

Introduction

CMPE 257 Machine Learning

Prerequisites

- Basic understanding of Linear Algebra, Multivariable Calculus and Probability.
- Familiarity with Python
- Strong organizational and team skills

Projects

Projects are an opportunity to further discussions and exploration through practical experience.

2 Programming assignment and 1 Group project

1. Programming projects – individual
 2. Group project: Team project design and implementation
-
- The project will be evaluated based on Problems Importance, Solutions Novelty, Technical Quality, Degree of Complexity/Efforts Creativity
 - There is a final project presentation.

What is Machine Learning?

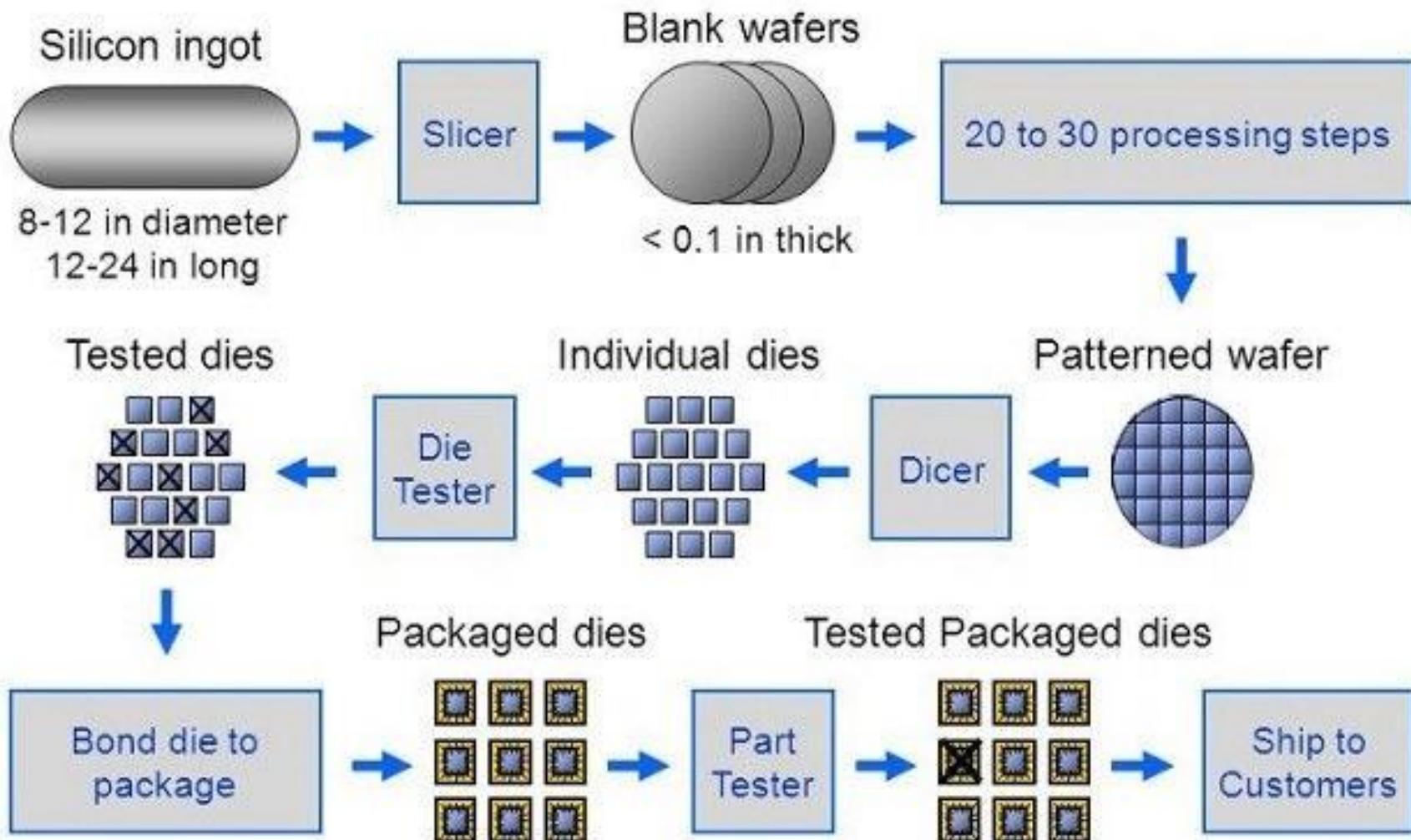
Samuel's definition of ML is still relevant

