
CSE711

Symbolic Machine Learning I

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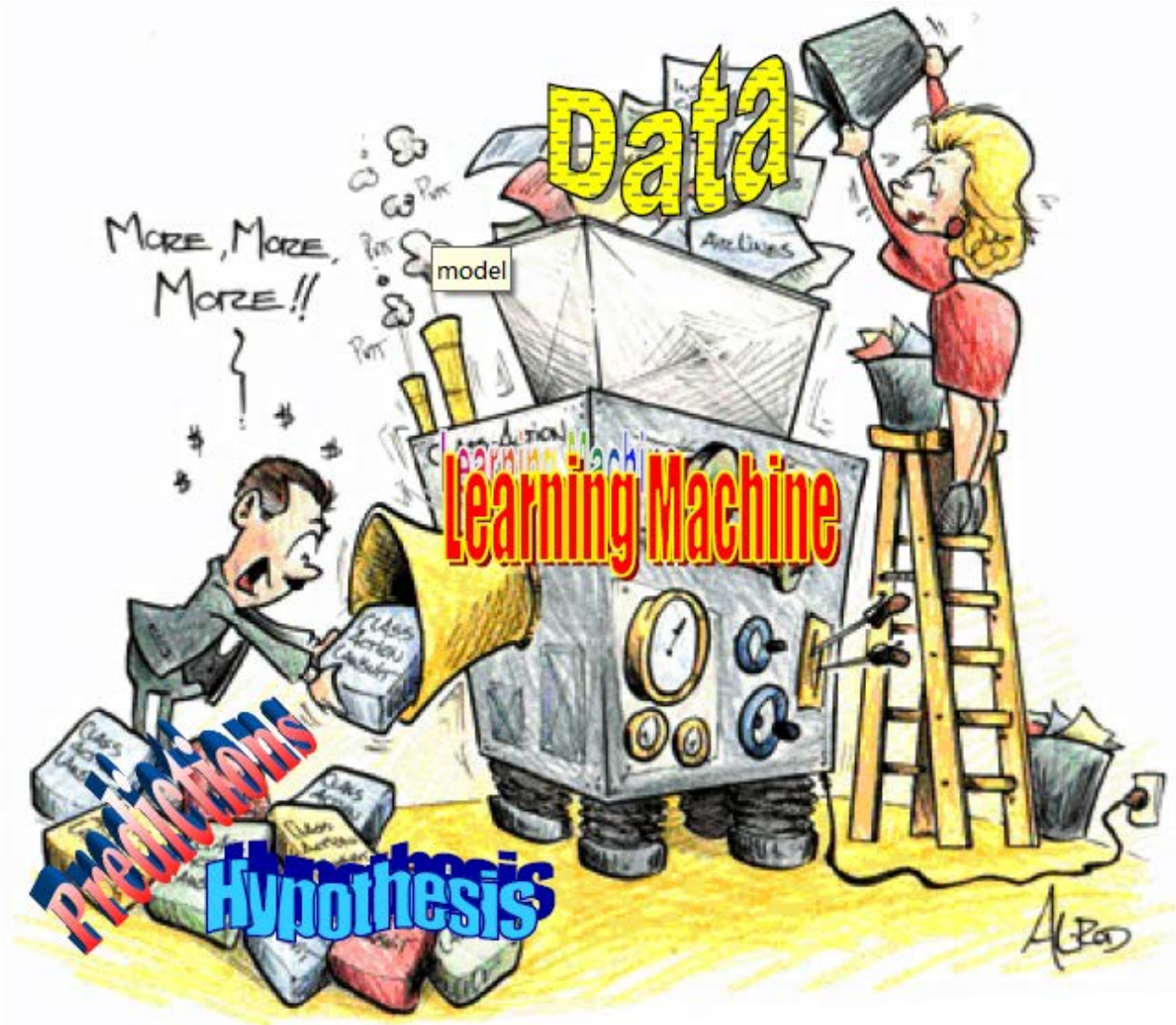
Lecture Outline

- Machine Learning
- Machine Learning Applications
- Supervised Learning
- Unsupervised Learning
- Reinforcement Learning
- Symbolic Machine Learning
- Conclusion

Machine Learning

Machine learning is an application of **artificial intelligence** (AI) that provides systems the ability to automatically learn and improve from experience **without being explicitly programmed**.

