

COMS21202: An Introduction to Doing Things with Data

[modified from Dima Damen lecture notes]

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What is Data?



What is Data?

- ▶ Data: Symbols, Patterns and Signals
 - ▶ Numeric (measurements, finances, ...)
 - ▶ Textual (emails, Web pages, medical records, ...)
 - ▶ Visual (images, video, graphics, animations)
 - ▶ Auditory (speech, audio)
 - ▶ Signals (GPS signals, neuronal activity, ...)
 - ▶ Many others...

This Unit

- ▶ This unit is about doing things with data... but not
 - ▶ storing, shuffling, searching (Data Structures and Algorithms)
 - ▶ sending (Networking)
 - ▶ compressing or encrypting (Crypto I and Crypto II)
- ▶ This unit is about:
 - ▶ extracting knowledge from data
 - ▶ generating data and making predictions
 - ▶ making decisions based on data
 - ▶ ... often referred to as: Data Science

This Unit

 **65 billion**

Location-tagged payments
made in the U.S. annually

154 billion

E-mails sent per day

 **87%**

U.S. adults whose location is
known via their mobile phone

Digital Information Created Each Year, Globally

2,000 BILLION GIGABYTES

1,800

1,600

1,400

1,200

1,000

800

600

400

2005

2006

2007

2008

2009

2010

2011

2,000%

Expected increase in
global data by 2020

**III
Megabytes**

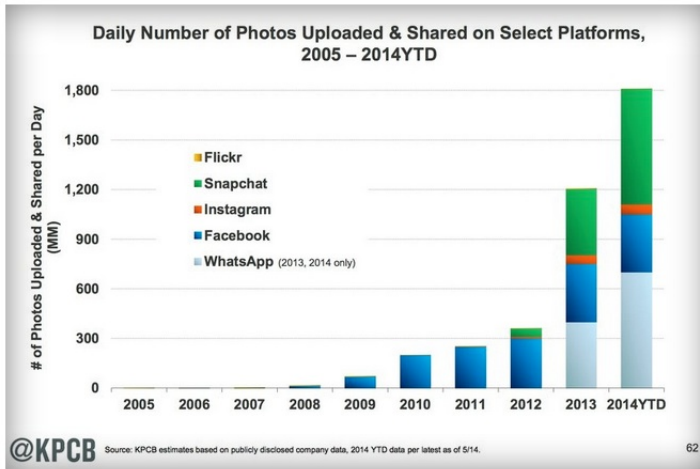
Video and photos stored
by Facebook, per user

75%

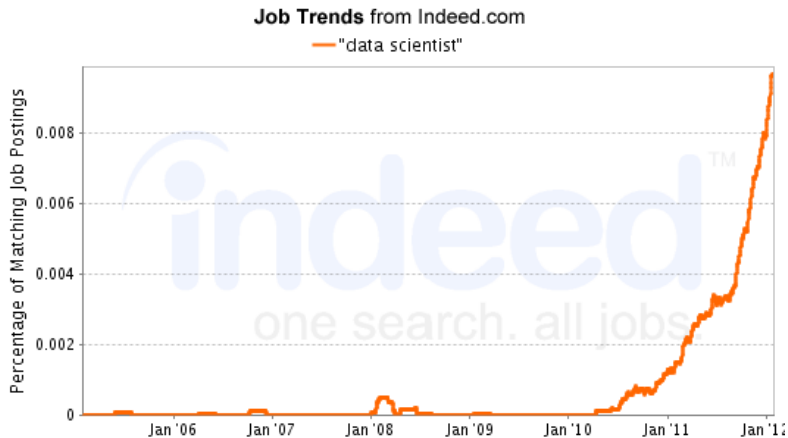
Percentage of all digital
data created by consumers

Sources: IDC, Radicati Group, Facebook, TR research, Pew Internet

This Unit



This Unit



This Unit



This Unit is an introduction to.....



sources:dmnews.com, infinitdatum.com, code-n.org

But it's not about the data, but the science

'Like' curly fries on Facebook? Then you're clever

'Like' curly fries? Then there's a good chance you've got a high IQ, according to a Cambridge University project to discover what we unwittingly reveal about ourselves on Facebook.



