

## Why are you here?

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What is Machine Learning?

Why are you taking this course?

What topics would you like to see covered?

## Machine Learning is...

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Machine learning is a subfield of computer science that evolved from the study of pattern recognition and computational learning theory in artificial intelligence.

WIKIPEDIA  
The Free Encyclopedia

## Machine Learning is...

Machine learning is programming computers to optimize a performance criterion using example data or past experience.

-- Ethem Alpaydin

The goal of machine learning is to develop methods that can automatically detect patterns in data, and then to use the uncovered patterns to predict future data or other outcomes of interest.

-- Kevin P. Murphy

The field of pattern recognition is concerned with the automatic discovery of regularities in data through the use of computer algorithms and with the use of these regularities to take actions.

-- Christopher M. Bishop

## Machine Learning is...

Machine learning is about predicting the future based on the past.

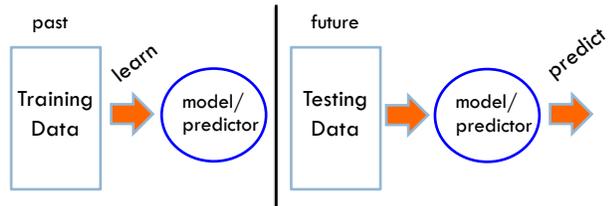
-- Hal Daume III



## Machine Learning is...

Machine learning is about predicting the future based on the past.

-- Hal Daume III



## Machine Learning, aka

*data mining*: data analysis, not prediction, though often involves some shared techniques

*inference and/or estimation* in statistics

*pattern recognition* in engineering

*signal processing* in electrical engineering

*induction*

*optimization*

## Goals of the course: learn about...

Different machine learning problems

Common techniques/tools used

- ▣ theoretical understanding
- ▣ practical implementation

Proper experimentation and evaluation

Dealing with large (huge) data sets

- ▣ Parallelization frameworks
- ▣ Programming tools

## Goals of the course



Be able to laugh at these signs  
(or at least know why one might...)

## Administrative

Course page:

<http://www.cs.pomona.edu/classes/cs158/>

Assignments

- ▣ Weekly
- ▣ Mostly programming (Java, mostly)
- ▣ Some written/write-up
- ▣ Generally due Sunday evenings

Two "midterm" exams and one final

Late Policy

Collaboration

## Course expectations

Plan to stay busy!

Applied class, so lots of programming

Machine learning involves math

## Other things to note

Videos before class

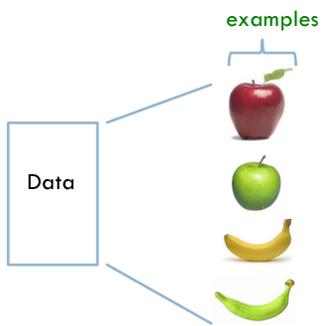
Lots of class participation!

Read the book (it's good)