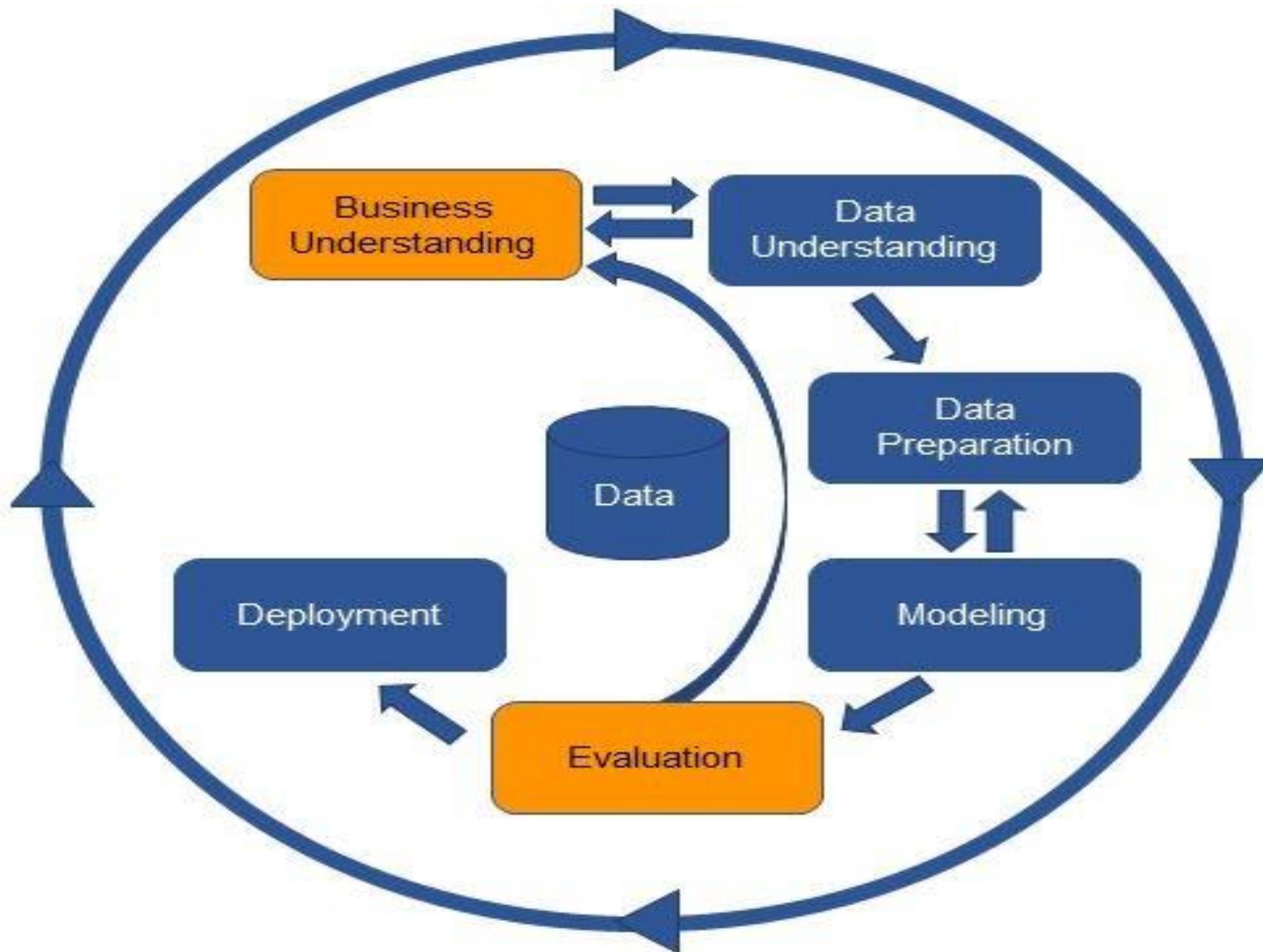
- Arthur Samuel (1959). Machine Learning:
Field of study that gives computers the ability
to learn without being explicitly programmed.

Tom Mitchell (1998): Well-posed Learning Problem

A computer program is said to learn from experience E with respect to some task T and some performance measure P , if its performance on T , as measured by P , improves with experience E .

Finding Hidden Patterns





1940s

Advances in mathematical logic, information theory, concept of neural computation

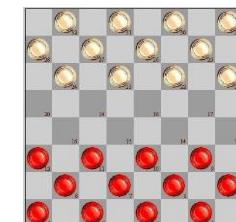
- 1943: McCulloch & Pitts Neuron
- 1948: Shannon: Information Theory
- 1949: Hebbian Learning
 - cells that fire together, wire together



1950s

Early computers. Dartmouth conference coins the phrase “artificial intelligence” and Lisp is proposed as the AI programming language

- 1950: Turing Test
- 1956: Dartmouth Conference
- 1958: Friedberg: Learn Assembly Code



1960s

A.I. funding increased (mainly military). Famous quote: “Within a generation ... the problem of creating 'artificial intelligence' will substantially be solved.”

Early symbolic reasoning approaches.

- Logic Theorist, GPS, Perceptrons
- 1969: Minsky & Papert “Perceptrons”

Ax. 1.	$P(\varphi) \wedge \square \forall x[\varphi(x) \rightarrow \psi(x)] \rightarrow P(\psi)$
Ax. 2.	$P(\neg\varphi) \leftrightarrow \neg P(\varphi)$
Th. 1.	$P(\varphi) \rightarrow \diamond \exists x [\varphi(x)]$
Df. 1.	$G(x) \iff \forall \varphi [P(\varphi) \rightarrow \varphi(x)]$
Ax. 3.	$P(G)$
Th. 2.	$\diamond \exists x G(x)$
Df. 2.	$\varphi \text{ ess } x \iff \varphi(x) \wedge \forall \psi \{\psi(x) \rightarrow \square \forall x[\varphi(x) \rightarrow \psi(x)]\}$
Ax. 4.	$P(\varphi) \rightarrow \square P(\varphi)$
Th. 3.	$G(x) \rightarrow G \text{ ess } x$
Df. 3.	$E(x) \iff \forall \varphi [\varphi \text{ ess } x \rightarrow \square \exists x \varphi(x)]$
Ax. 5.	$P(E)$
Th. 4.	$\square \exists x G(x)$

1970s

A.I. “winter” – Funding dries up as people realize this is a hard problem!

