Machine Learning 1.01: Introduction

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Before we get started I. . .

- Per week:
  - 2 hour lab session.
  - 2 lectures.
- Lectures:
  - 16 normal.
  - 1 to introduce optional modules.
  - 1 for recap.

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Before we get started II...

- Marks:
  - 60% from 4 lab writeups (15% each).
  - 40% from final report (maximum 3000 words).
  - You will be submitting Jupyter workbooks!

- Using Jupyter:
  - Workbook via a web interface.
  - Python 3 + machine learning libraries.

  - Jupyter hub running at `http://dia.bath.ac.uk` (not yet!).
  - Of questionable value – best to use local install (Anaconda 3).
  - Do not run Anaconda from start menu – use shortcut on Moodle.

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What is ML?

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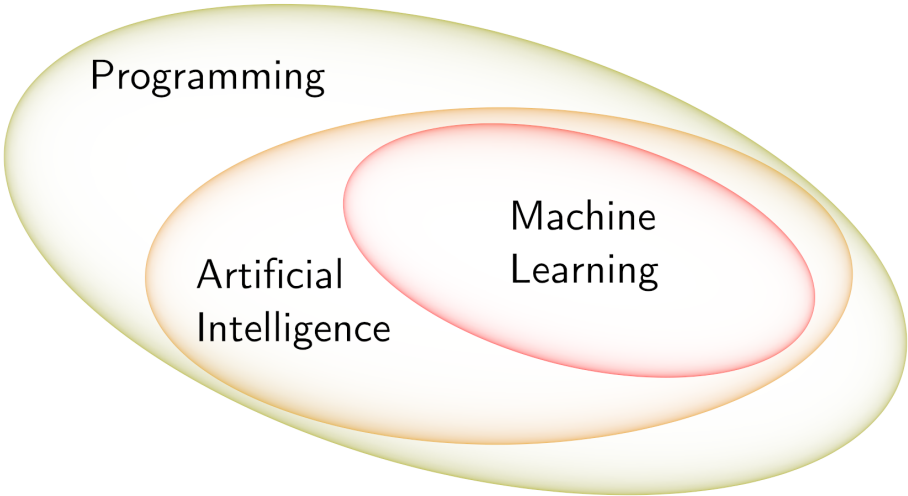

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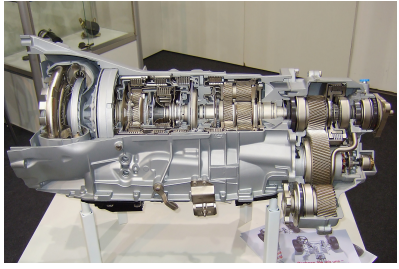
Imagine a car. . .

- Programming:

  Computer as an idiot –
  it only does exactly what you tell it to.

- e.g. automatic gear box:

```
while True:
  if engine.revs > 5000 and
     transmission.gear < 5:
    clutch.disengage()
    transmisison.gear += 1
    clutch.engage()
  elif engine.revs < 1000 and
       transmission.gear > 1:
    clutch.disengage()
    transmisison.gear -= 1
    clutch.engage()
```



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Imagine a car. . .

- Artificial Intelligence:

  Computer uses optimisation to find the best solution to a problem, but only knows exactly what you tell it.

- e.g. gps navigation:

```
graph.load_map('uk.h5')
graph.set_start('bath')
graph.set_end('bletchley')
route = graph.shortest_route()
```

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Imagine a car. . .

- Machine Learning:
  Computer learns from examples and generalises to all cases.

- e.g. recognising road signs:

```
model = Recogniser('15mph_sign.h5')
while True:
  if model.search(camera.image()):
    engine.target = 6.7 # m/s
```

- How can this go wrong?

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- Warning 2: ML is often used instead of AI because it's "fashionable".

What can you do with it?

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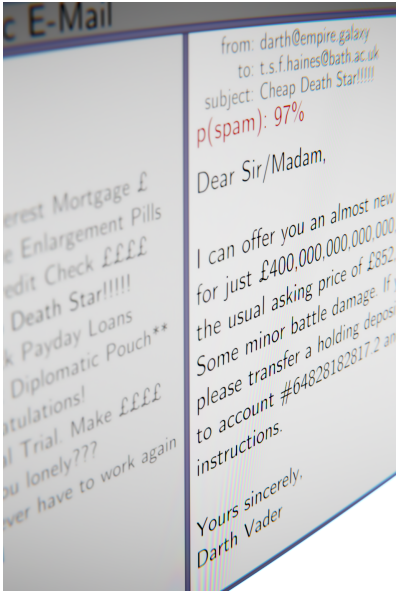
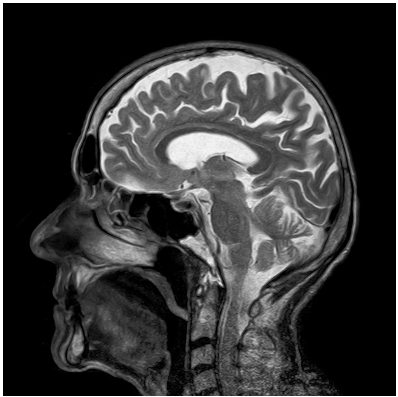
Motivation: Text



- Spam filtering.
- Organising content (e.g. classifying news by area).
- Search engines (e.g. classifying if a web page is accurate).
- Automatic marking.

Motivation: Medical



- Identifying a disease.
- Identifying an abnormality.
- Drug development (e.g. predicting which chemical to test).

