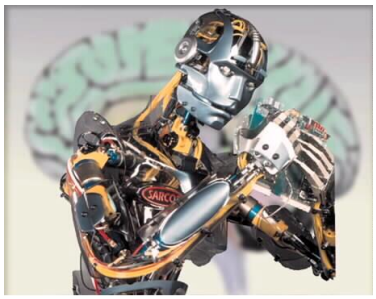
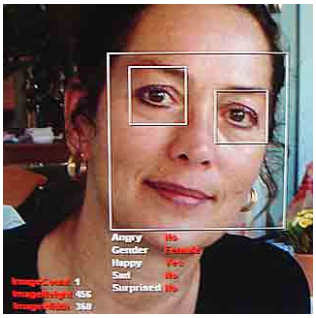
What is Machine Learning?



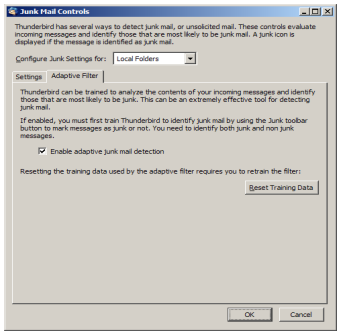
amazon.com

facebook



Microsoft

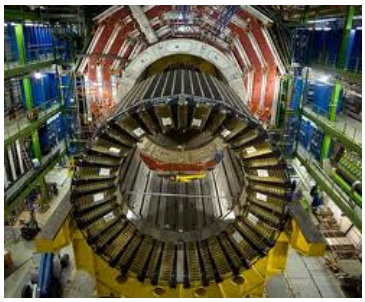
Lloyds TSB

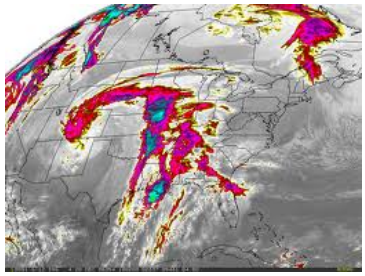


Learning from Data

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

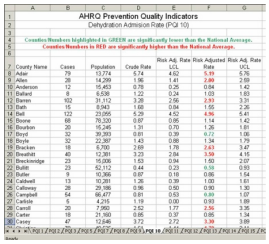
Data is recorded from some real-world phenomenon.
What might we want to do with that data?

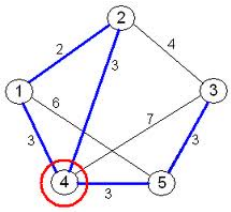
Prediction

- 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 take decisions?

How can we automate decisions from data?

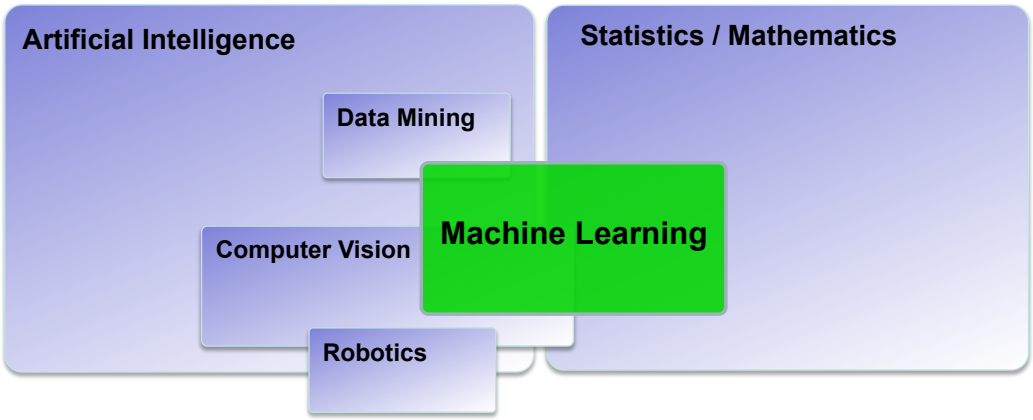
How can we adapt systems dynamically to enable better user experiences?