Limited computing power and dead-end frameworks lead to failures.

- eg: Machine Translation Failure

1980s

Rule based “expert systems” used in medical / legal professions.
Bio-inspired algorithms (Neural networks, Genetic Algorithms).

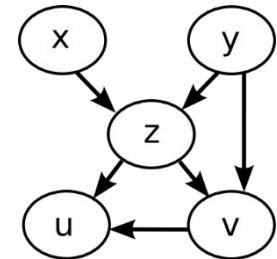
Again: A.I. promises the world – lots of commercial investment

Expert Systems (Mycin, Dendral, EMYCIN)

Knowledge Representation and reasoning:

Frames, Eurisko, Cyc, NMR, fuzzy logic

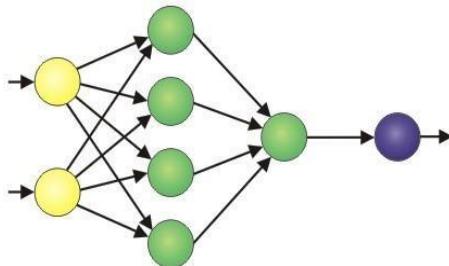
Speech Recognition (HEARSAY, HARPY, HWIM)



ML:

$$P(A|B) = \frac{P(B|A) P(A)}{P(B)}.$$

- 1982: Hopfield Nets, Decision Trees, GA & GP.
- 1986: Backpropagation, Explanation-Based Learning

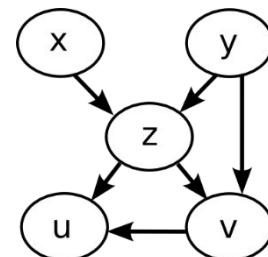
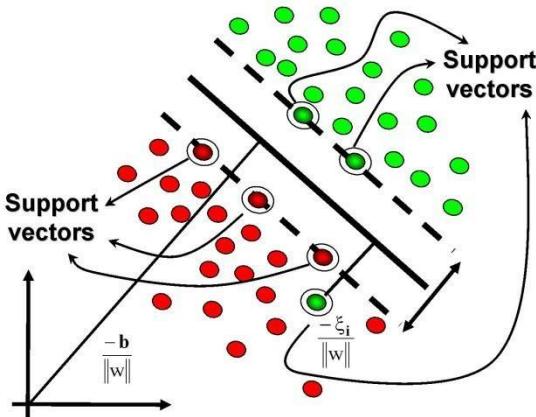


1990s

Some concrete successes begin to emerge. AI diverges into separate fields: Computer Vision, Automated Reasoning, Planning systems, Natural Language processing, **Machine Learning**...

...Machine Learning begins to overlap with statistics / probability theory.

- 1992: Koza & Genetic Programming
- 1995: Vapnik: Support Vector Machines

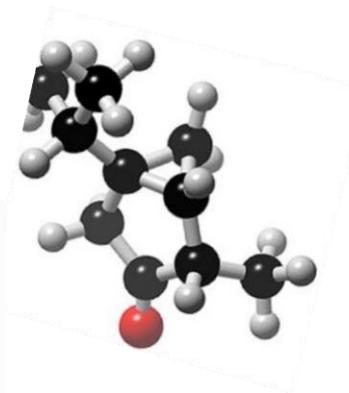


$$P(A|B) = \frac{P(B|A) P(A)}{P(B)}.$$

2000s

First commercial-strength applications: Google, Amazon, computer games, route-finding, credit card fraud detection, spam filters, etc...

Tools adopted as standard by other fields e.g. biology



- Using machine learning to recommend books.

Amazon.co.uk: Recommended For You - Mozilla Firefox

File Edit View History Bookmarks Tools Help

Facebook | Home | Dr Gavin Brown | Feature Selection - Fro... | Nouveau Port AI AFIA ... | Graduate Research, Wri... | Twenty-One Suggestio... | A Quick & Dirty Guide t...

amazon.co.uk Hello Gavin Brown. We have recommendations for you. (Not Gavin?)

Gavin's Amazon.co.uk | Deals of the Week | Gift Certificates | Gifts & Wish Lists

Shop All Departments Search All Departments Go Basket

Gavin's Amazon.co.uk Page You Made Recommended For You Rate These Items Improve Your Recommendations Your Profile Learn More

Gavin's Amazon.co.uk > Recommended for you
(If you're not Gavin Brown, click here.)