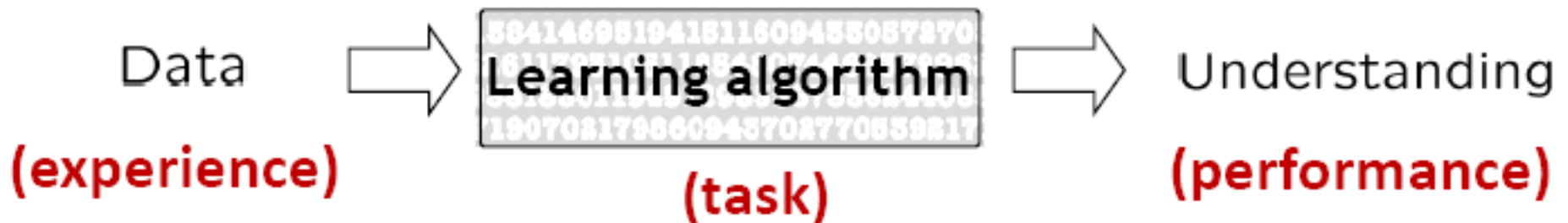
What is Machine Learning?



What is Machine Learning?

Study of algorithms that

- improve their performance
- at some task
- with experience



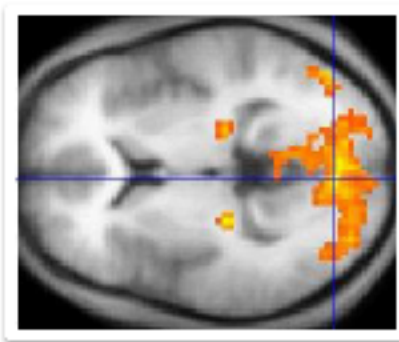
What is Machine Learning?

From Data to Understanding ...

Machine Learning in Action

Machine Learning in Action

- Decoding thoughts from brain scans



Rob a bank ...

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Brain Scans: Are You a Criminal?



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MRI Scans as Courtroom Evidence

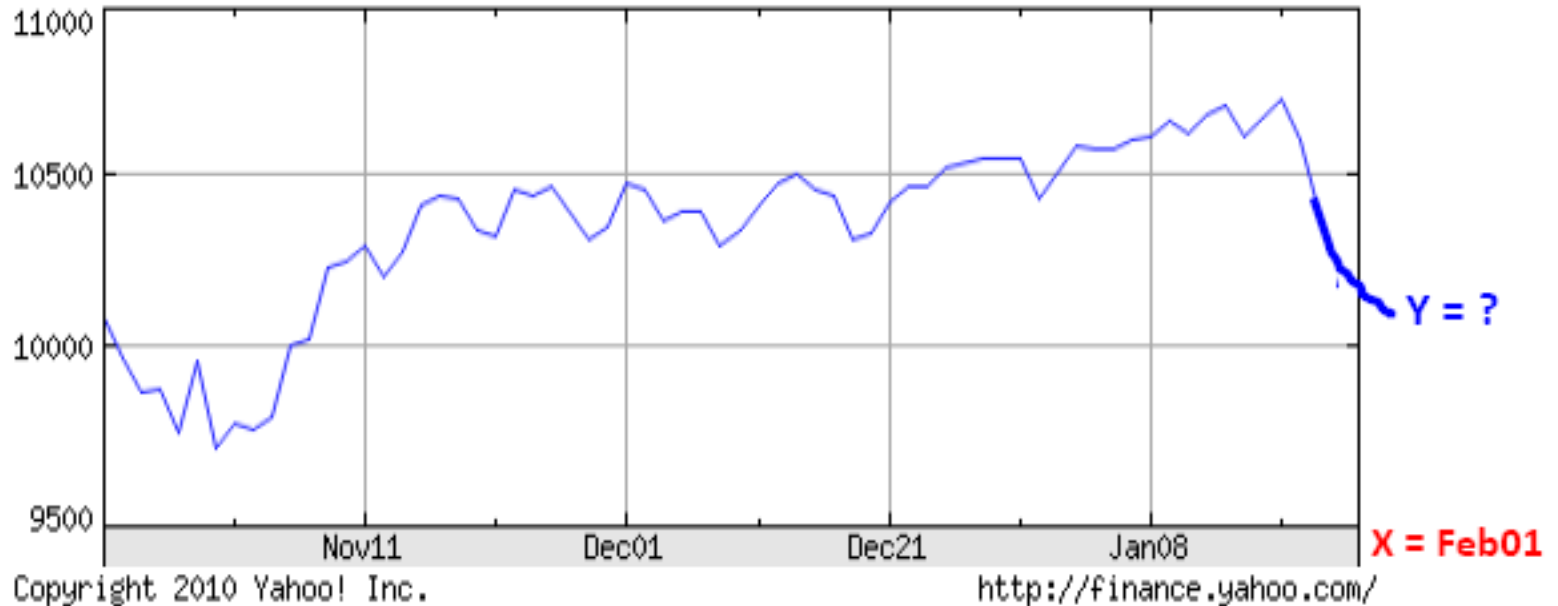
The average Joe's MRI scan can show a brain abnormality, do we proceed to check him into the nearest mental institution or prison? That would make about as much sense as trying to prove a defendant innocent of a violent