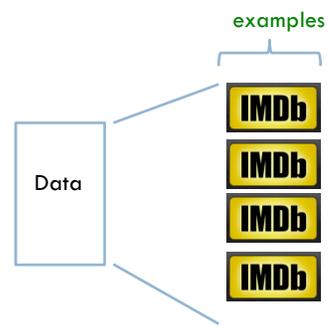
## Machine learning problems

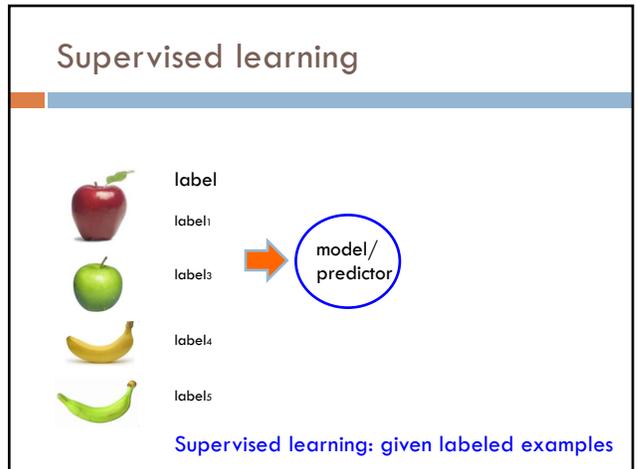
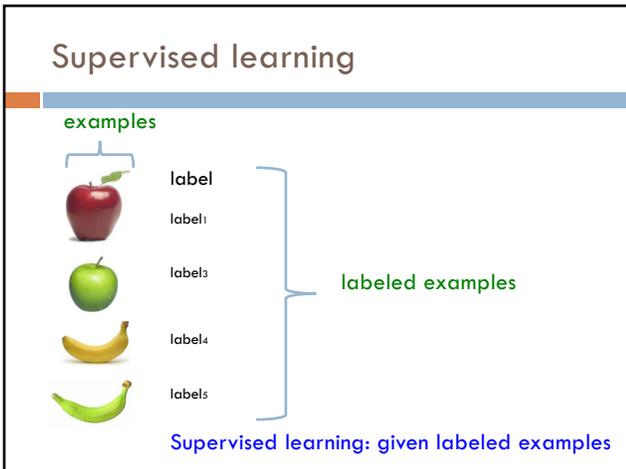
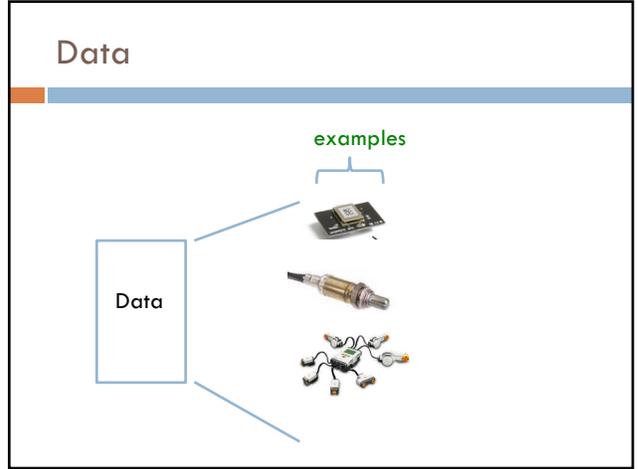
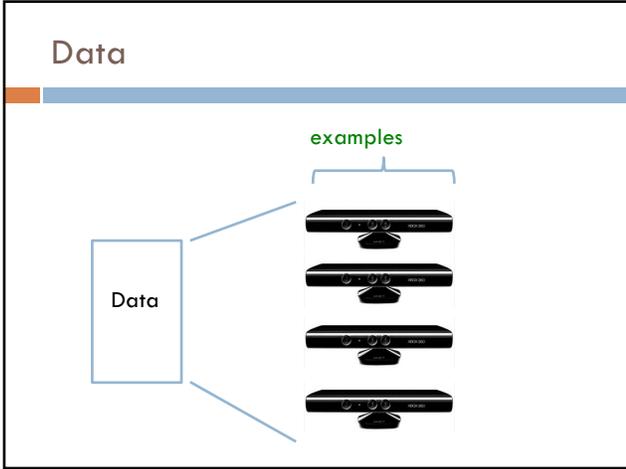
What high-level machine learning problems have you seen or heard of before?

## Data

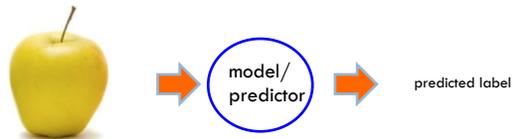


## Data



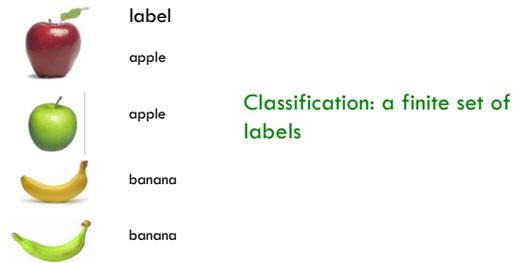


## Supervised learning



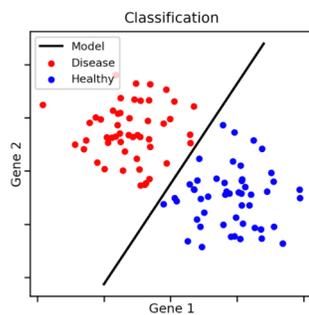
Supervised learning: learn to predict new example

## Supervised learning: classification



Supervised learning: given labeled examples

## Classification Example



## Classification Applications

Face recognition

Character recognition

Spam detection

Medical diagnosis: From symptoms to illnesses

Biometrics: Recognition/authentication using physical and/or behavioral characteristics: Face, iris, signature, etc

...