Just For Today These recommendations are based on items you own and more.
view: All | New Releases | Coming Soon More results

Recommendations

- Baby Books
- DIY & Tools
- DVD
- Electronics & Computing
- Garden & Outdoors
- Health & Beauty
- Home & Garden
- Jewellery
- MP3 Downloads
- Music
- PC & Video Games
- Shoes & Accessories
- Software
- Sports & Leisure
- Toys & Games
- Video
- Watches

1. **Bad Science**
by Ben Goldacre (April 2, 2009)
Average Customer Review: ★★★★ (181)
In stock
RRP: £8.99
Price: £3.60 Add to Basket Add to Wish List
31 used & new from £1.99
 I own it Not interested Rate this item
Recommended because you purchased **Outliers: The Story of Success** and more (Fix this)

2. **Irrationality**
by Stuart Sutherland (Jan 10, 2007)
Average Customer Review: ★★★★ (31)
In stock
RRP: £8.99
Price: £6.99 Add to Basket Add to Wish List
36 used & new from £3.50
 I own it Not interested Rate this item
Recommended because you purchased **Outliers: The Story of Success** and more (Fix this)

3. **LOOK INSIDE!** **Blink: The Power of Thinking Without Thinking**
by Malcolm Gladwell (Feb 23, 2006)
Average Customer Review: ★★★★ (88)
In stock

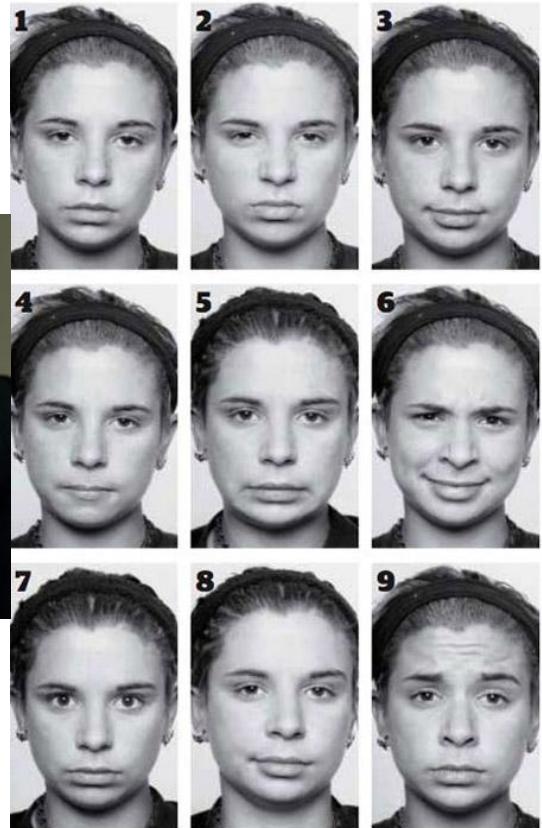
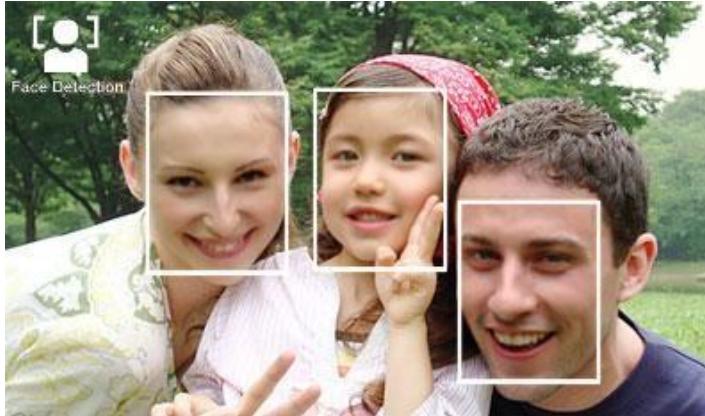
ALGORITHMS

Collaborative Filtering

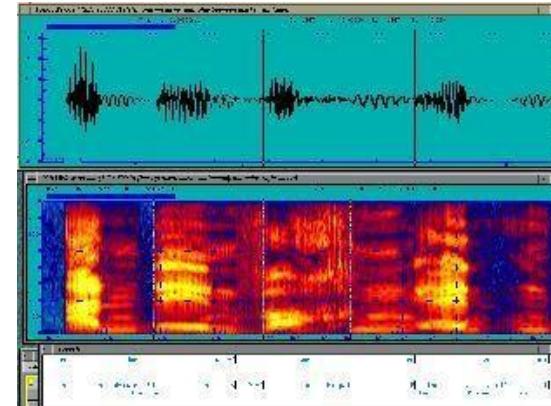
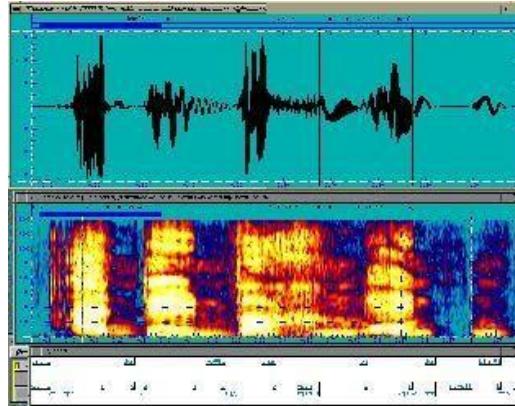
Nearest Neighbour

Clustering

- Using machine learning to identify faces and expressions.



- Using machine learning to identify vocal patterns



ALGORITHMS
Feature Extraction
Probabilistic Classifiers
Support Vector Machines
+ many more....

- ML for working with social network data: detecting fraud, predicting click-thru patterns, targeted advertising, etc etc etc .