Machine Learning in Action

- Stock Market Prediction

DJ INDU AVERAGE (DOW JONES & CO
as of 22-Jan-2010



Machine Learning in Action

- Document Classification



Sports
Science
News

Machine Learning in Action

Welcome to New Media Installation: Art that Learns

Hi everyone,

Welcome to New Media Installation: Art that Learns

The class will start tomorrow.

Make sure you attend the first class, even if you are on the Wait List.

The classes are held in Doherty Hall C316, and will be Tue, Thu 01:30-4:20 PM.

By now, you should be subscribed to our course mailing list: 10615-announce@cs.cmu.edu.

Natural _LoseWeight SuperFood Endorsed by Oprah Winfrey, Free Trial 1 bottle, pay only \$5.95 for shipping mfw rlk Spam | X

=== Natural WeightLOSS Solution ===

Vital Acai is a natural WeightLOSS product that Enables people to lose wieght and cleansing their bodies faster than most other products on the market.

Here are some of the benefits of Vital Acai that You might not be aware of. These benefits have helped people who have been using Vital Acai daily to Achieve goals and reach new heights in there dieting that they never thought they could.



Spam/
Not spam

Machine Learning in Action

- Cars navigation on their own



The self-driving SUV 1st place in the
DARPA Urban Challenge

Machine Learning in Action

- Helicopters can learn aerial tricks by watching other helicopters perform the stunts first



