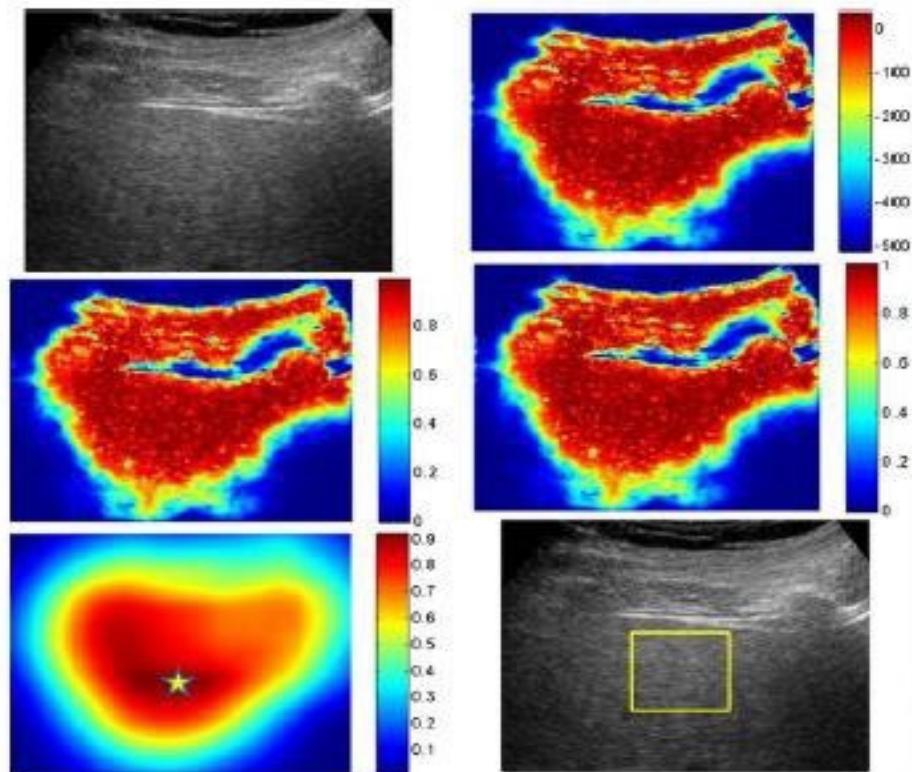
Carnegie Mellon University

Alexei A. Efros

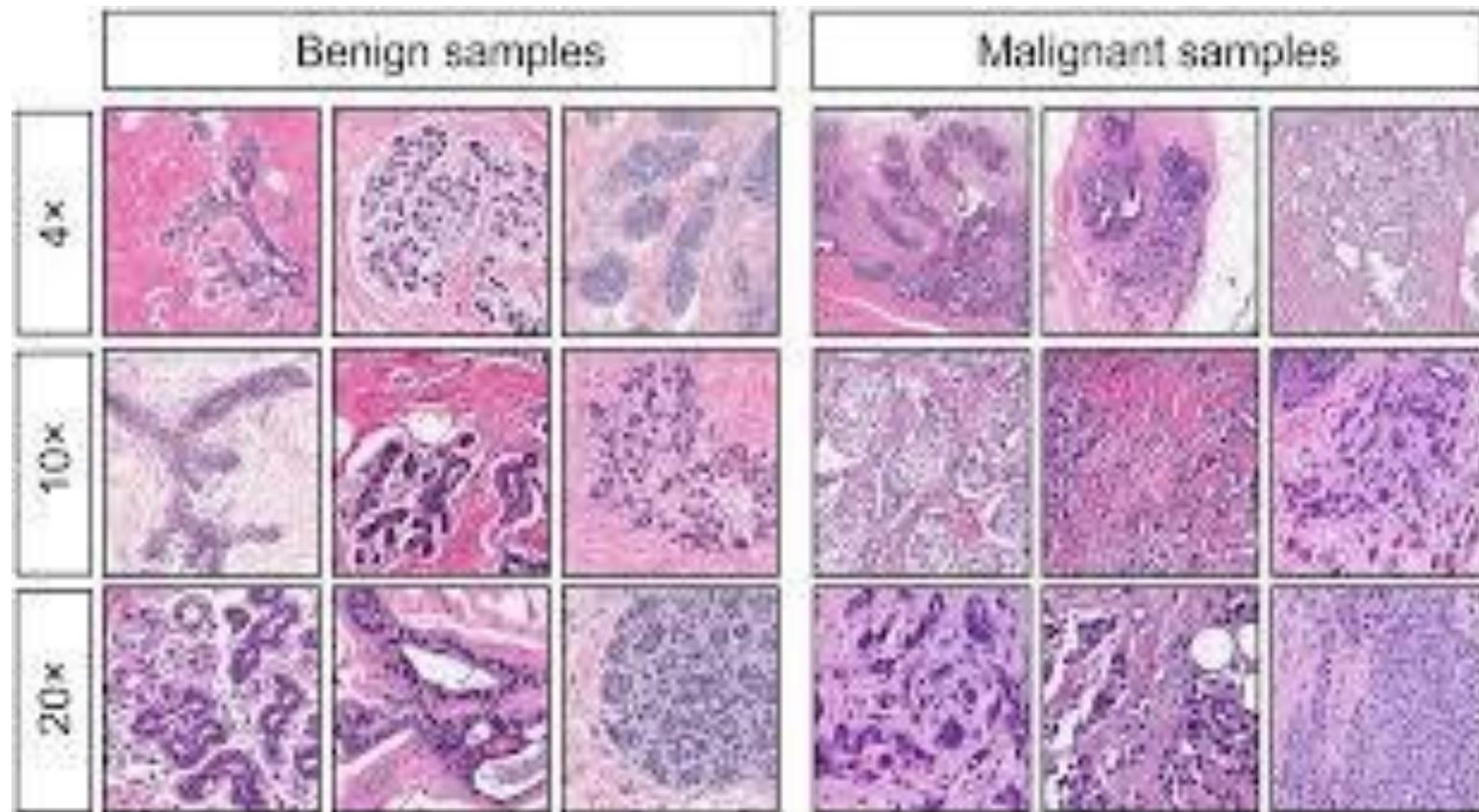


Medical Image Processing

Liver surface irregularity using ultrasound images



Histopathology Image Analysis



Gesture Recognition

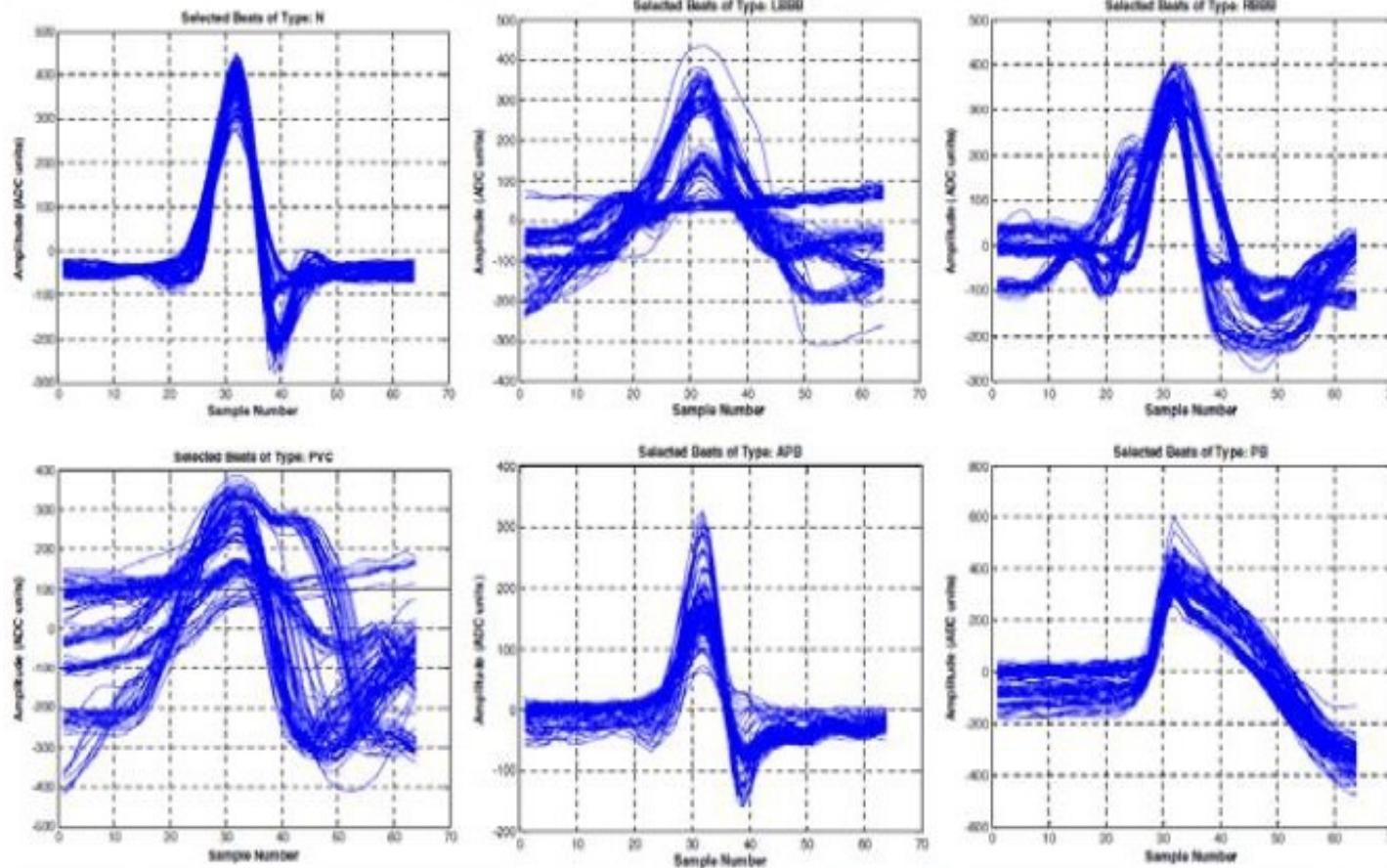


Recommender Systems



- Recommend movies based on user preferences, interests and likes
- Similar ideas for facebook...
 - Find friends that share your interests

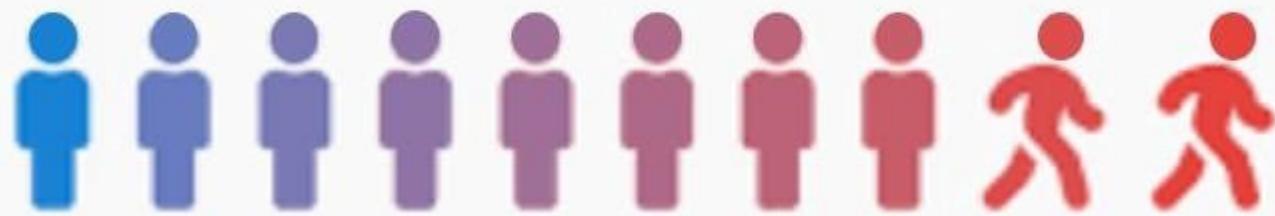
Signal Analysis



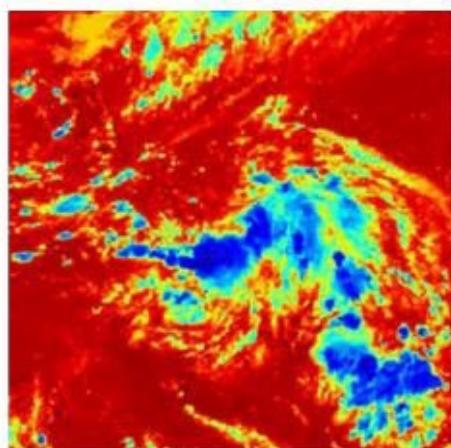
Computer/Network Security

- Prediction of threats
- Prediction of bugs / vulnerabilities in software
- Identification of malicious activity
- Identification of malicious software / viruses
- Attacking through side channels
 - Keyboard acoustics