ALGORITHMS

**Support Vector Machines
Collaborative filtering
Rule mining algorithms
Many many more....**

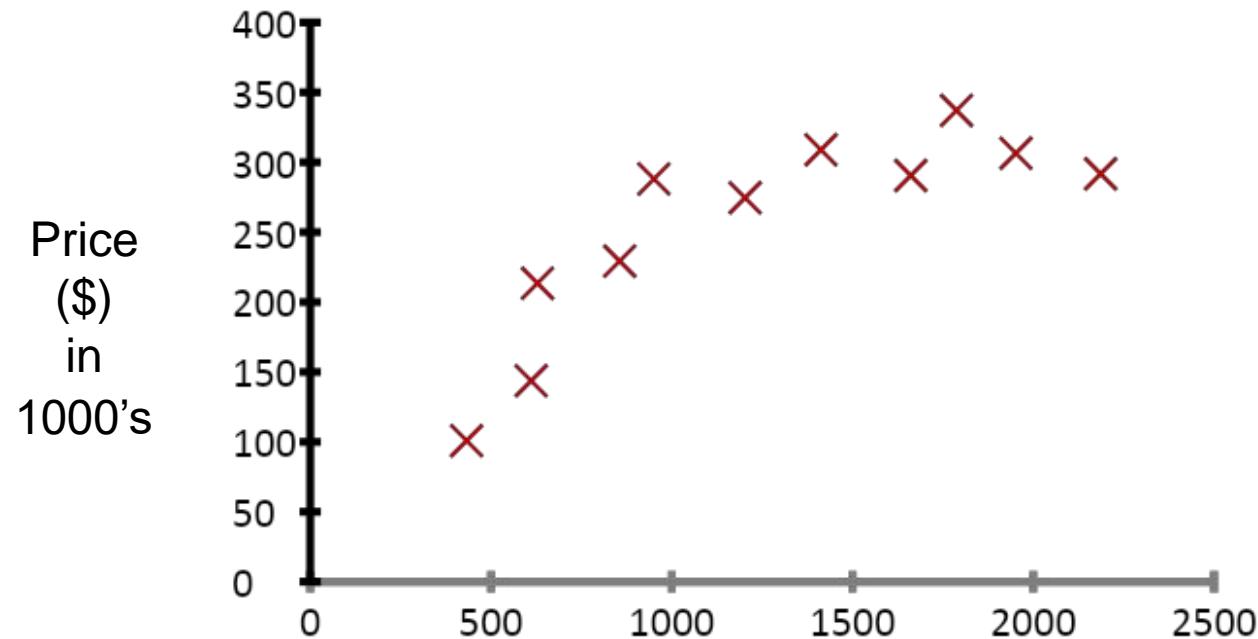
Machine learning

- Supervised Learning
 - Classification
 - Regression
- Unsupervised learning

Others: Reinforcement learning, recommender systems.

Also talk about: Practical advice for applying learning algorithms.

Housing price prediction.