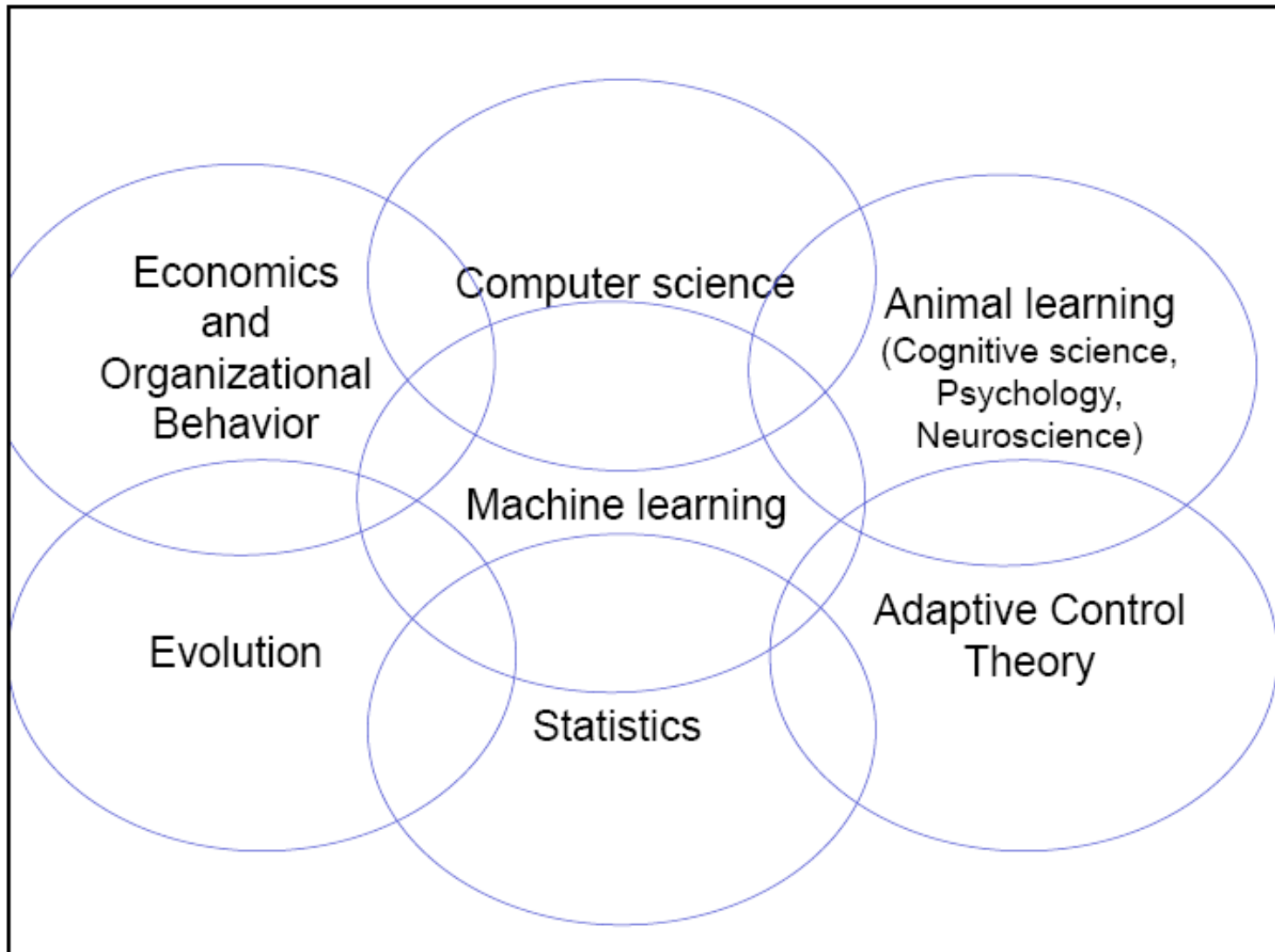
Machine Learning in Action

- Many, many more...
 - Speech recognition, Natural language processing
 - Computer vision
 - Medical outcomes analysis
 - Sensor networks
 - Social networks
 - ...

ML is trending!

- Wide applicability
- Very large-scale complex systems
 - Internet (billions of nodes), sensor network...
- Huge multi-dimensional data sets
 - 30000 genes x 10000 drugs x 100 species x ...
- Software too complex to write by hand
- Demand for self-customization to user, environment

ML is not isolated!



Machine Learning Tasks

Broad categories-

- **Supervised learning:** classification, regression
- **Unsupervised learning:** Clustering, density estimation
- Semi-supervised learning
- Online learning
- Reinforcement learning
- Many more...

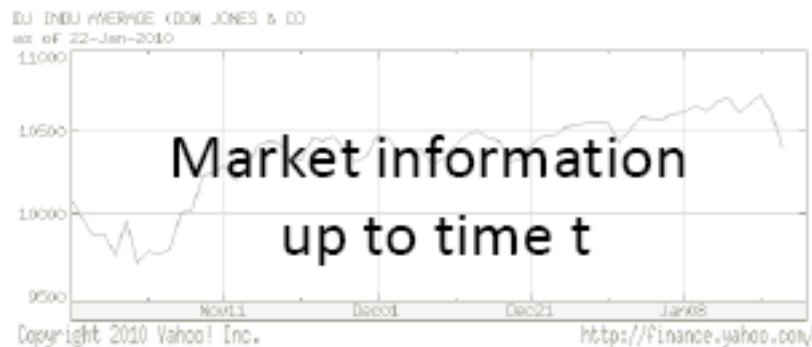
Supervised Learning

Feature Space \mathcal{X}



Label Space \mathcal{Y}

"Sports"
"News"
"Science"
...



Share Price
"\$ 24.50"

Task: Given $X \in \mathcal{X}$, predict $Y \in \mathcal{Y}$.

Supervised Learning - Classification

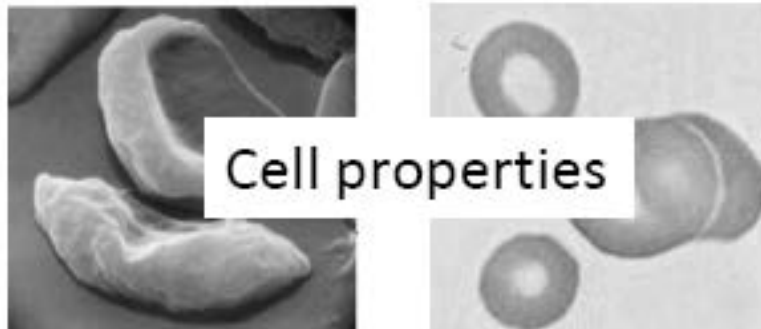
Feature Space \mathcal{X}



Label Space \mathcal{Y}



"Sports"
"News"
"Science"
...