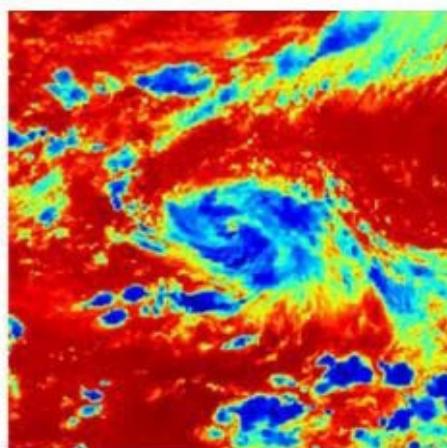
Customer Churn Prediction



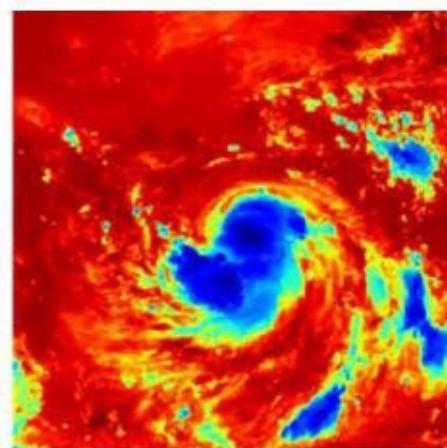
Hurricane Intensity Prediction



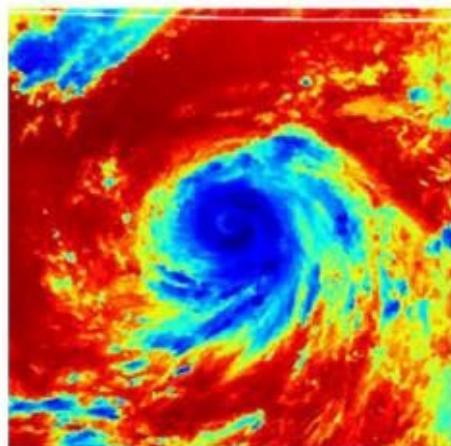
26kt



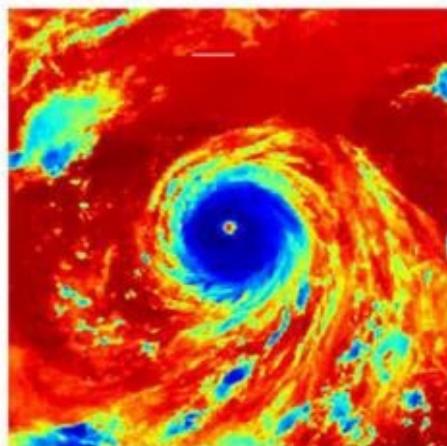
37kt



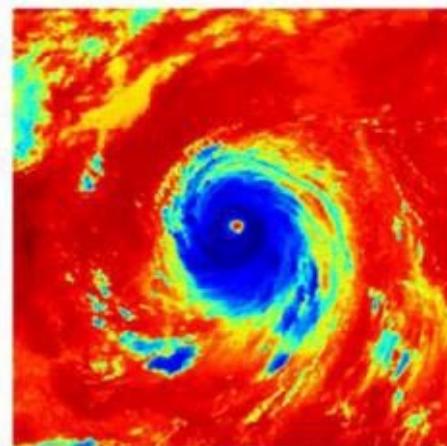
62kt



88kt



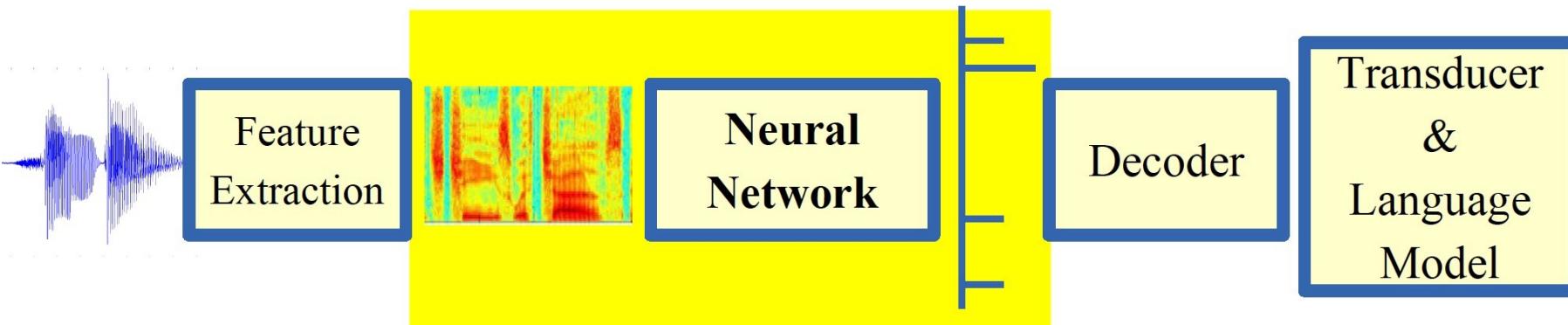
119kt



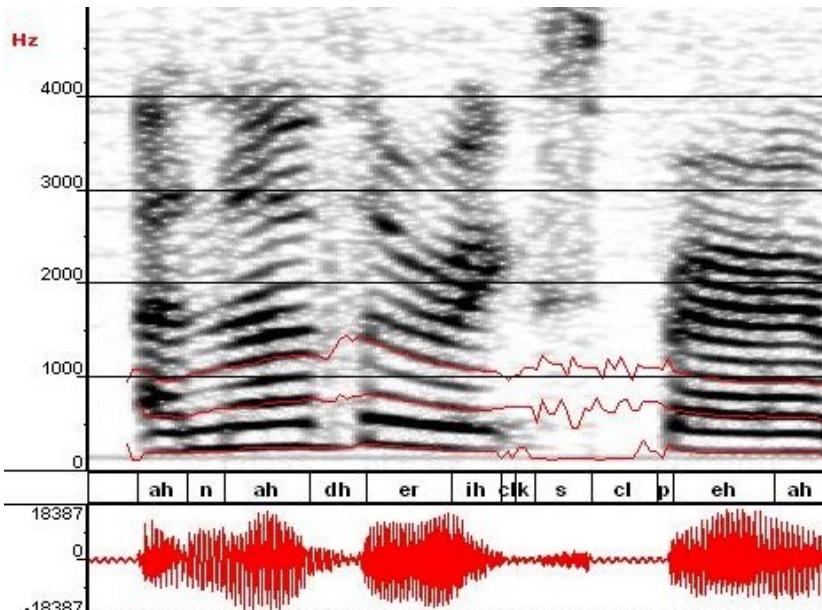
130kt

Automatic Speech Recognition

A Typical Speech Recognition System



ML used to predict of phone states from the sound spectrogram



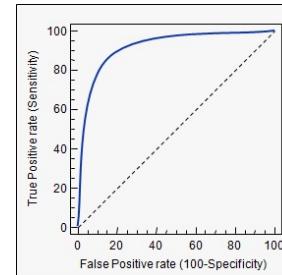
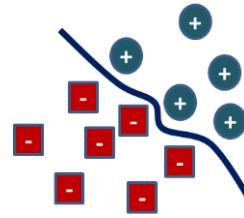
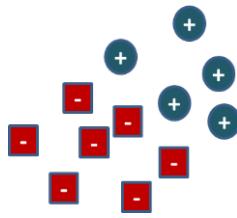
Deep learning has state-of-the-art results

# Hidden Layers	1	2	4	8	10	12
Word Error Rate %	16.0	12.8	11.4	10.9	11.0	11.1

Baseline GMM performance = 15.4%

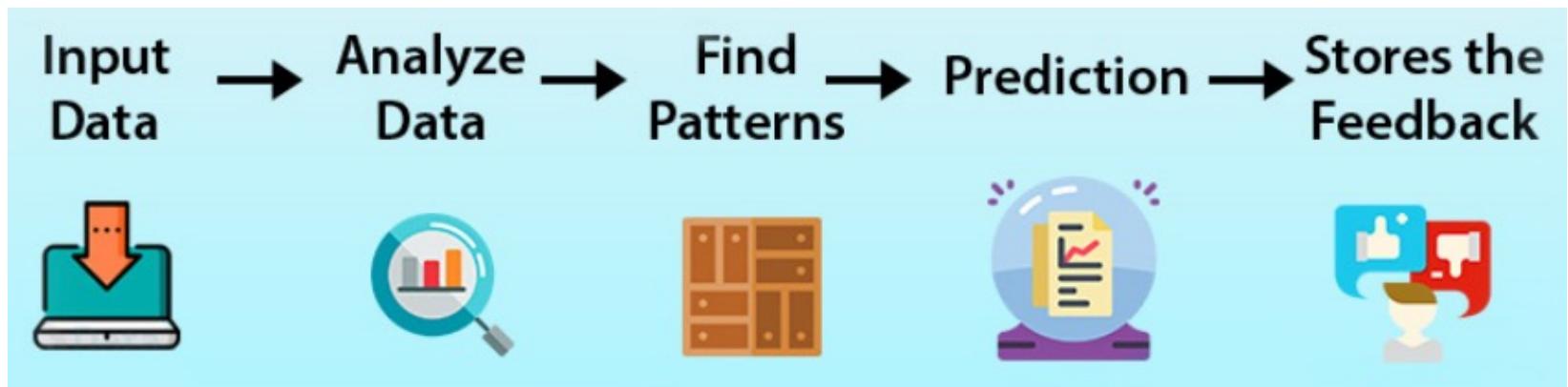
[Zeiler et al. "On rectified linear units for speech recognition" ICASSP 2013]