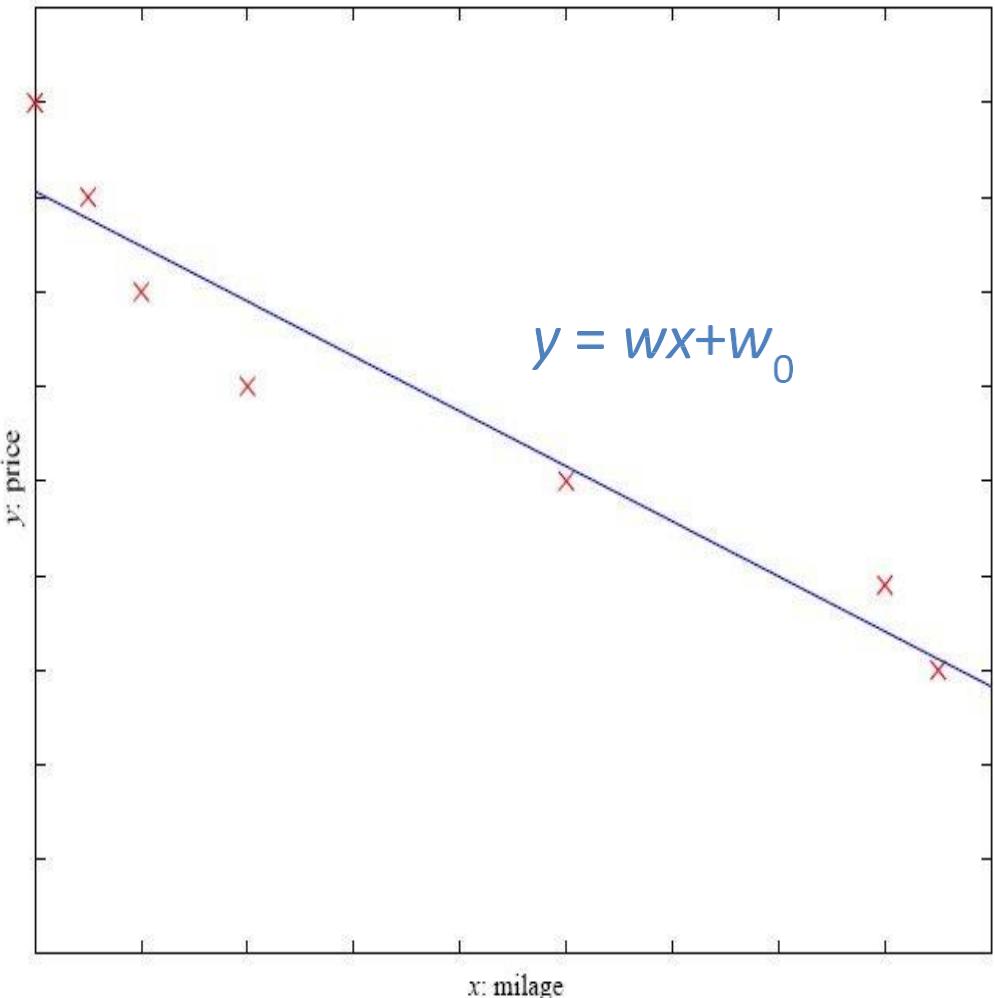


Supervised Learning
“right answers” given

Regression: Predict continuous
valued output (price)

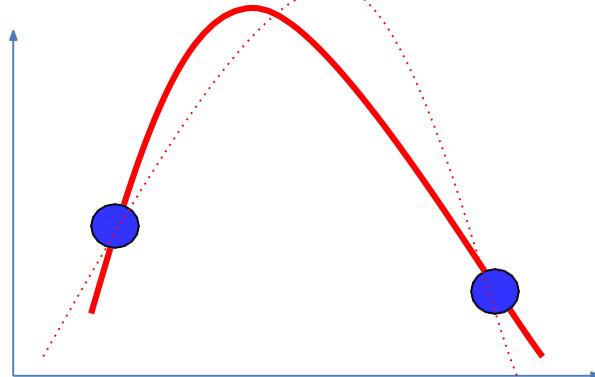
Regression

- Example: Price of a used car
- x : car attributes
 y : price
$$y = g(x \mid \theta)$$
$$g(\cdot) \text{ model,}$$
$$\theta \text{ parameters}$$