"Anemic cell"
"Healthy cell"

Discrete Labels

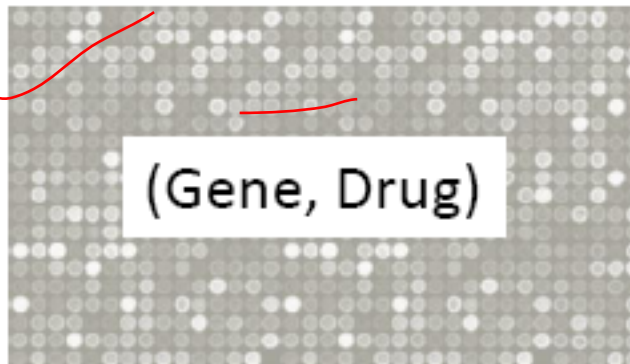
Supervised Learning - Regression

Feature Space \mathcal{X}



Label Space \mathcal{Y}

Share Price
"\$ 24.50"



Expression level
"0.01"









Continuous Labels

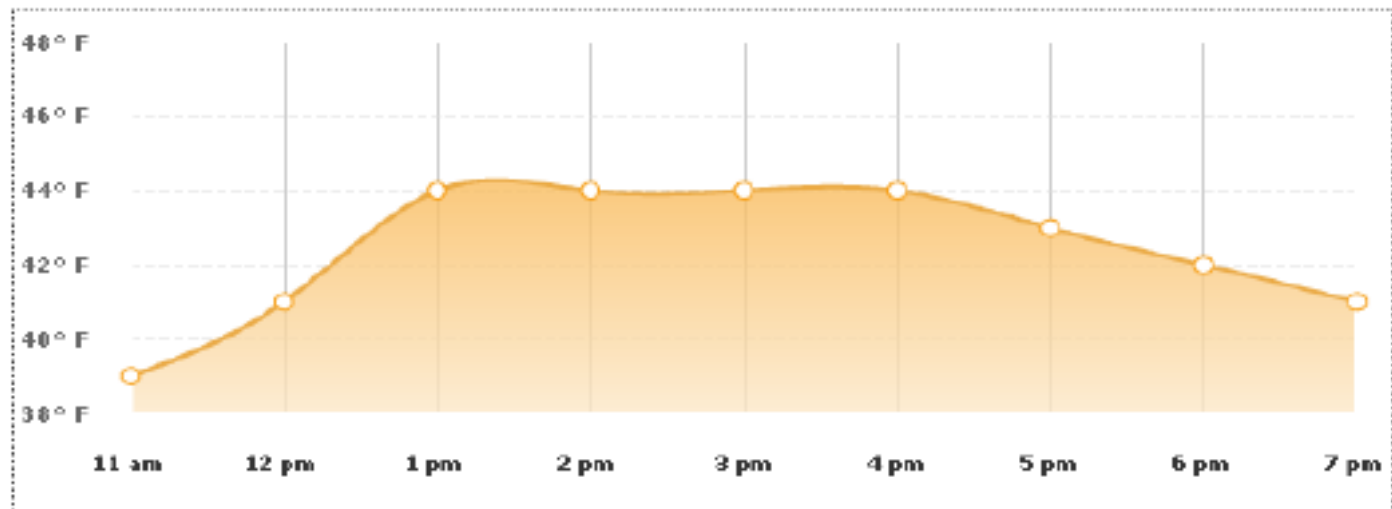
Supervised Learning Problems

Features?

Labels?

Classification/Regression?

11 am	12 pm	1 pm	2 pm	3 pm	4 pm	5 pm	6 pm
							
39° F	41° F	44° F	44° F	44° F	44° F	43° F	42° F
Precip: 10%	Precip: 10%	Precip: 10%	Precip: 10%	Precip: 10%	Precip: 10%	Precip: 10%	Precip: 0%