A Typical MLSystem

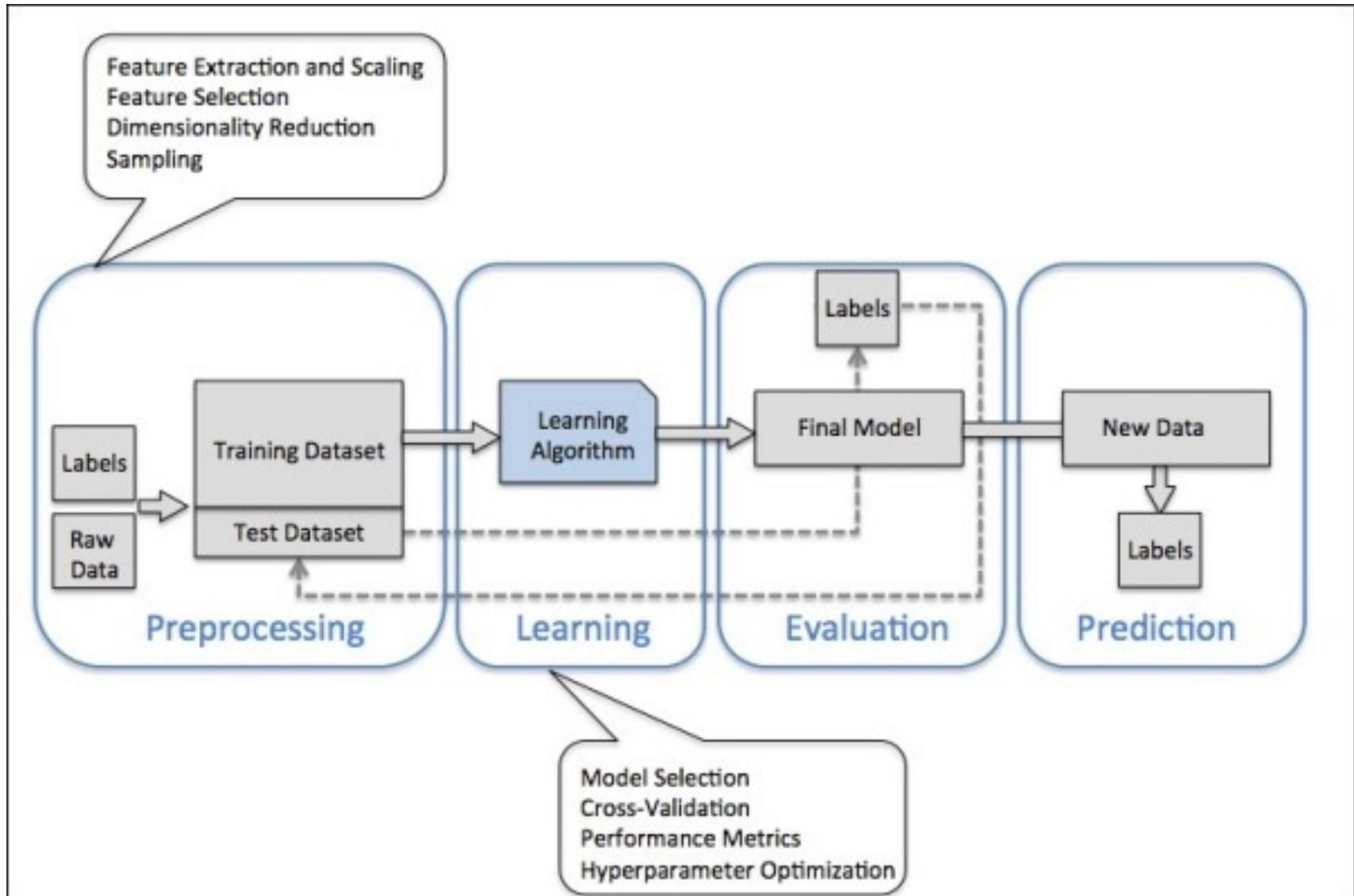


Webserver
Software Package

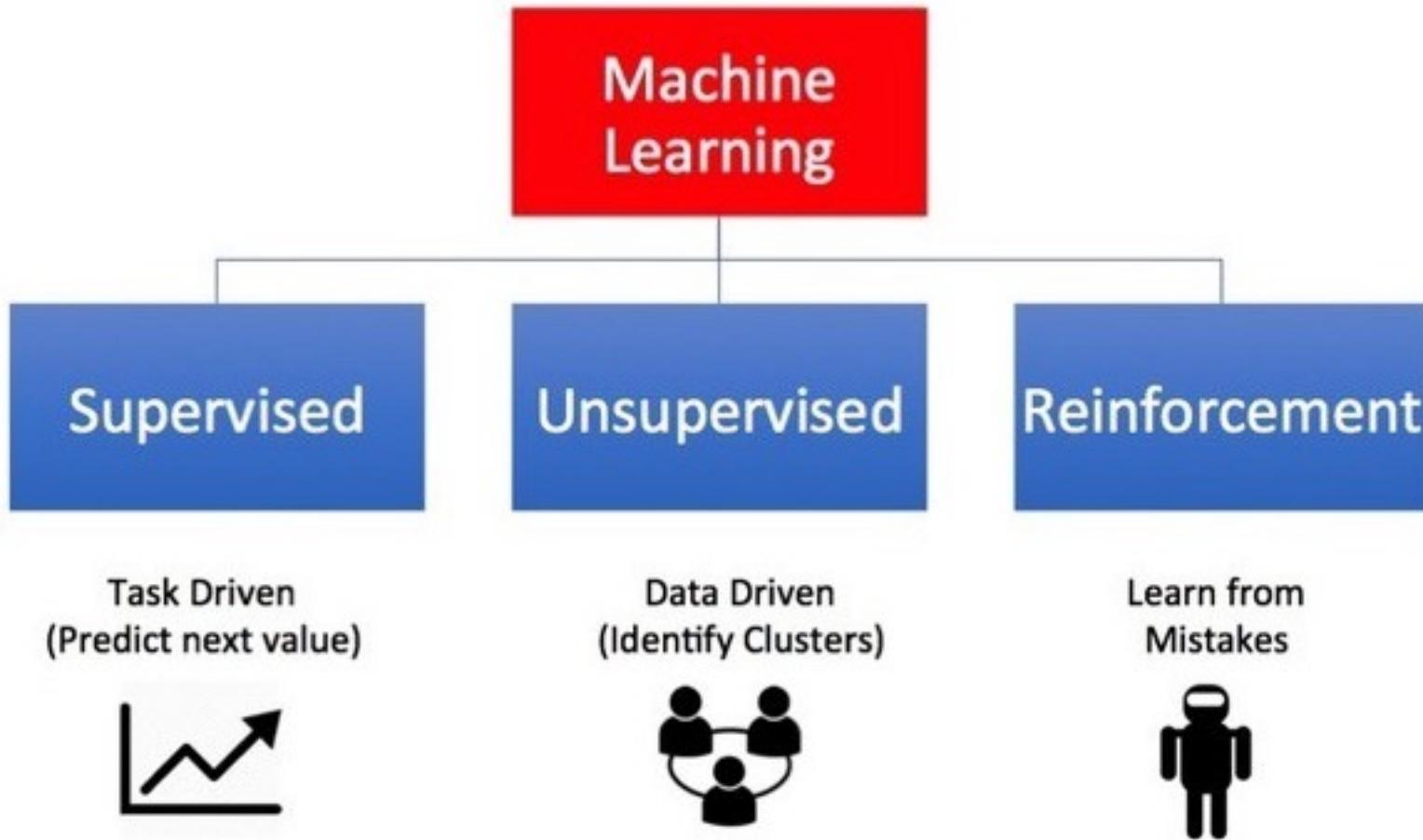
How does ML Work?



How does ML Work?