Motivation: Human-computer interaction

- Handwriting or speech recognition.
- Personal assistants (e.g. Siri).
- Recommendation systems (e.g. product suggestions on Amazon).
- Automated design.

Motivation: People

- Advertising, polling.
- Text analysis for contracts and law enforcement.
- Detecting terrorism.

Motivation: Financial

- Detecting fraud.
- Mortgage applications.
- Algorithmic trading.

Motivation: Robots

- Walking robots.
- Autonomous vehicles.
- Playing games (e.g. Deep Mind's Alpha Go).

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The process

1. Choose a **problem**.
2. Obtain required **data**.
3. Choose or design a **model**.
4. Fit model to data using **optimisation**.
5. **Measure** performance.

(there are variants. . .)

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1. Choose a problem

e.g. this toy problem:

Given something in the ocean identify if it is a **fish** or an **invertebrate**.

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e.g. this toy problem:

Given something in the ocean identify if it is a **fish** or an **invertebrate**.

Input: Yes/no answers to questions such as:
Does it have teeth?

Output: Fish or invertebrate.

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2. Obtain required data

Animal name	bass	clam	carp	crab	catfish	crayfish	chub	lobster
Does it have teeth?	1	0	1	0	1	0	1	0
Does it breathe?	0	0	0	0	0	0	0	0
Does it have a backbone?	1	0	1	0	1	0	1	0
Is it aquatic?	1	0	1	1	1	1	1	1
Does it have a tail?	1	0	1	0	1	0	1	0
Is it a predator?	1	1	0	1	1	1	1	1
Is it an invertebrate?	0	1	0	1	0	1	0	1

- Use of 1 for “yes” and 0 for “no” is typical.
- This module will be ignoring real data collection.

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- This is a **classification** problem – the output is a discrete label.
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- This is a **classification** problem – the output is a discrete label.
- It is one of the two main problem types in machine learning.

- There are hundreds of models for solving it.
- Lets use another "model": A rule (algorithm) created by a human!

4. Fit model to data using optimisation

You have three minutes to come up with an algorithm:

Animal name	bass	clam	carp	crab	catfish	crayfish	chub	lobster
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Is it an invertebrate?	0	1	0	1	0	1	0	1

Write your algorithm down!

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5. Measure performance I

- Previous slide was a **training set**.
- Below is a **testing set**:

Animal letter Animal name	A	B	C	D	E	F	G
Does it have teeth?	1	0	0	1	1	0	1
Does it breathe?	0	0	1	0	0	0	1
Does it have a backbone?	1	0	0	1	1	0	1
Is it aquatic?	1	1	0	1	1	1	0
Does it have a tail?	1	0	1	1	1	0	1
Is it a predator?	1	1	1	0	1	1	1

- Apply algorithm and record results.

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5. Measure performance II

Animal letter	A	B	C	D	E	F	G
Animal name	dogfish	octopus	scorpion	haddock	pike	seawasp	bear
Does it have teeth?	1	0	0	1	1	0	1
Does it breathe?	0	0	1	0	0	0	1
Does it have a backbone?	1	0	0	1	1	0	1
Is it aquatic?	1	1	0	1	1	1	0
Does it have a tail?	1	0	1	1	1	0	1
Is it a predator?	1	1	1	0	1	1	1
Is it an invertebrate?	0	1	1	0	0	1	mammal

- How well did your algorithm do? (ignore the bear!)

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- How well did your algorithm do? (ignore the bear!)
- Is the bear unreasonable?
- Does the algorithm really ask *"Is it an invertebrate?"*?

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What was your algorithm?

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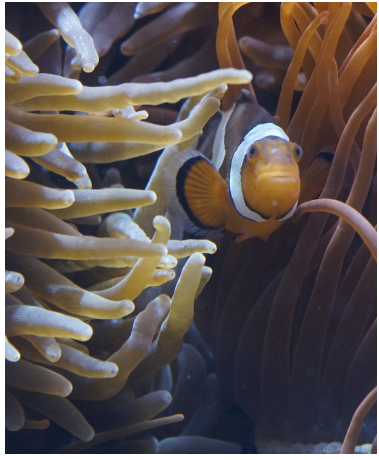
4. Any others?



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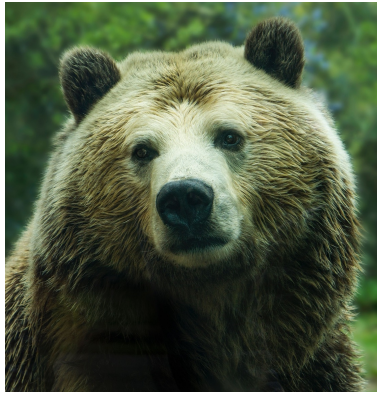

If you get the right answer, does how really matter?

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- But what was your algorithm for step 1?

Supplementary definition

- Machine Learning is discovering the rule (step 1).
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- But parameters are more practical than code, e.g.

```
# Learn these:
feature = 'teeth'
match = False

# Code for model:
def evaluate(fv):
  return fv[feature] == match
```

Summary

- What is ML?
- Use cases.
- The typical process.
- Walk through with yourselves instead of computers.

Further reading & sources

- "Information Theory, Inference and Learning Algorithms" by **David J. C. MacKay**.
- "Pattern Recognition and Machine Learning" by **Christopher M. Bishop**.
- "Computer Vision: Models, Learning, and Inference" by **Simon J. D. Prince**.

- Zoo animal classification: `https://archive.ics.uci.edu/ml/datasets/Zoo`.

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