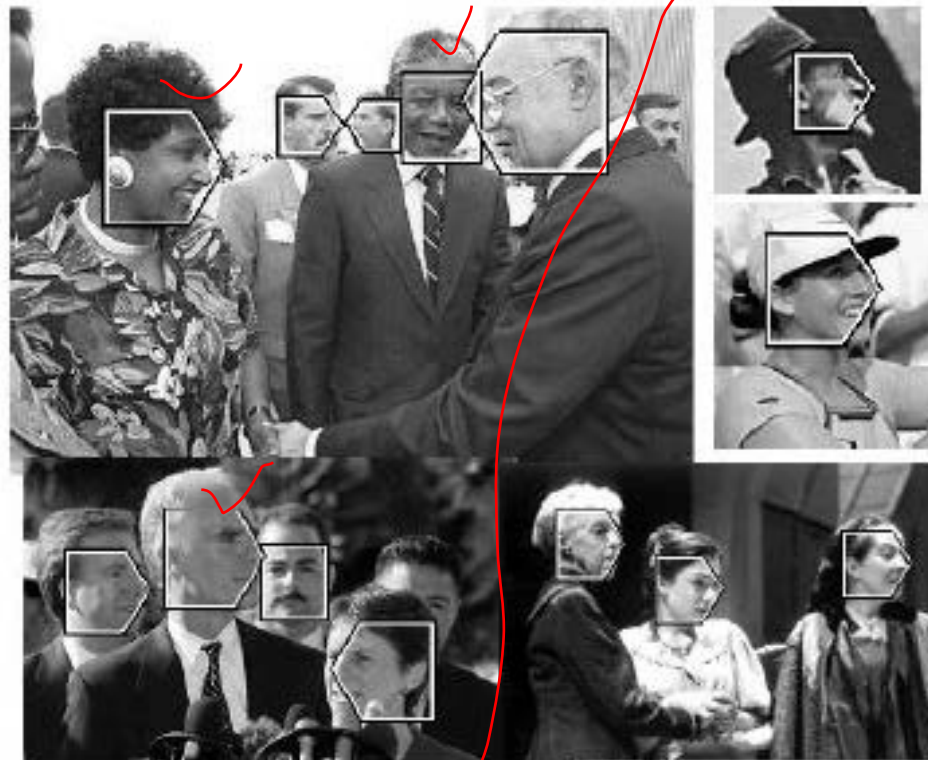
Temperature/Weather prediction

Supervised Learning Problems

Features?

Labels?

Classification/Regression?



Face Detection

Supervised Learning Problems

Features?

Labels?

Classification/Regression?



Robotic Control

Supervised Learning

- **Data:** A set of data records (also called examples, instances or cases) described by
 - k attributes: $A_1, A_2, \dots A_k$.
 - a class: Each example is labelled with a pre-defined class.
- **Goal:** To learn a **classification/regression model** from the data that can be used to predict the classes/values of new (future, or test) cases/instances.