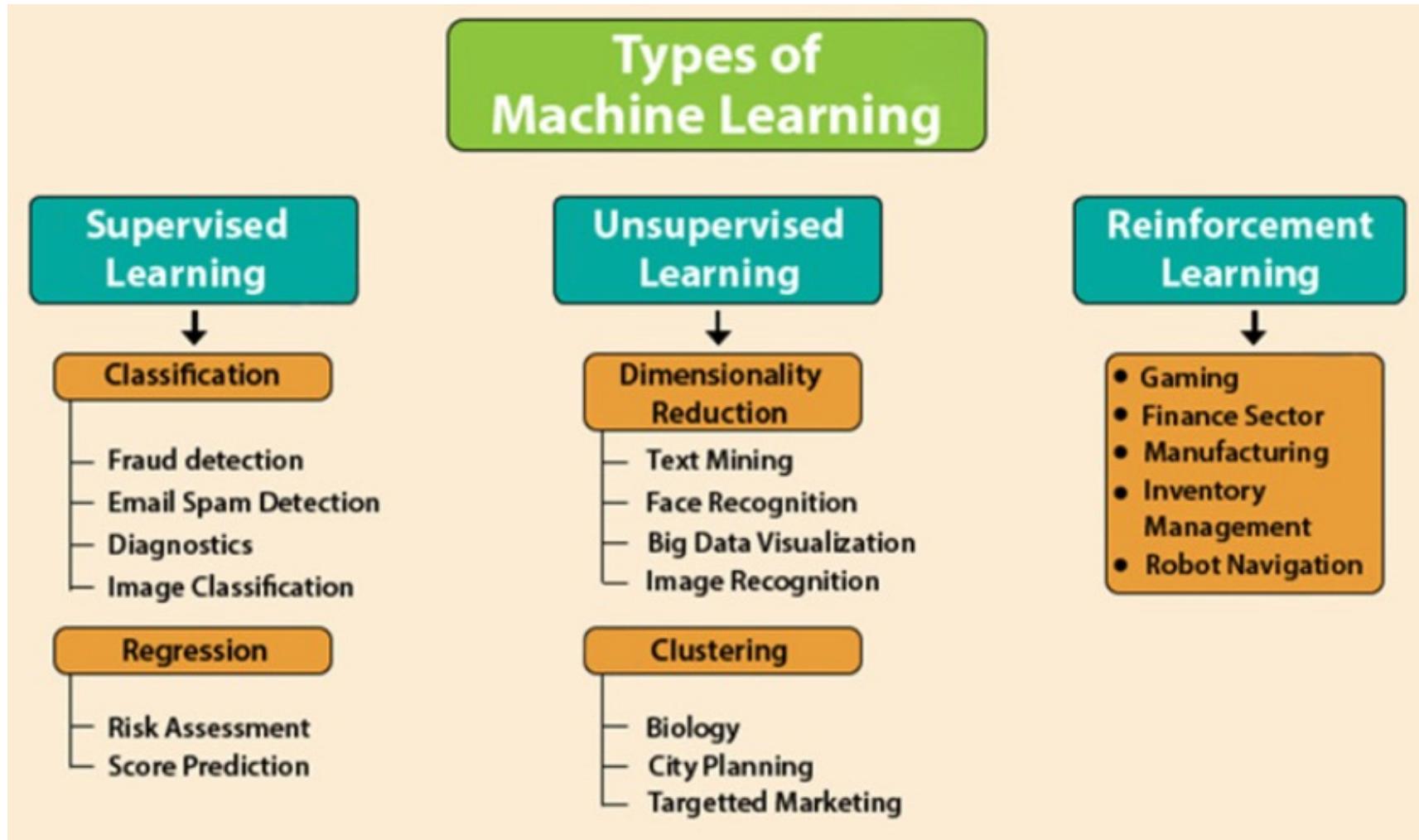


Types of Machine Learning

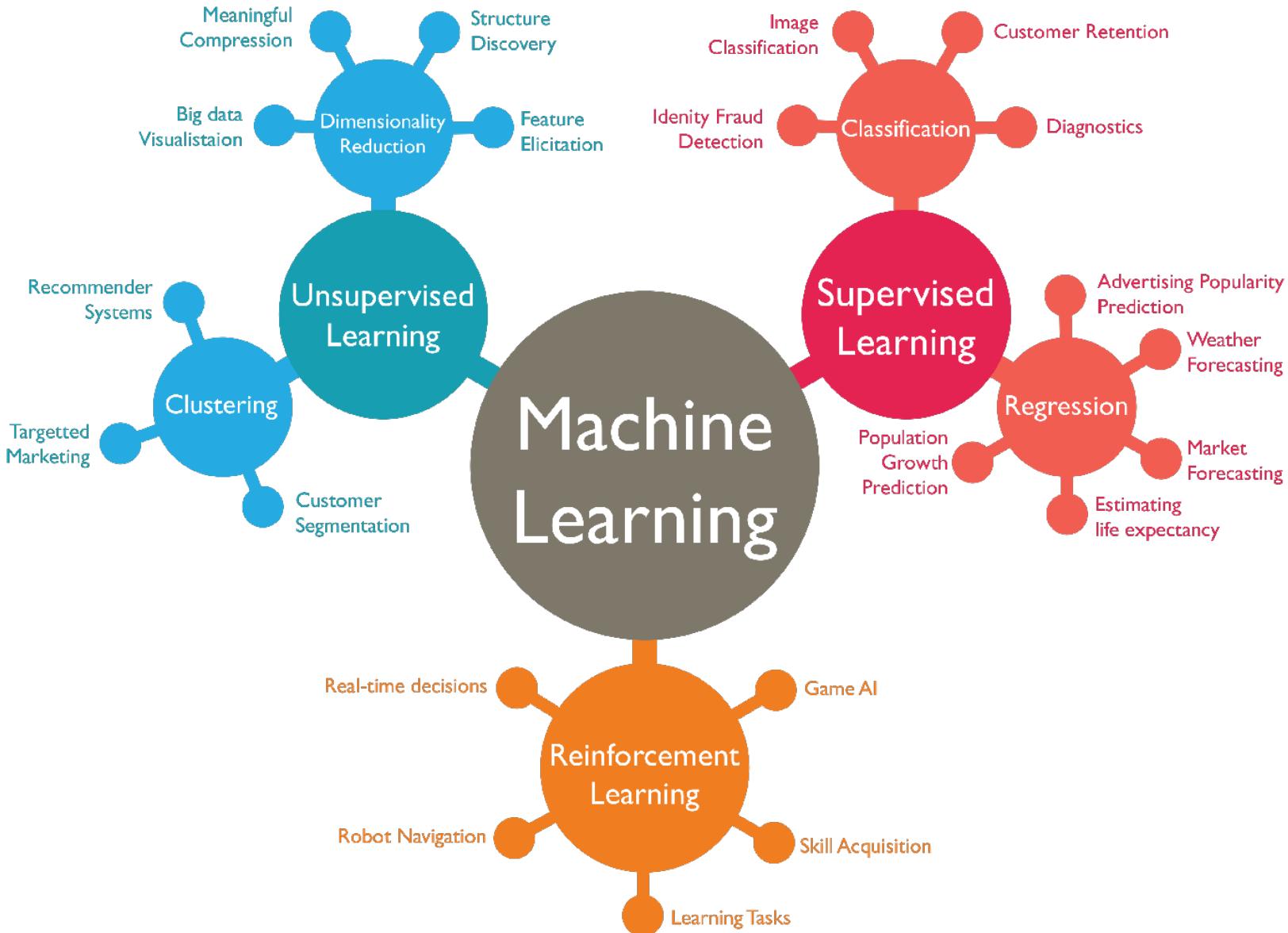


Source: <https://towardsdatascience.com/reinforcement-learning-101-e24b50e1d292>

Methods of Machine Learning

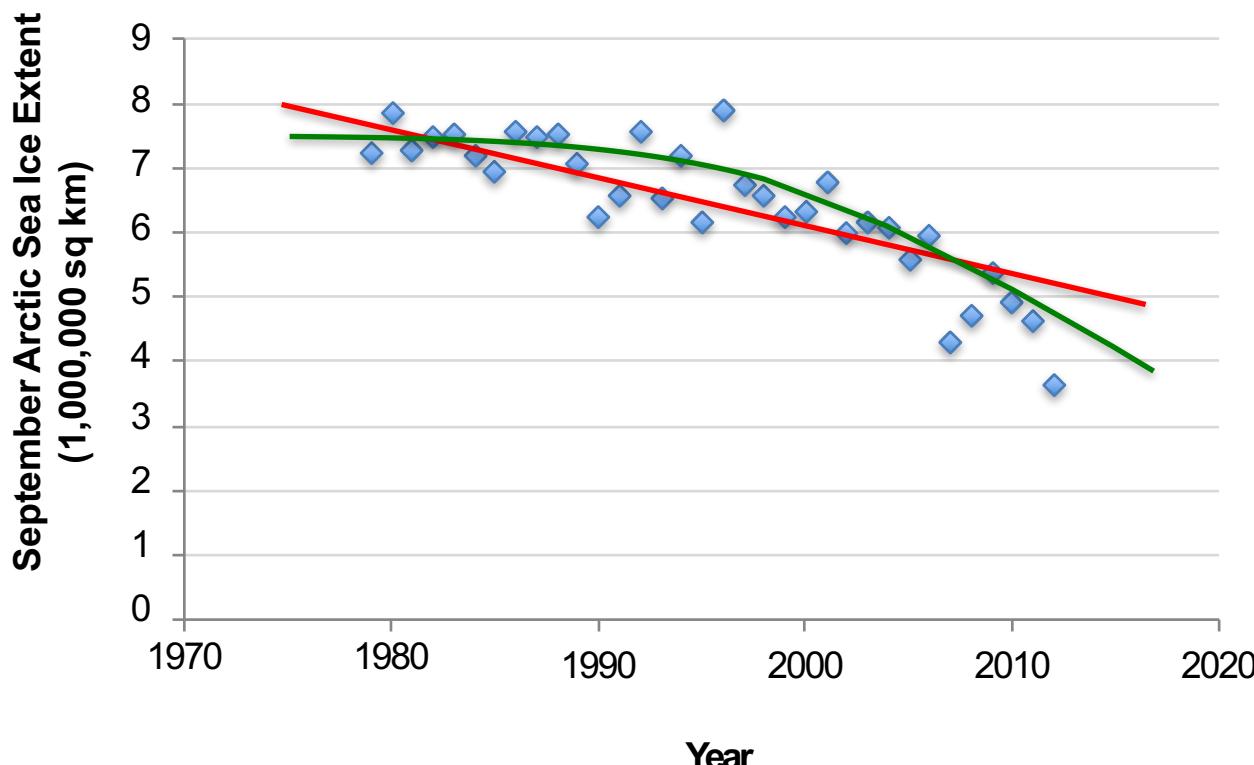


