

Introduction and Motivation

Lecture 1

Machine Learning
Fall 2015



Our goal today

What is (machine) learning?

Let's play a game

The badges game

Attendees of the 1994 conference on Computational Learning Theory received conference badges labeled $+$ or $-$

Only one person (Haym Hirsh) knew the function that generated the labels

Depended *only* on the attendee's name



The task for the attendees: Look at as many examples as you want in the conference and find the unknown function

Let's play

Name	Label
Claire Cardie	-
Peter Bartlett	+
Eric Baum	?
Haym Hirsh	?
Shai Ben-David	?
Michael I. Jordan	?

How were the labels generated?

What is the label for my name? Yours?

Let's play

Name	Label
Claire Cardie	-
Peter Bartlett	+
Eric Baum	-
Haym Hirsh	+
Shai Ben-David	-
Michael I. Jordan	+

How were the labels generated?

What is the label for my name? Yours?

(Full data on the class website, you can stare at it longer if you want)

What is machine learning?

Machine learning is everywhere!

What Other Items Do Customers Buy After Viewing This Item?



Wasabi Power Battery (2-Pack) and Dual Charger for GoPro HERO4 and GoPro AHDBT-401, AHBBP-401

★★★★★ (238)

\$23.99



SanDisk Extreme 64GB UHS-I/U3 Micro SDXC Memory Card Up To 60MB/s Read With Adapter...

★★★★★ (443)

\$79.99



EEEKIT 8-in-1 Accessories Kit for Gopro Hero4 Black/Silver Hero HD 3+/3/2/1 Camera, Head Belt Strap ...

★★★★★ (299)

\$29.99

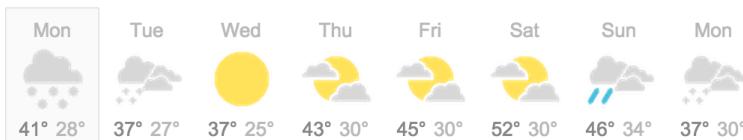


SanDisk Ultra 32GB UHS-I/Class 10 Micro SDHC Memory Card Up to 48MB/s With Adapter...

★★★★★ (2,719)

\$19.44

Explore similar items



Translate

English Spanish French Dutch - detected ▾



English Spanish

Jan de kinderen zag zwemmen



John said



Machine learning is everywhere!

And you are probably already using it

- Is an email spam?
- Find all the people in this photo
- If I like these three movies, what should I watch next?
- Based on your purchase history, you might be interested in...
- Will a stock price go up or down tomorrow? By how much?
- Handwriting recognition

Machine learning is everywhere!

And you are probably already using it

- What are the best ads to place on this website?
- Will it rain tomorrow?
- I would like to read that Dutch website in English
- Ok Google....
- Drive this car for me. And, fly this helicopter for me.
- Does this genetic marker correspond to Alzheimer's disease?

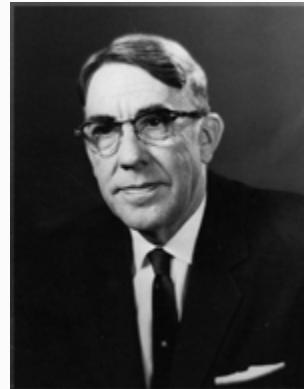
But what is learning?

Let's try to define (machine) learning

What is machine learning?

“Field of study that gives computers the ability to learn without being explicitly programmed”

Arthur Samuel (1959)



Learning as generalization

“Learning denotes changes in the system that are adaptive in the sense that they enable the system to do the task (or tasks drawn from the same population) more effectively the next time.”

Herbert Simon (1983)



Learning as generalization

“A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P , if its performance at tasks in T , as measured by P , improves with experience E .”

Tom Mitchell (1999)



Why study learning?

- Build computer programs/systems with new capabilities
- Understand biological learning
- Understanding teaching

Machine learning is the future

- Gives a system the ability to perform a task in a situation which has never been encountered before
 - New way to think about programming
- Learning allows programs to interact more robustly with messy data
- Starting to make inroads into end-user facing applications already

How many people in this picture?



How many people in this picture?



Three heads

Three hands

Four legs

And yet five people!

Classifiers are not used in isolation, but used in conjunction with each other

And in the context of a larger application

Related fields

All very active research areas!

- The artificial intelligence dream: Computers that are as intelligent as humans
 - Machine learning closely tied to AI
- Theoretical CS and mathematics
 - Formalizing and understanding learning mathematically
 - Uses ideas from probability and statistics, linear algebra, theory of computation
- Philosophy, cognitive psychology, neuroscience, linguistics, robotics,...
- Many, many application areas
 - AI, medicine, engineering, other areas of CS like compilers, psychology, marketing....

Overview of this course

Topics

1. Defining models
2. Different learning protocols
3. Learning algorithms
4. Computational learning theory
5. Representing data

We will see different “models”

Or: what kind of a function should a learner learn

- Linear classifiers
- Decision trees
- Non-linear classifiers, kernels
- Ensembles of classifiers

Different learning protocols

- **Supervised learning**
 - A *teacher* supplies a collection of examples with labels
 - The *learner* has to learn to label new examples using this data
- **Unsupervised learning**
 - No *teacher, learner* has only unlabeled examples
 - Data mining
- **Semi-supervised learning**
 - *Learner* has access to both labeled and unlabeled examples
- **Active learning**
 - *Learner* and *teacher* interact with each other
 - *Learner* can ask questions
- **Reinforcement learning**
 - Learner learns by interacting with the environment

Who has seen
supervised
learning
before?

Learning algorithms

- **Online algorithms:** Learner can access only one labeled at a time
 - Perceptron, Winnow
- **Batch algorithms:** Learner can access to the entire dataset
 - Naïve Bayes
 - Support vector machines, logistic regression
 - Decision trees and nearest neighbors
 - Boosting
- **Unsupervised/semi-supervised algorithms**
 - Expectation maximization
 - K-Means

Who has used any of
these algorithms
before

Representing data

What is the best way to represent data for a particular task?

- Features
- Dimensionality reduction

The theory of machine learning

Mathematically defining learning

- Online learning
- Probably Approximately Correct (PAC) Learning
- Bayesian learning

This course

Focuses on the **underlying concepts** and **algorithmic ideas** in the field of machine learning

This course is **not** about

- Using a specific machine learning tool
- Any single learning paradigm

What will you learn?

1. A broad theoretical and practical understanding of machine learning paradigms and algorithms
2. Ability to implement learning algorithms
3. Identify where machine learning can be applied and make the most appropriate decisions (about algorithms, models, supervision, etc)

How will you learn?

or: Course information