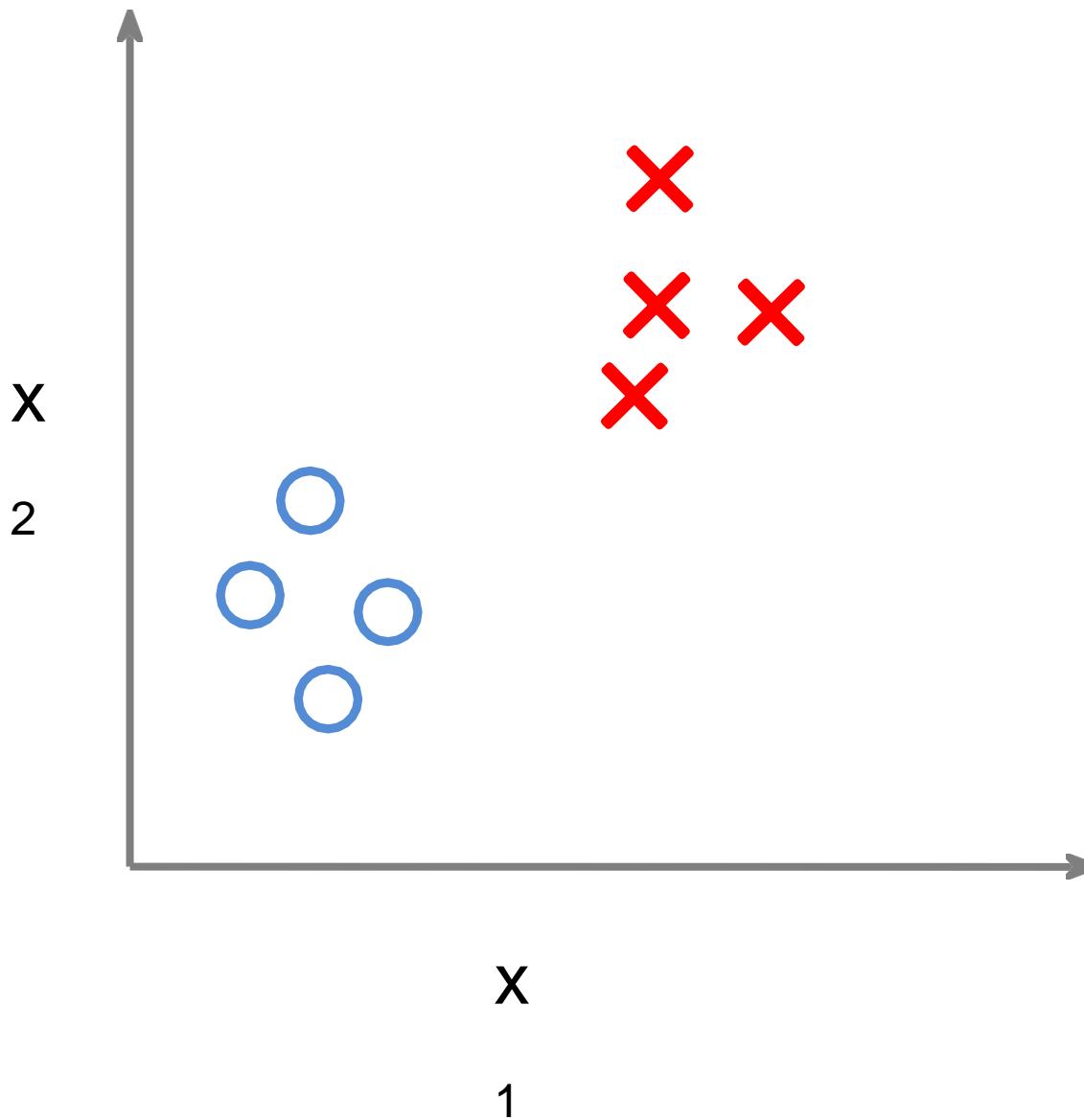


Regression Applications

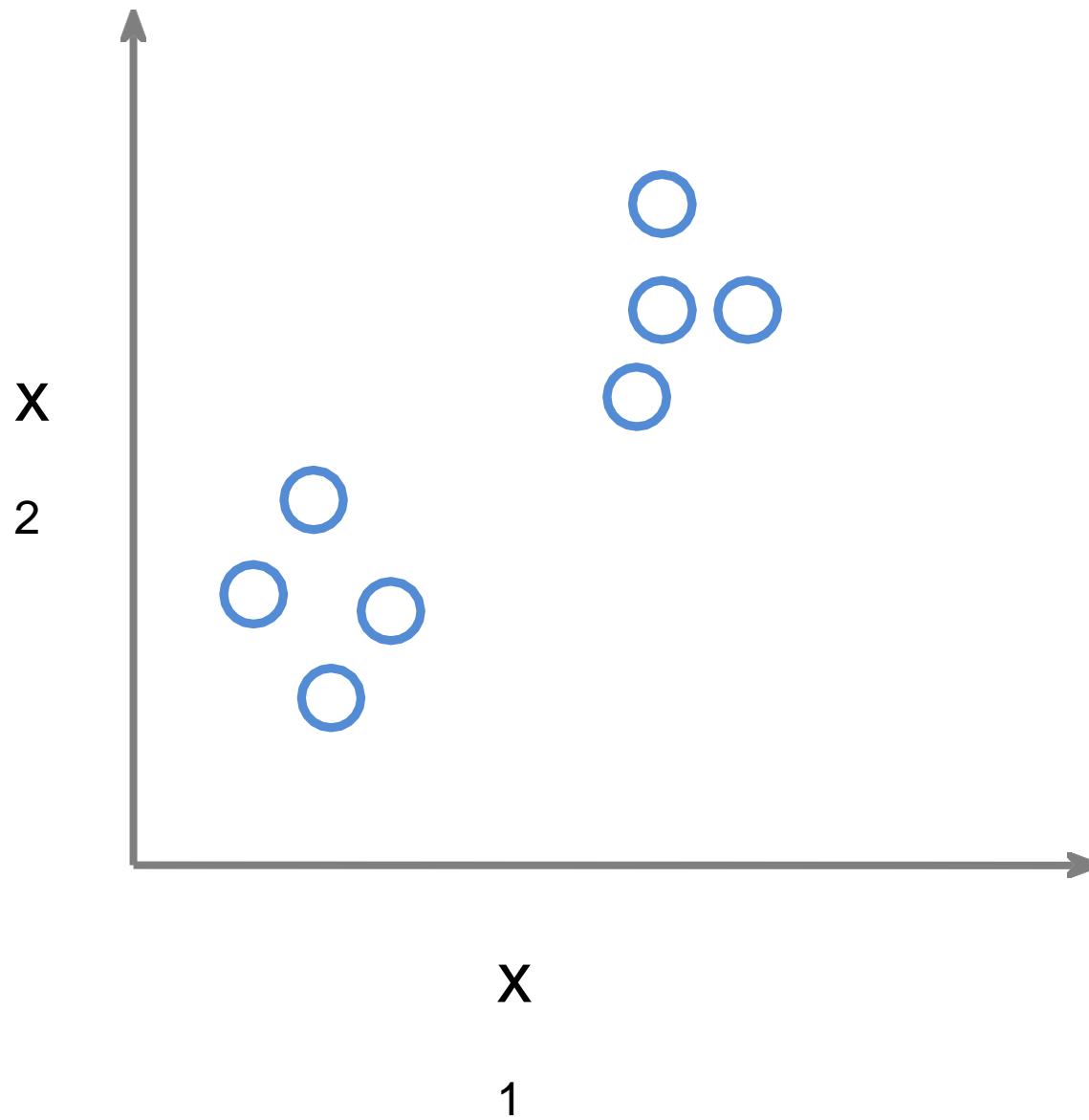
- Navigating a car: Angle of the steering
- Kinematics of a robot arm