Methods of Machine Learning



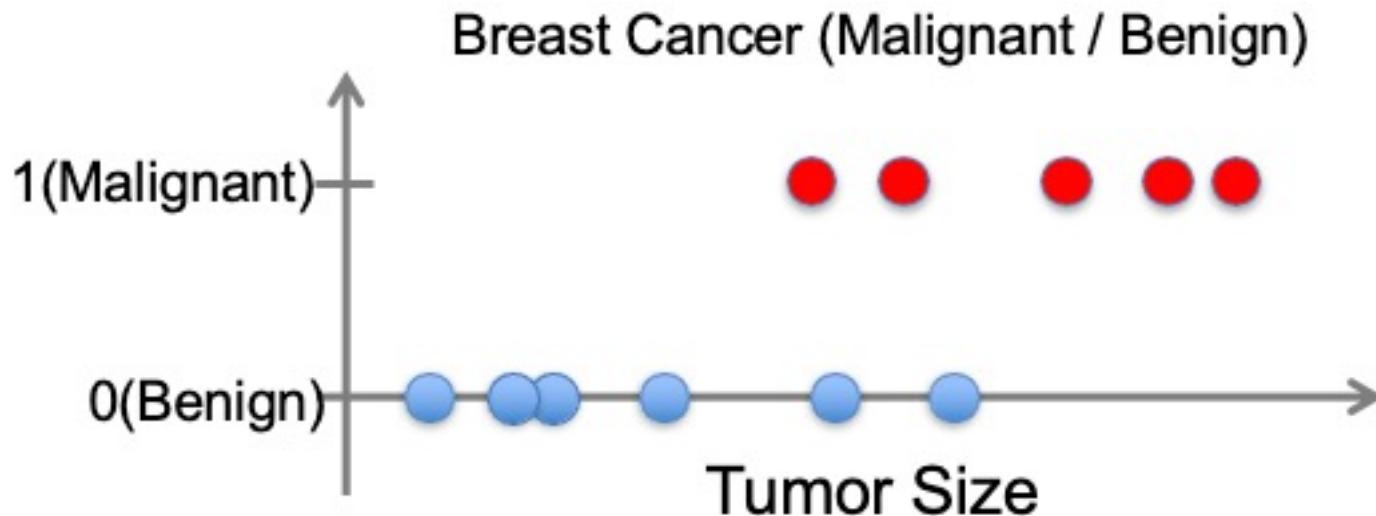
Supervised Learning: Regression

- Given $(x_1, y_1), (x_2, y_2), \dots, (x_n, y_n)$
- Learn a function $f(x)$ to predict y given x
- – y is real-valued == regression