Write code to explicitly do the above tasks

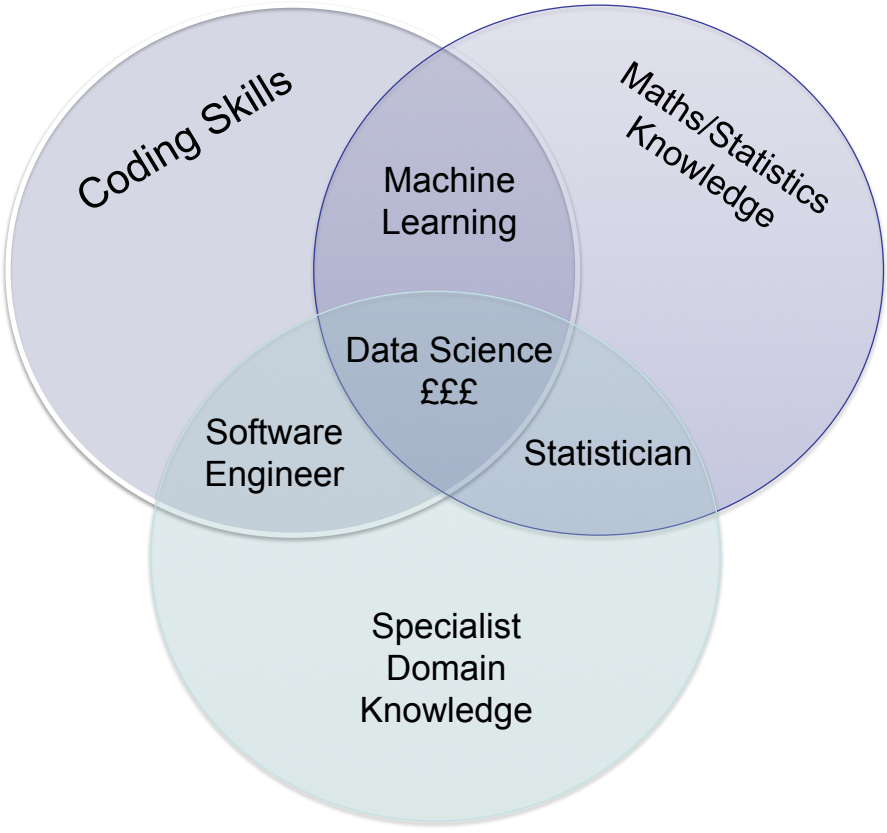
Write code to make the computer ***learn*** how to do the tasks

Machine Learning

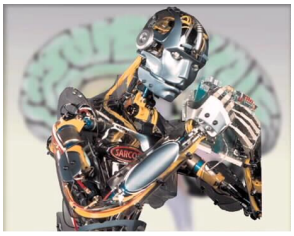
*Where does it fit? What is it **not**?*



(No definition of a field is perfect – the diagram above is just one interpretation, mine ;-)



Humans can:
- think, **learn**, see, understand language, reason, etc.



Artificial Intelligence aims to reproduce these capabilities.
Machine Learning is **one** part of Artificial Intelligence.

COMP14112	Fundamentals of Artificial Intelligence
COMP24111	Introduction to Machine Learning
COMP24412	Symbolic AI
COMP37212	Computer Vision
COMP34512	Knowledge Representation/Reasoning
COMP34411	Natural Language Systems
COMP34120	Artificial Intelligence and Games