## Supervised learning: regression

	label	
	-4.5	Regression: label is real-valued
	10.1	
	3.2	
	4.3	

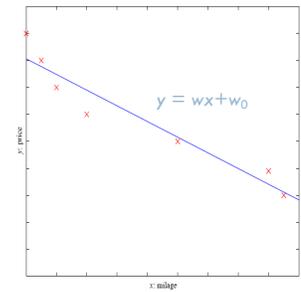
Supervised learning: given labeled examples

## Regression Example

Price of a used car

$x$  : car attributes  
(e.g. mileage)

$y$  : price



## Regression Applications

Economics/Finance: predict the value of a stock

Epidemiology

Car/plane navigation: angle of the steering wheel, acceleration, ...

Temporal trends: weather over time

...

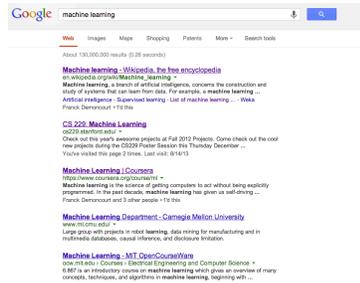
## Supervised learning: ranking

	label	
	1	Ranking: label is a ranking
	4	
	2	
	3	

Supervised learning: given labeled examples

## Ranking example

Given a query and  
a set of web pages,  
rank them according  
to relevance



## Ranking Applications

User preference, e.g. Netflix "My List" -- movie queue ranking

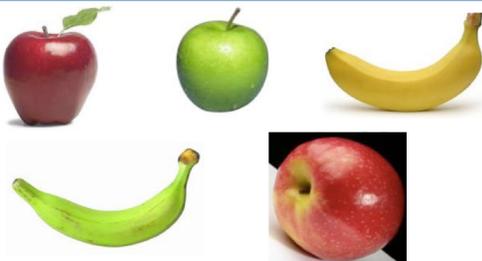
iTunes

flight search (search in general)

reranking N-best output lists

...

## Unsupervised learning



Unsupervised learning: given data, i.e. examples, but no labels

## Unsupervised learning applications

learn clusters/groups without any label

customer segmentation (i.e. grouping)

image compression

bioinformatics: learn motifs

...

## Reinforcement learning

left, right, straight, left, left, left, straight **GOOD**

left, straight, straight, left, right, straight, straight **BAD**

left, right, straight, left, left, left, straight **18.5**

left, straight, straight, left, right, straight, straight **-3**

Given a **sequence** of examples/states and a **reward** after completing that sequence, learn to predict the action to take for an individual example/state

## Reinforcement learning example

Backgammon



Given sequences of moves and whether or not the player won at the end, learn to make good moves

## Reinforcement learning example



[https://www.youtube.com/watch?v=W\\_axLKsSjE](https://www.youtube.com/watch?v=W_axLKsSjE)

## Other learning variations

What data is available:

- Supervised, unsupervised, reinforcement learning
- semi-supervised, active learning, ...

How are we getting the data:

- online vs. offline learning

Type of model:

- generative vs. discriminative
- parametric vs. non-parametric

## Representing examples

examples

What is an example?  
How is it represented?

## Features

examples

features

$f_1, f_2, f_3, \dots, f_n$

How our algorithms actually "view" the data

Features are the questions we can ask about the examples

## Features

examples

features

red, round, leaf, 3oz, ...

green, round, no leaf, 4oz, ...

yellow, curved, no leaf, 8oz, ...

green, curved, no leaf, 7oz, ...

How our algorithms actually "view" the data

Features are the questions we can ask about the examples

## Classification revisited

examples

red, round, leaf, 3oz, ...

green, round, no leaf, 4oz, ...

yellow, curved, no leaf, 8oz, ...

green, curved, no leaf, 7oz, ...