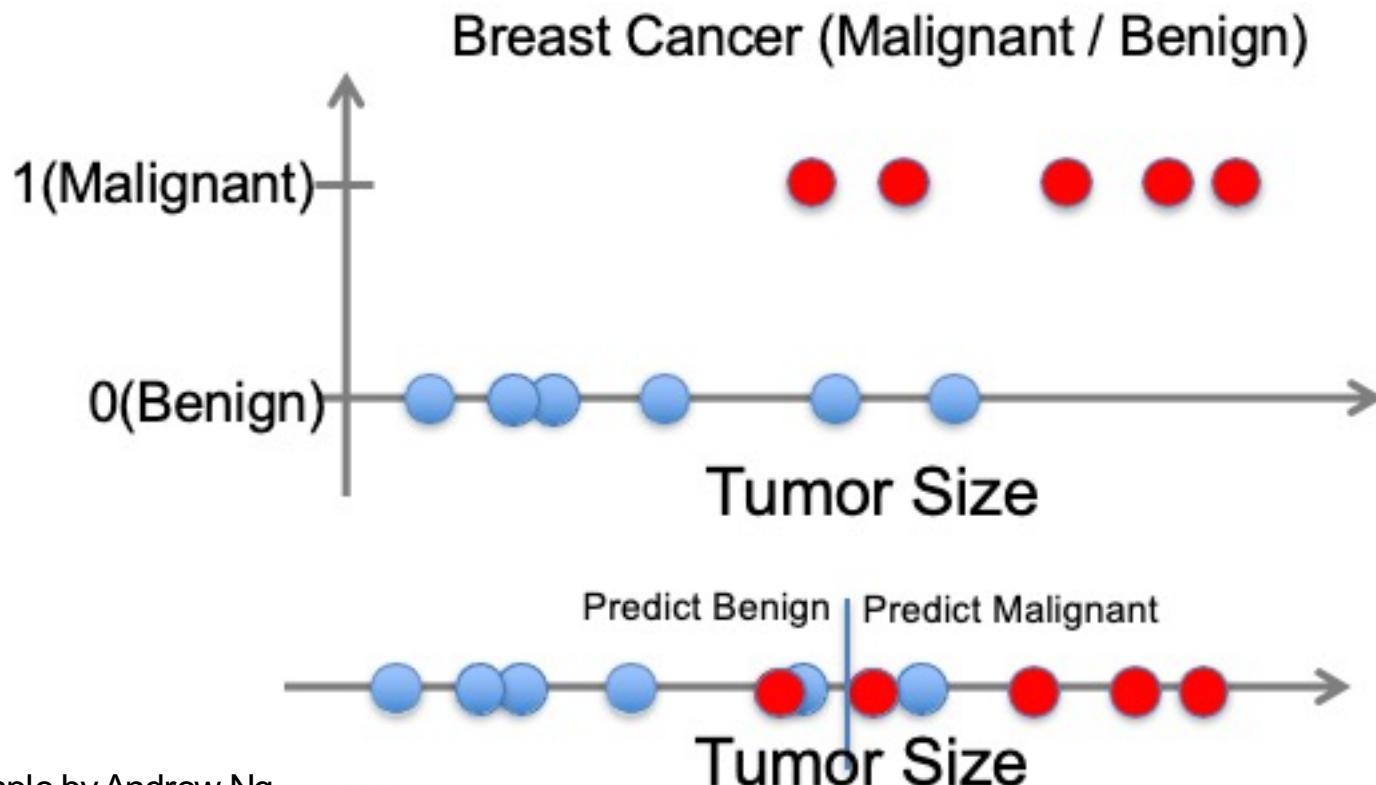
Supervised Learning: Classification

- Given $(x_1, y_1), (x_2, y_2), \dots, (x_n, y_n)$
- Learn a function $f(x)$ to predict y given x
- – y is categorical == classification



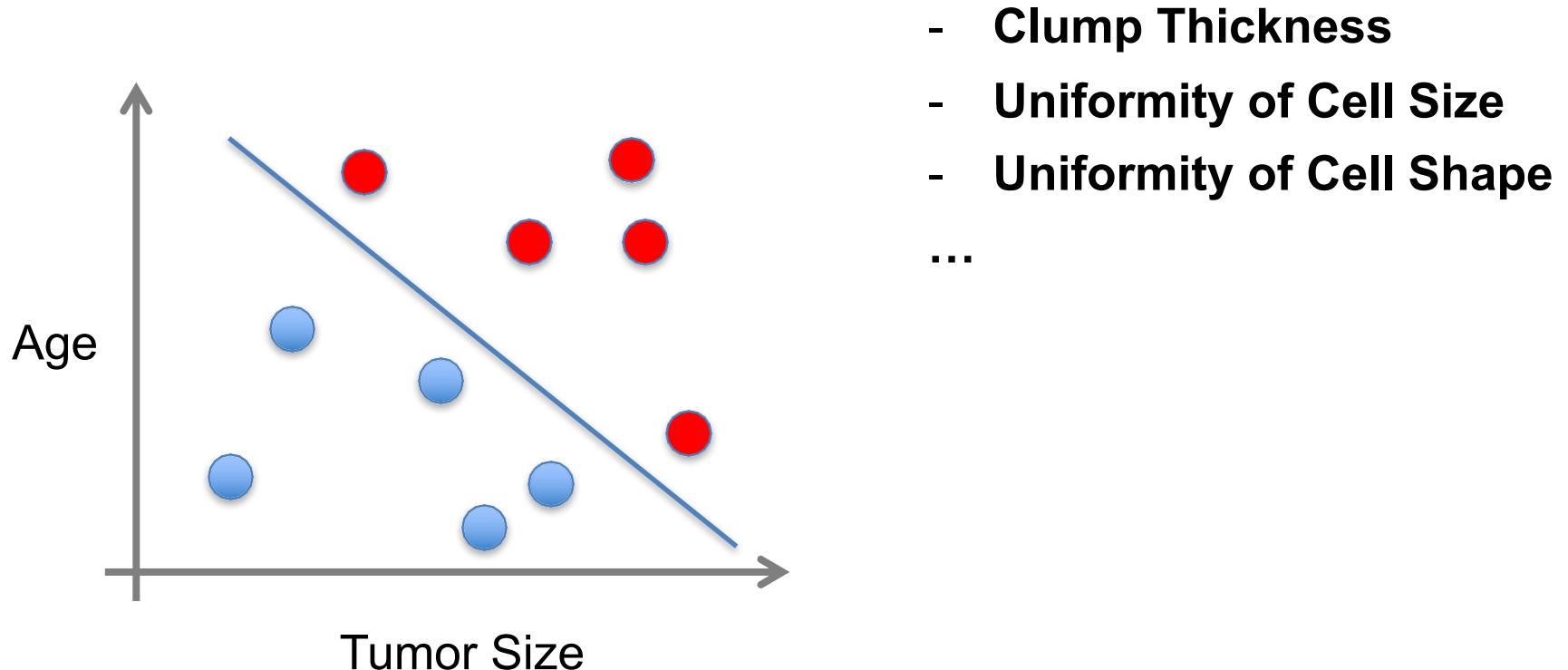
Supervised Learning: Classification

- Given $(x_1, y_1), (x_2, y_2), \dots, (x_n, y_n)$
- Learn a function $f(x)$ to predict y given x
- y is categorical == classification