Unsupervised Learning

- Learning without a teacher

Feature Space \mathcal{X}



Words in a document

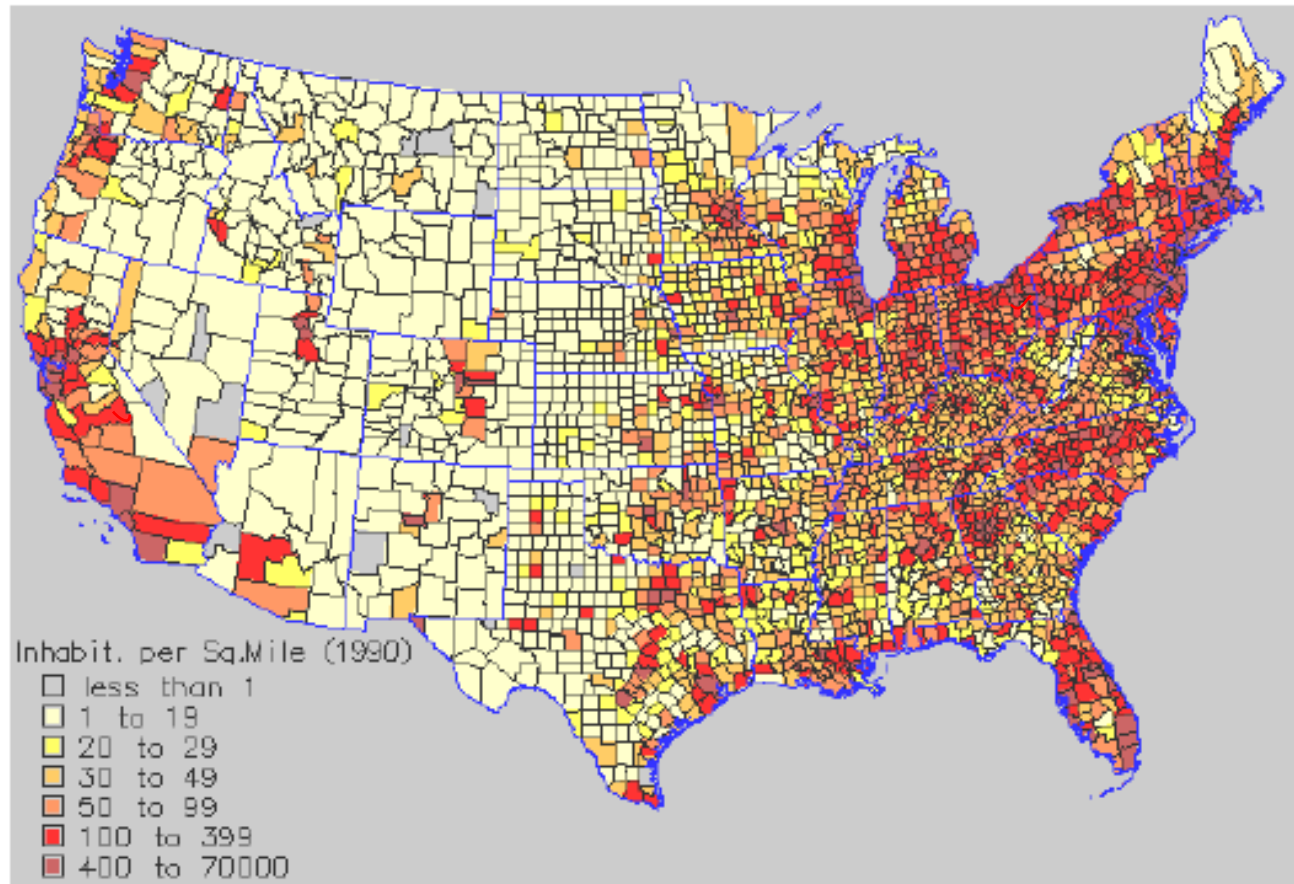


Word distribution
(Probability of a word)

Task: Given $X \in \mathcal{X}$, learn $f(X)$.

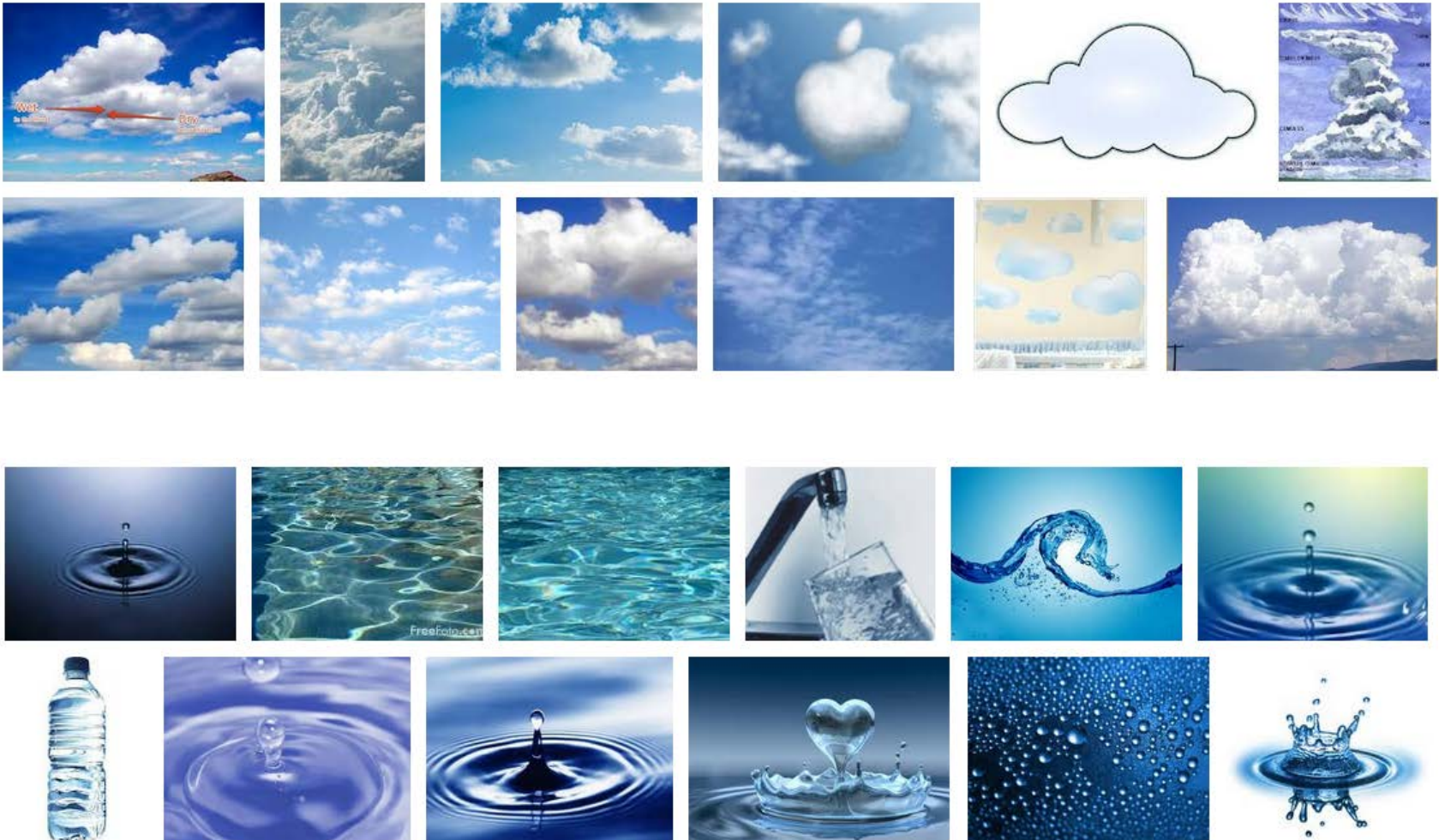
Unsupervised Learning - Density Estimation