Supervised Learning



Unsupervised Learning

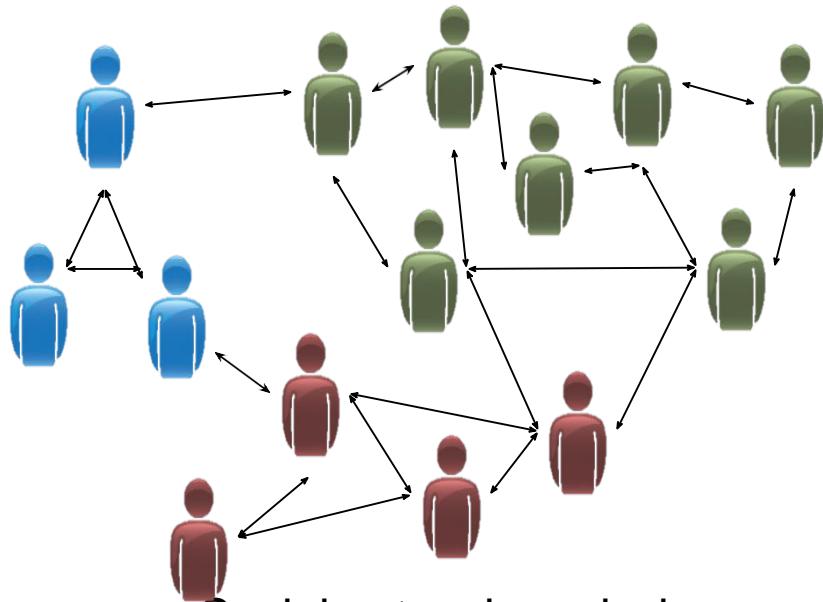


Unsupervised Learning

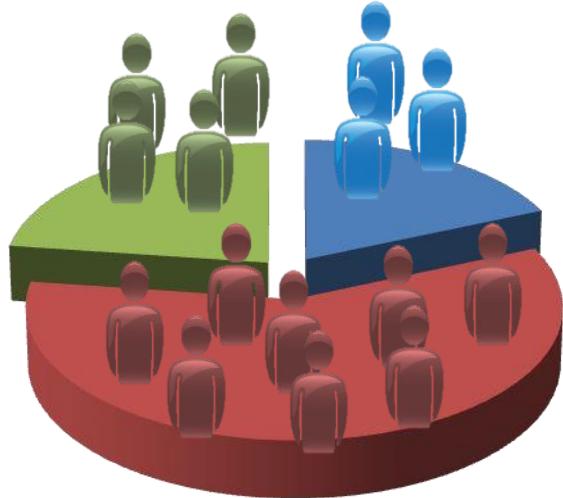
- Learning “what normally happens”
- Clustering: Grouping similar instances
- Example applications
 - Customer segmentation
 - Image compression: Color quantization
 - Bioinformatics: Learning motifs



Organize computing clusters



Social network analysis



Market segmentation

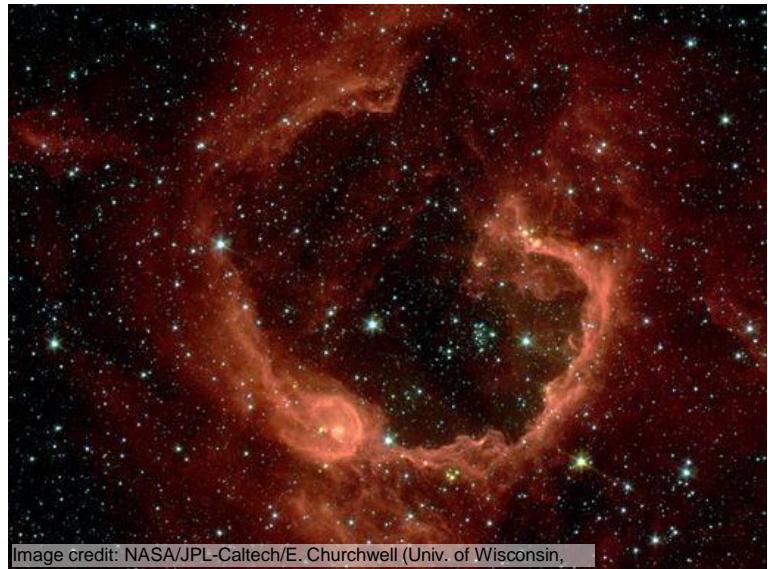


Image credit: NASA/JPL-Caltech/E. Churchwell (Univ. of Wisconsin, Madison)

Astronomical data analysis

Reinforcement Learning

- Learning a policy: A sequence of outputs
- No supervised output but delayed reward
- Credit assignment problem
- Game playing
- Robot in a maze
- Multiple agents, partial observability, ...

Autonomous Driving

<https://www.youtube.com/watch?v=mj4QLsemKEY>

<https://www.youtube.com/watch?v=GMvgtPN2IBU>

Keynote from Jeff Dean

<https://www.youtube.com/watch?v=ZH0NF28Nj98>

Resources: Journals

- Journal of Machine Learning Research www.jmlr.org
- Machine Learning
- Neural Computation
- Neural Networks
- IEEE Transactions on Neural Networks
- IEEE Transactions on Pattern Analysis and Machine Intelligence
- Annals of Statistics
- Journal of the American Statistical Association
- ...

Resources: Conferences

- International Conference on Machine Learning (ICML)
- European Conference on Machine Learning (ECML)
- Neural Information Processing Systems (NIPS)
- Uncertainty in Artificial Intelligence (UAI)
- Computational Learning Theory (COLT)
- International Conference on Artificial Neural Networks (ICANN)
- International Conference on AI & Statistics (AISTATS)
- International Conference on Pattern Recognition (ICPR)
- ...