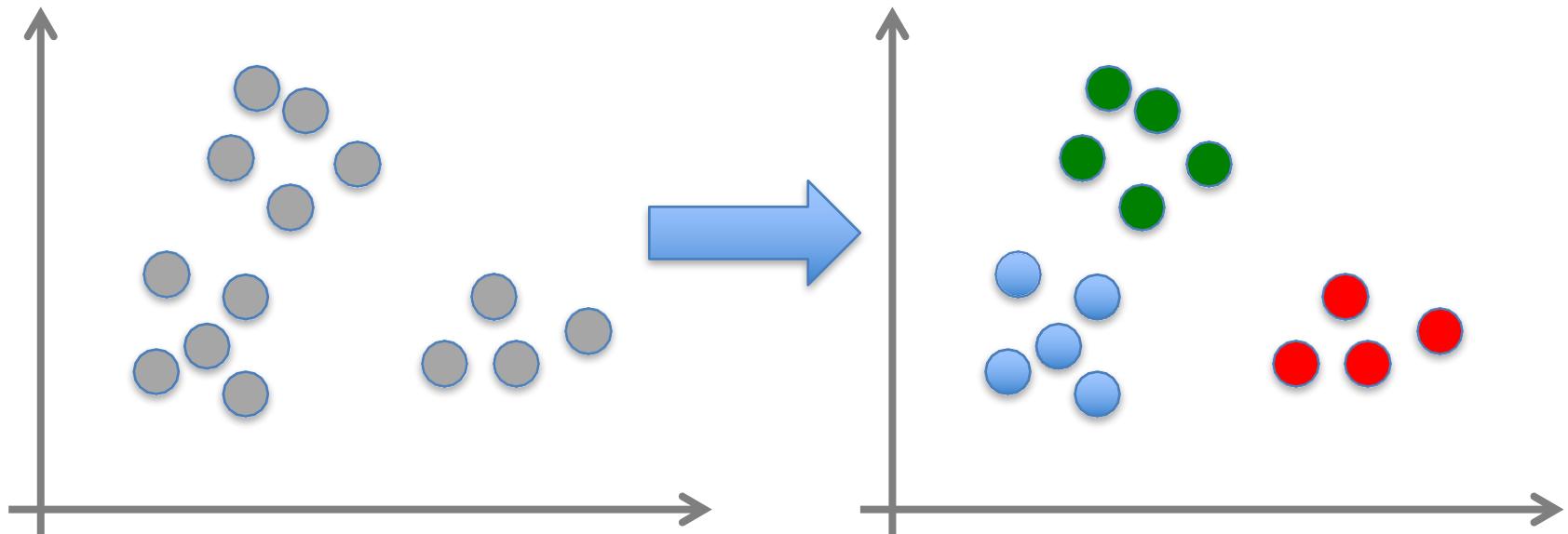
Supervised Learning: Classification

- x can be multi-dimensional
 - Each dimension corresponds to an attribute



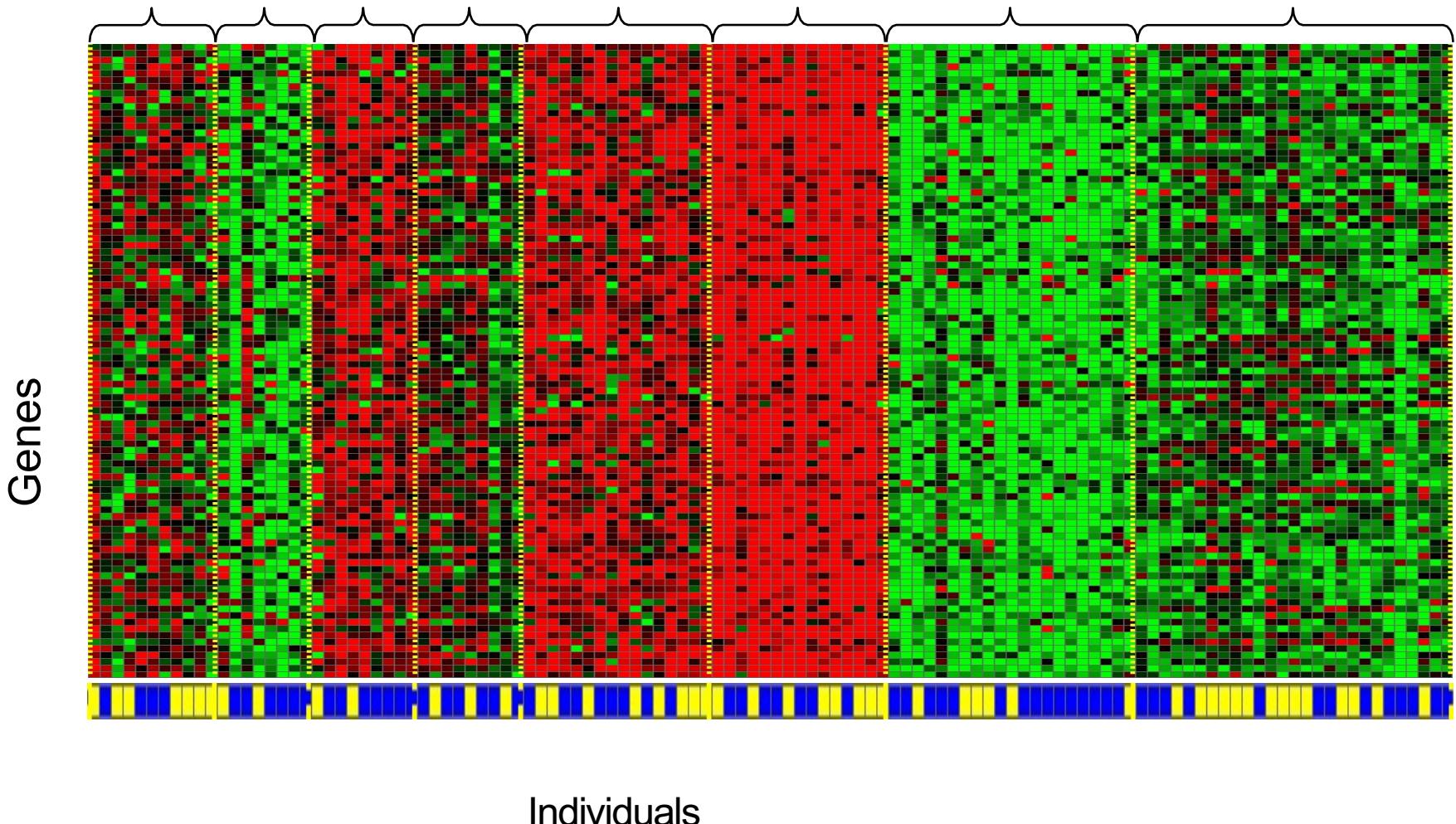
Unsupervised Learning

- Given x_1, x_2, \dots, x_n (without labels)
- Output hidden structure behind the x 's
- – E.g., clustering