label

apple

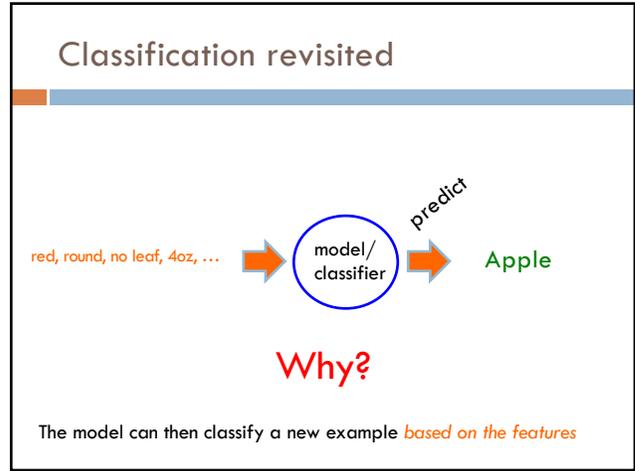
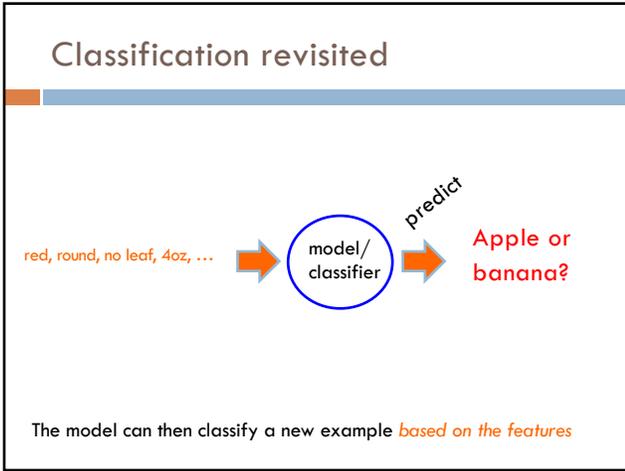
apple

banana

banana

learn

During learning/training/induction, learn a model of what distinguishes apples and bananas *based on the features*



### Classification revisited

Training data		Test set
examples	label	
red, round, leaf, 3oz, ...	apple	
green, round, no leaf, 4oz, ...	apple	red, round, no leaf, 4oz, ... ?
yellow, curved, no leaf, 4oz, ...	banana	
green, curved, no leaf, 5oz, ...	banana	

### Classification revisited

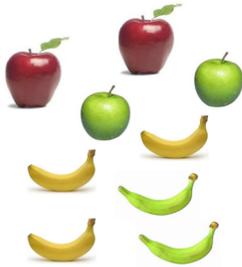
Training data		Test set
examples	label	
red, round, leaf, 3oz, ...	apple	
green, round, no leaf, 4oz, ...	apple	red, round, no leaf, 4oz, ... ?
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Learning is about **generalizing** from the training data

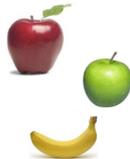
What does this assume about the training and test set?

## Past predicts future

Training data

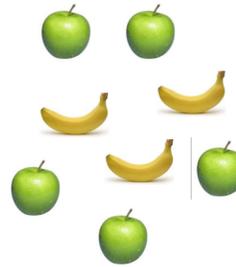


Test set

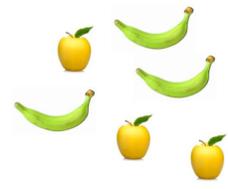


## Past predicts future

Training data



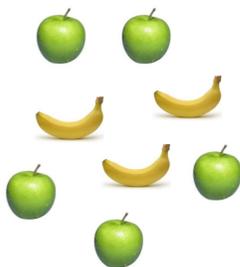
Test set



Not always the case, but we'll often assume it is!

## Past predicts future

Training data



Test set



Not always the case, but we'll often assume it is!

## More technically...

We are going to use the *probabilistic model* of learning

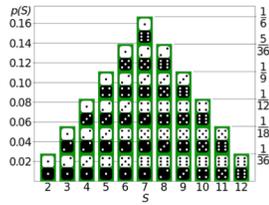
There is some probability distribution over example/label pairs called the *data generating distribution*

**Both** the training data **and** the test set are generated based on this distribution

What is a probability distribution?

### Probability distribution

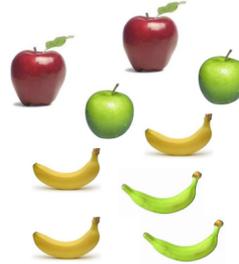
Describes how likely (i.e. probable) certain events are



- Describes probabilities for all possible events
- Probabilities are between 0 and 1 (inclusive)
- Sum of probabilities over all events is 1

### Probability distribution

Training data



High probability

Low probability

round apples

curved apples

curved bananas

red bananas

apples with leaves

yellow apples

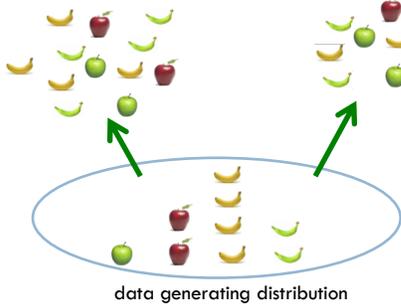
...

...

### data generating distribution

Training data

Test set



### data generating distribution

Training data

Test set

