Introduction to Machine Learning

MSE 2400 EaLiCaRA

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Based in part on notes from Gavin Brown, University of Manchester

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What is Machine Learning?

Machine Learning

- a branch of artificial intelligence, is about the construction and study of systems that can learn from data.
- The ability of a computer to improve its own performance through the use of software that employs artificial intelligence techniques to mimic the ways by which humans seem to learn, such as repetition and experience.
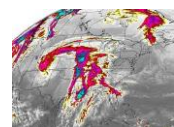

Learning from Data

The world is driven by data.

- Germany's climate research centre generates 10 petabytes per year
- Google processes 24 petabytes per day
- The Large Hadron Collider produces 60 gigabytes per minute (~12 DVDs)
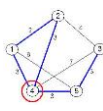- There are over 50m credit card transactions a day in the US alone.

Learning from Data

- **Data** is recorded from some real-world phenomenon.
- What might we want to do with that data?

- **Prediction**
-    - what can we **predict** about this phenomenon?

- **Description**
-    - how can we **describe/understand** this phenomenon in a new way?

Learning from Data

How can we extract knowledge from data to help humans make decisions?

How can we automate decisions from data?

How can we adapt systems dynamically to enable better user experiences?

Write code to explicitly do the above tasks

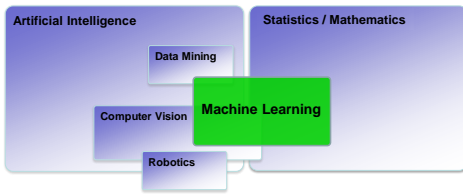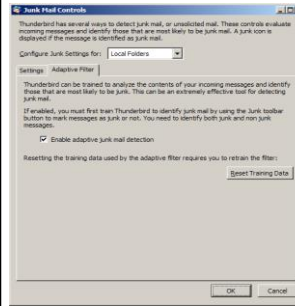Write code to make the computer *learn* how to do the tasks

Machine Learning

• *Where does it fit? What is it **not**?*

Artificial Intelligence

Data Mining

Computer Vision

Machine Learning

Robotics

Statistics / Mathematics

Note that there are many definitions… this is just one way of looking at it.

• Using machine learning to detect spam emails.

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ALGORITHM
Naïve Bayes
Rule mining
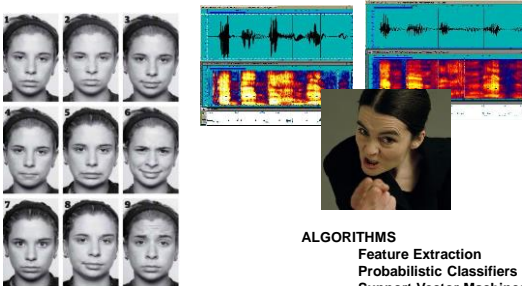

• Using machine learning to recommend books.

ALGORITHMS
Collaborative Filtering
Nearest Neighbour
Clustering

• Using machine learning to identify faces and expressions.

ALGORITHMS
Decision Trees
Adaboost

• 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 .

facebook

amazon.com

ebaY

Lloyds TSB

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

Driving a car
Recognizing spam emails
Recommending books
Reading handwriting
Recognizing speech, faces, etc.

What would Machine Learning have to do to make these things possible?
Even if we could, should we ?!?!?!?

Many applications are immensely hard to program directly.
These almost always turn out to be "pattern recognition" tasks.

1. Program the computer to do the pattern recognition task directly. ✗

1. Program the computer to be able to **learn** from examples.
2. Provide "training" data. ✓

Definition of Machine Learning

• _self-configuring_ data structures that allow a computer to do things that would be called "intelligent" if a human did it

• "making computers behave like they do in the movies"

A Bit of History

• Arthur Samuel (1959) wrote a program that **learned** to play the game of Checkers.
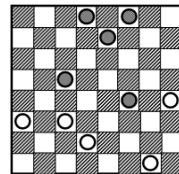
1940s
Human reasoning / logic first studied as a formal subject within mathematics (Claude Shannon, Kurt Godel et al).

1950s
The "Turing Test" is proposed: a test for true machine intelligence, expected to be passed by year 2000. Various game-playing programs built. 1956 "Dartmouth conference" coins the phrase "artificial intelligence".

1960s
A.I. funding increased (mainly military). Famous quote: "Within a generation ... the problem of creating 'artificial intelligence' will substantially be solved."

1970s
A.I. "winter". Funding dries up as people realize it's hard.
Limited computing power and dead-end frameworks.

1980s
Revival through bio-inspired algorithms: Neural networks, Genetic Algorithms.
A.I. promises the world – lots of commercial investment – mostly fails.
Rule based "expert systems" used in medical / legal professions.

1990s
AI diverges into separate fields: Computer Vision, Automated Reasoning, Planning systems, Natural Language processing, **Machine Learning**…

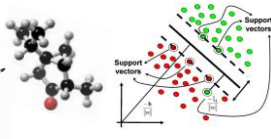_…Machine Learning begins to overlap with statistics / probability theory._

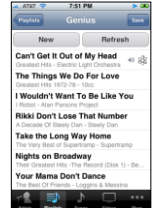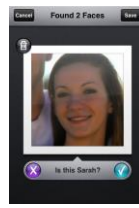$P(A|B) = \dfrac{P(B|A)\,P(A)}{P(B)}$

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2000s

ML merging with statistics continues. Other subfields continue in parallel.

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

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

2010s…. ??????

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The future?

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Microsoft

Chris Bishop

Microsoft has a MAJOR worldwide investment in Machine Learning

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Programming language : "Matlab"
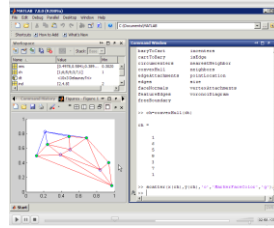
MATrix **LAB**oratory

• Interactive scripting language
• Interpreted (i.e. no compiling)
• Objects possible, not compulsory
• Dynamically typed
• Flexible GUI / plotting framework
• Large libraries of tools
• Highly optimized for maths

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