Unsupervised Learning

- Genomics application: group individuals by genetic similarity



Unsupervised Learning



Organize computing clusters



Social network analysis



Market segmentation

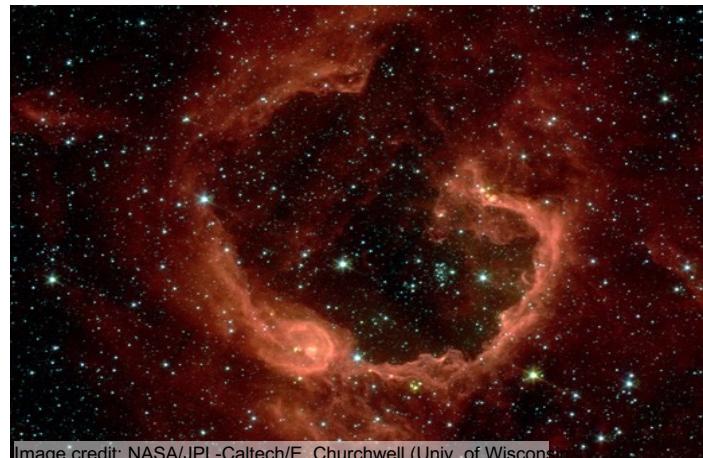
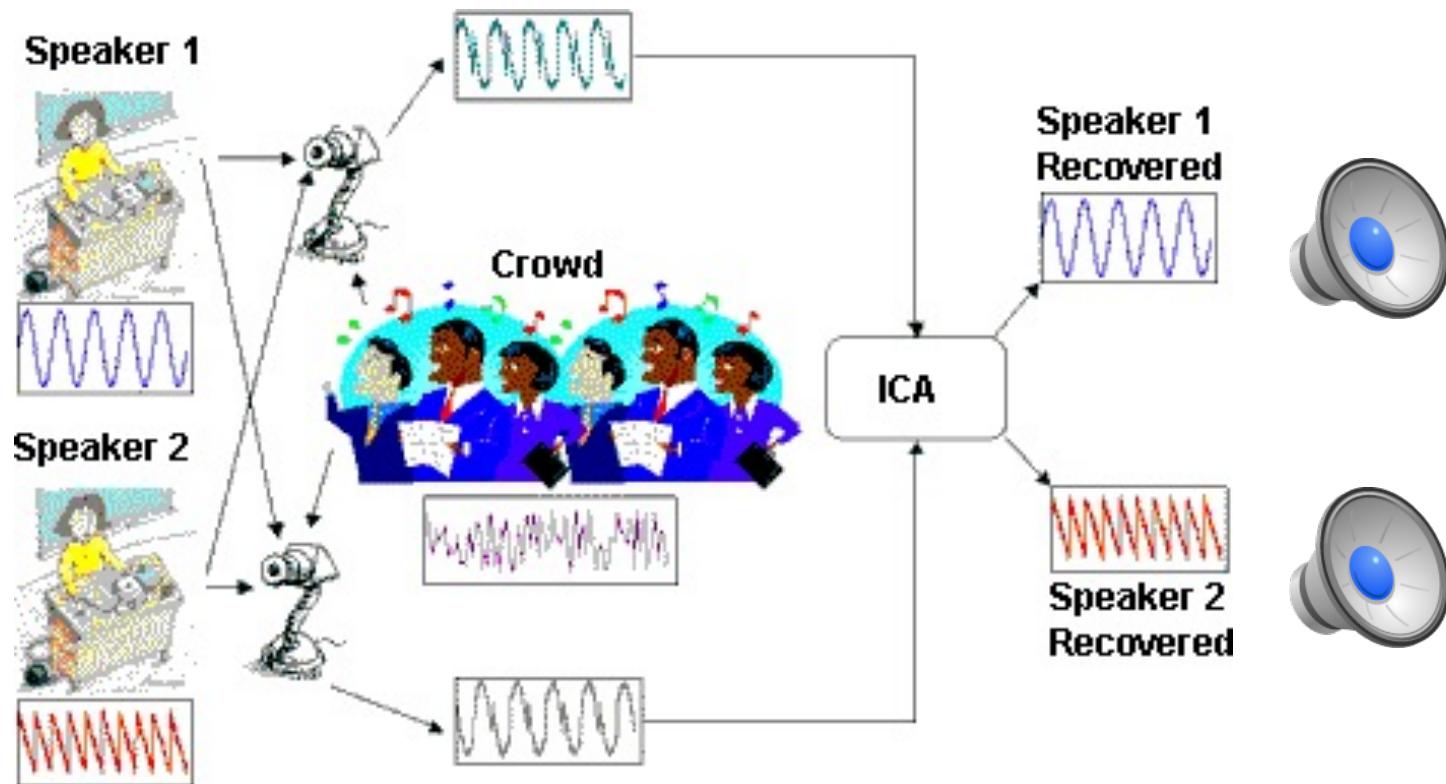


Image credit: NASA/JPL-Caltech/E. Churchwell (Univ. of Wisconsin-Madison)

Astronomical data analysis

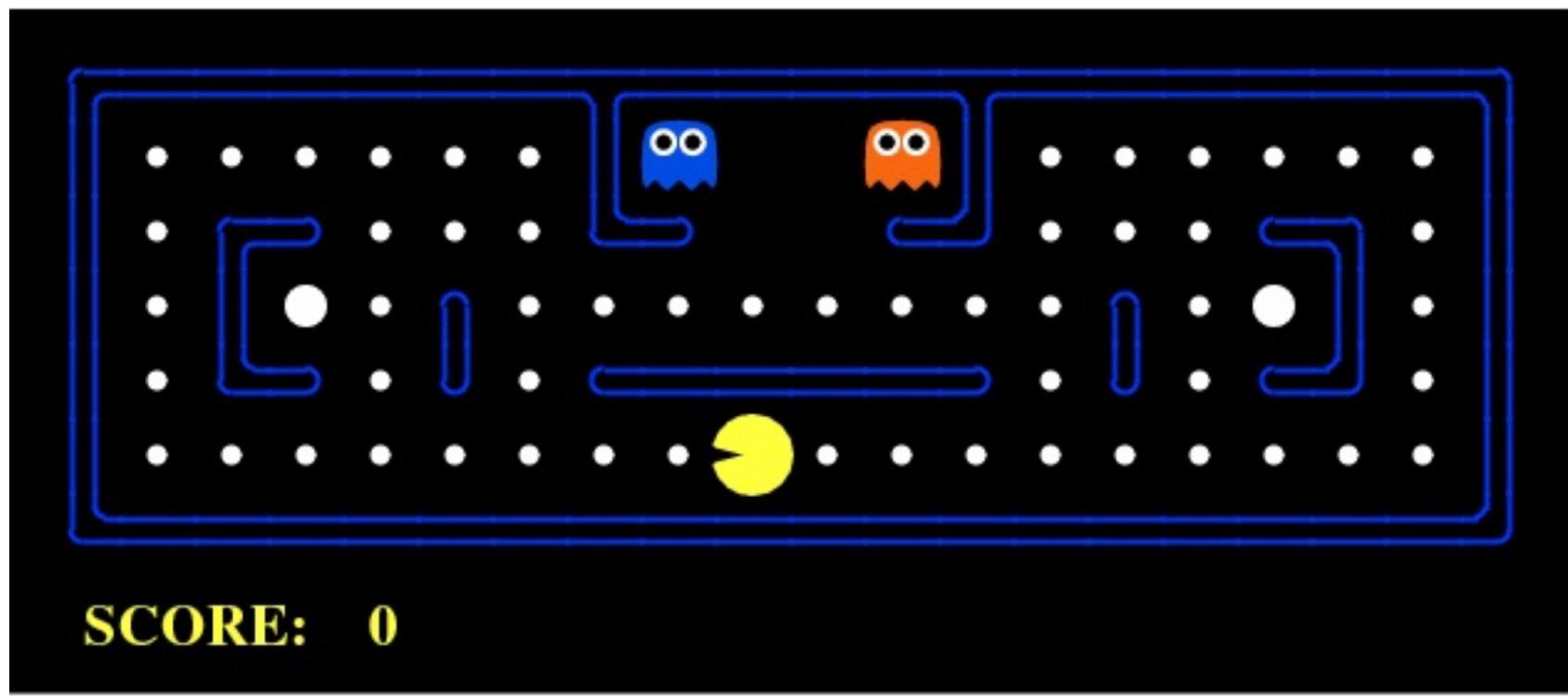
Unsupervised Learning

- Independent component analysis – separate a combined signal into its original sources



Reinforcement Learning

- Learning in an interactive environment by trial and error using feedback from its own actions and experiences.



Source: <https://towardsdatascience.com/reinforcement-learning-101-e24b50e1d292>

Types of ML

1. Discriminating between apples and pears
 - ❖ Classification
2. Identifying the painter
 - ❖ Classification
3. Grouping the apples
 - ❖ Clustering
4. Picking the odd one out
 - ❖ Anomaly detection
5. Predicting the series
 - ❖ Regression
6. Removing redundant dimensions
 - ❖ Dimensionality reduction

Benefits of Machine Learning

Decision making is faster

Adaptability

Innovation

Insight

Business growth

Outcome will be good

Python Programming

- Python Expertise level required
 - Concept of basic programming constructs in Python
 - Packages to be used frequently: Numpy, Matplotlib, Sci-kit learn and Pytorch
- Before next class, install Anaconda (Python 3.7) from
- <https://www.anaconda.com/distribution/>

Summary

- About me
- Course information
- Teaching team
- Learning outcomes
- Course contents and schedule
- Assessments
- Resources
- Lecture 01

Next week

- Academic Writing
- Briefing about Assessment I