Introduction to Machine Learning

http://studentnet.cs.manchester.ac.uk/ugt/COMP24111

50% lab / coursework

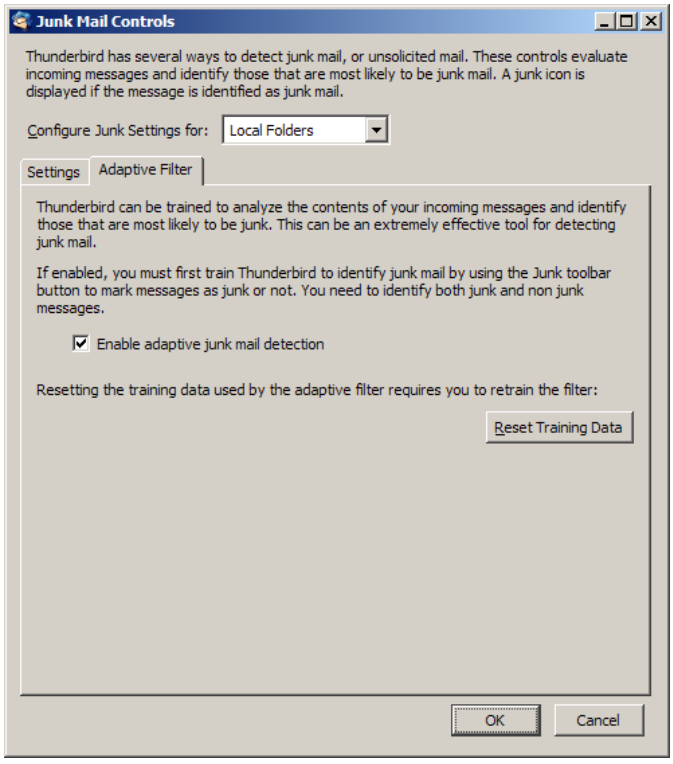
- Ex1 (due this week) …. 10%
- Ex2 (due end of Oct) …… 20%
- Ex3 (due end of Nov) ……20%

50% January exam

Programming : Matlab (no experience required)
Maths : A little bit – would help you to revise A-level.

See notes/slides on course website.

- Using machine learning to detect spam emails.



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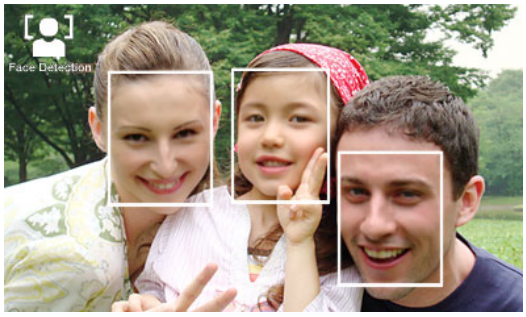
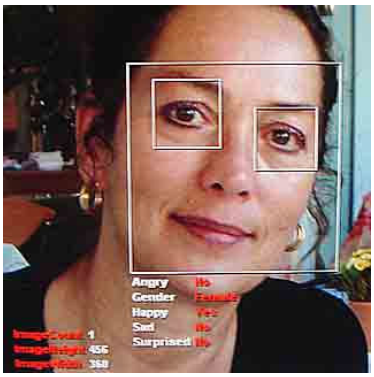
ALGORITHM
Naïve Bayes
Rule mining

- Using machine learning to recommend books.

ALGORITHMS
Collaborative Filtering
Nearest Neighbour
Clustering

- Using machine learning to identify faces and expressions.