Population density



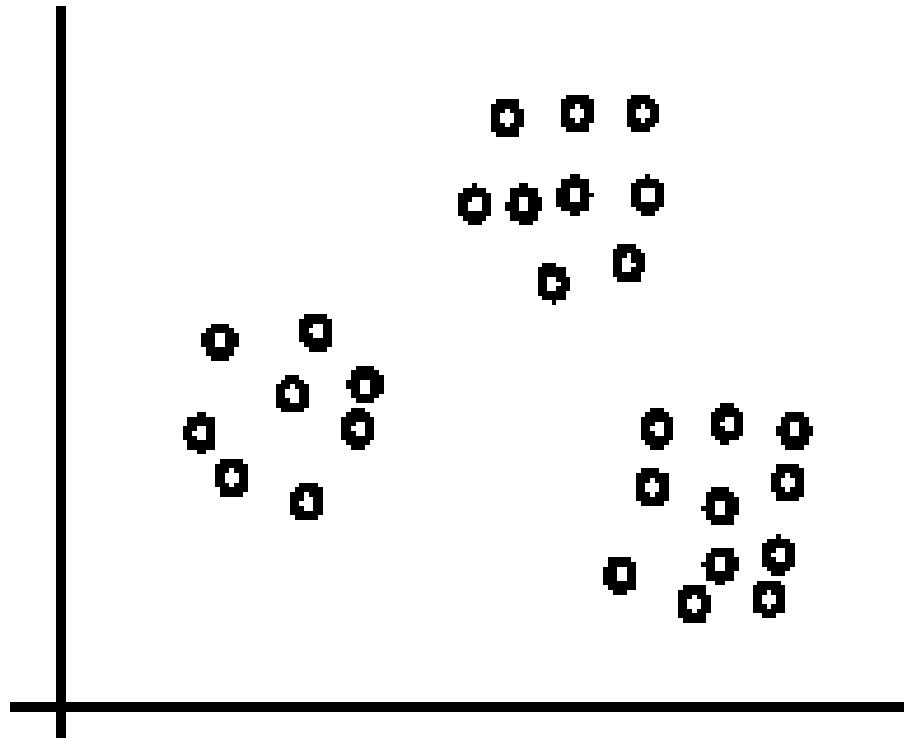
Unsupervised Learning - Clustering

- Group similar things e.g. images



Unsupervised Learning - Clustering

- The data set has three natural groups of data points, i.e., 3 natural clusters.



Symbolic ML

- The ML methods, which represents learned knowledge in a declarative symbolic form is called Symbolic ML. Example: Decision trees, Random forests, K-NN, and RL
- The ML methods, which represents learned knowledge more numerically oriented statistical or neural network form is called Non-symbolic ML. Example: NB, SVM, NN.

Approaches of Symbolic ML

- Top-down induction based learning: Decision trees

- Instance based learning: Categorize new examples based on the similarity of existing instance.

Example: K-NN

- Rule induction based learning: learning through propositional and 1st order logic.

uncle(Tom, Frank), uncle(Bob, John), \neg uncle(Tom, Cindy), \neg uncle(Bob, Tom)

parent(Bob, Frank), parent(Cindy, Frank), parent(Alice, John), parent(Tom, John),

brother(Tom, Cindy), sister(Cindy, Tom), husband(Tom, Alice), husband(Bob, Cindy).

- Reinforcement learning

What this course is about

- Covers a wide range of ML techniques
 - from basic to state-of-the-art
- You will learn about the methods you heard about
 - Decision trees, Random forests, Naive Bayes, logistic regression, k-nearest-neighbor, boosting, dimensionality reduction, PCA, SVMs, kernels, k-means, EM, HMMs, semi-supervised learning, graphical models, reinforcement learning.
- Covers algorithms, theory and applications

Reference Books

- Machine Learning, Tom Mitchell, McGraw Hill, 1997
- * • Sebastian Raschka, Vahid Mirjalili - Python Machine Learning. Machine Learning and Deep Learning with Python, scikit-learn and Tensor Flow (2017, Packt)
- Stuart Russell and Peter Norvig: Artificial Intelligence: A Modern Approach, Prentice Hall 2010