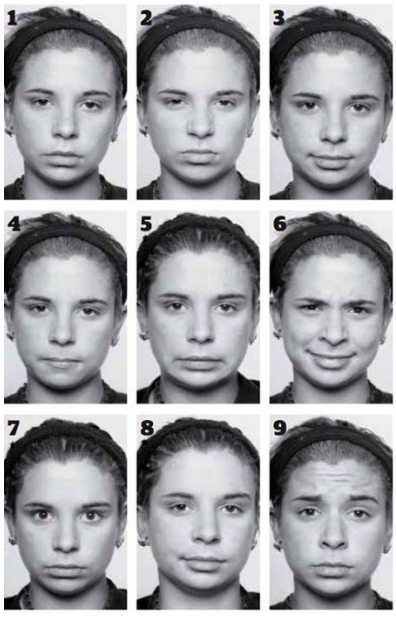


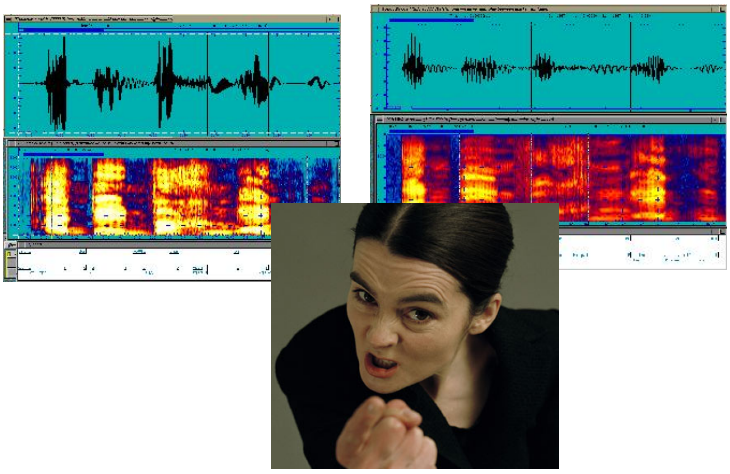


ALGORITHMS

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

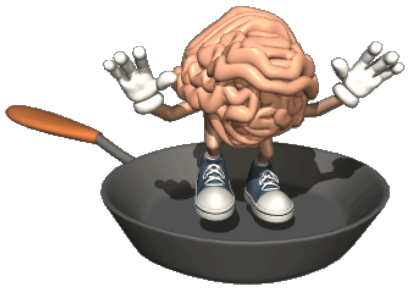
Lloyds TSB

ALGORITHMS

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

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

How would you write these programs?
Would you want to?!?!?!?



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.

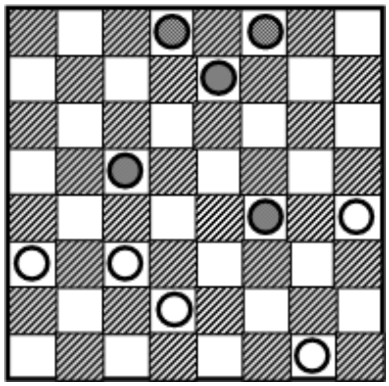
Definition of Machine Learning

- *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 **learnt** to play draughts ("checkers" if you're American).

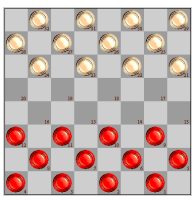


1940s
Human reasoning / logic first studied as a formal subject within mathematics (Claude Shannon, Kurt Godel et al).

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."

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

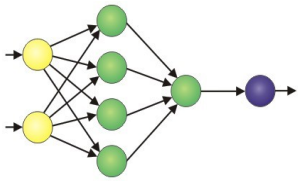


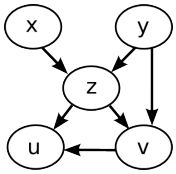
1970s
A.I. "winter". Funding dries up as people realise it's hard.
Limited computing power and dead-end frameworks.

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.





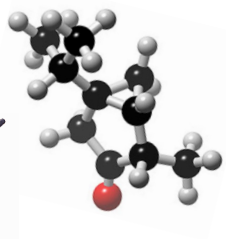
$$P(A|B) = \frac{P(B|A)\,P(A)}{P(B)}.$$

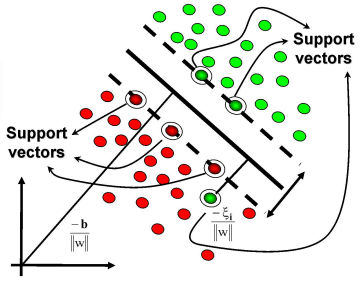
2000s

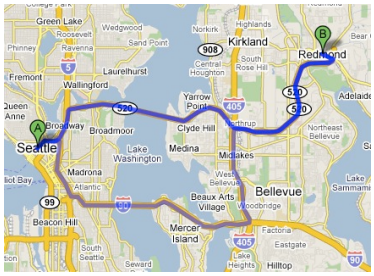
ML merging with statistics continues. Other subfields continue in parallel.

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

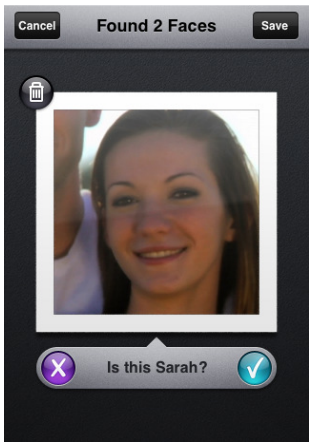


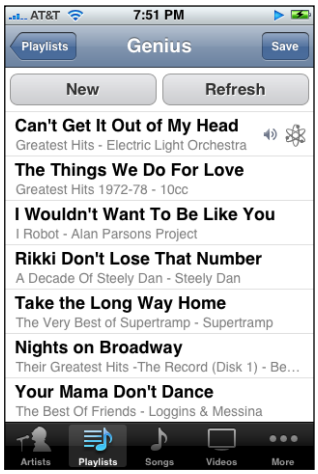




2010s…. ??????

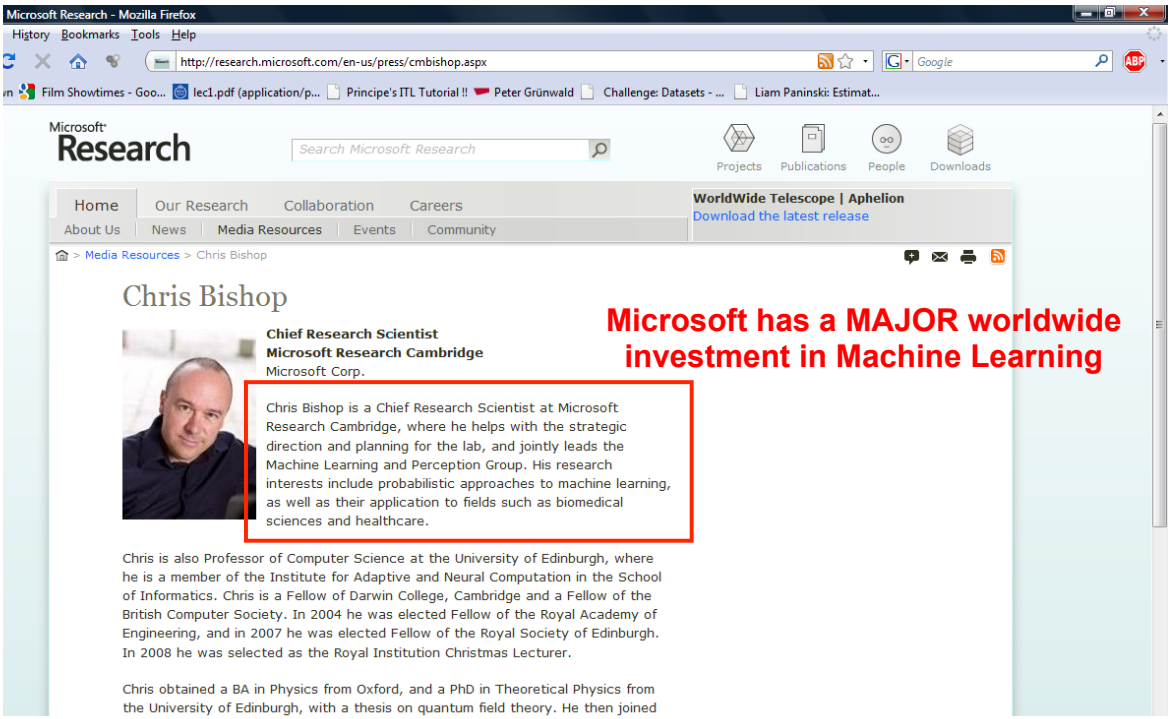
The future?





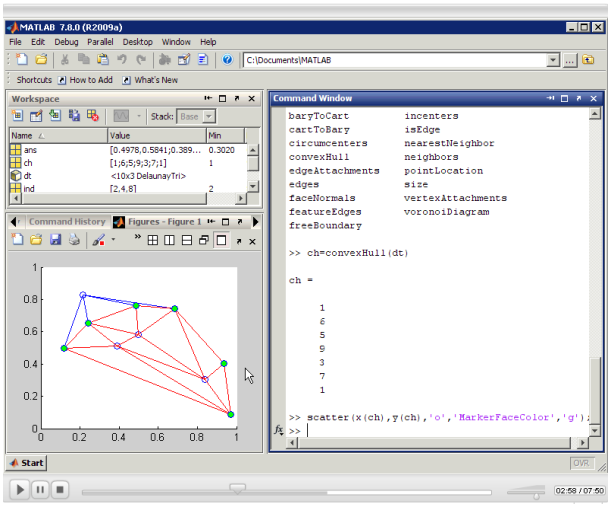
http://www.youtube.com/watch?v=NS_L3Yyv2RI

Microsoft®



Microsoft has a MAJOR worldwide investment in Machine Learning

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

Introduction to Machine Learning
http://studentnet.cs.manchester.ac.uk/ugt/COMP24111

Now – short break – prompt!

After the break:
Your first machine learning algorithm.