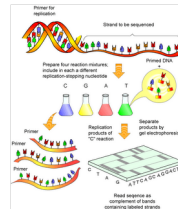
Curly Fries: Researchers at Cambridge's Psychometric Centre have joined forces with Microsoft to analyse more than nine million 'likes' on Facebook. Photo: ALAMY

Correlation **does not** imply causation! telegraph.co.uk

This Unit

Why is it important for Computer Science?

- ▶ Fundamental to many application areas:
 - ▶ Artificial Intelligence, Machine Learning, Deep Learning
 - ▶ Image Processing and Pattern Recognition
 - ▶ Graphics, Animation and Virtual Reality
 - ▶ Computer Vision and Robotics
 - ▶ Speech and Audio Processing.
 - ▶ With growing applications in: neuroscience, literature, agriculture, etc.
- ▶ Hence, preparation for application units in years 3 and 4.



Ex1. A Fishy Problem

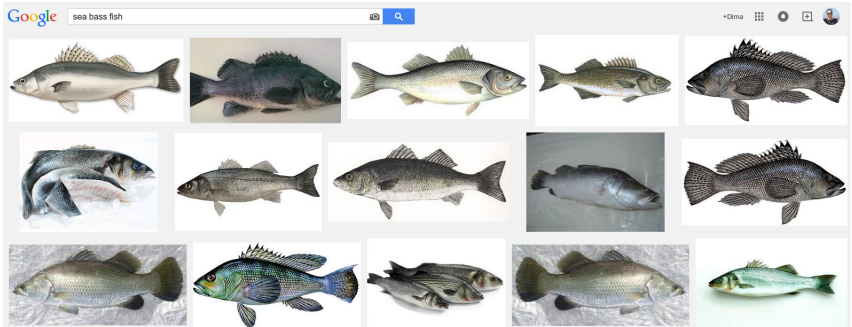


From: Pattern Classification by Duda, Hart and Stork

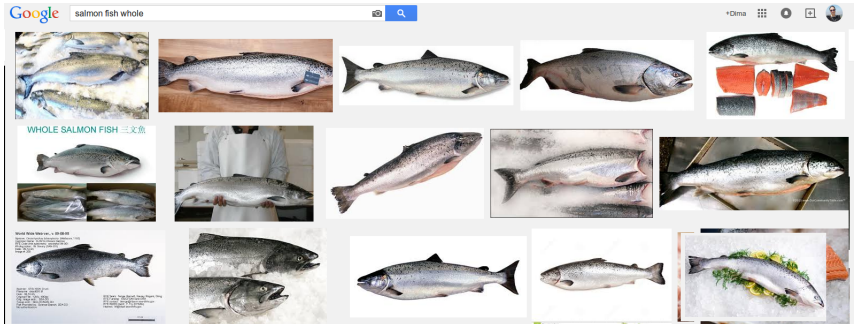
Data: images of fish

Aim: distinguish between sea bass and salmon

Ex1. A Fishy Problem



Ex1. A Fishy Problem



Ex1. A Fishy Problem

Steps:

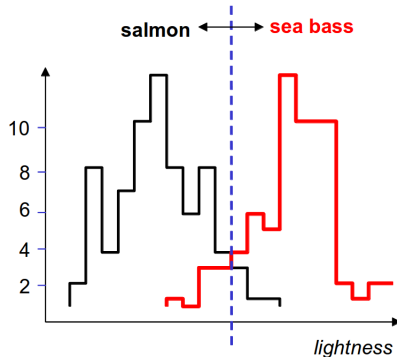
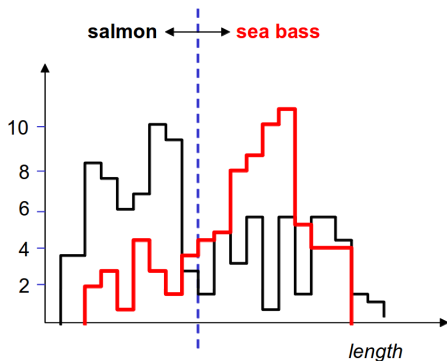
1. Pre-processing [Unit - Part 1]» Rui Ponte Costa
2. Feature Selection [Unit - Part 3]» Majid Mirmehdi
3. Classification [Unit - Part 2]» Laurence Aitchison **[unit director]**



Fishing for a Solution

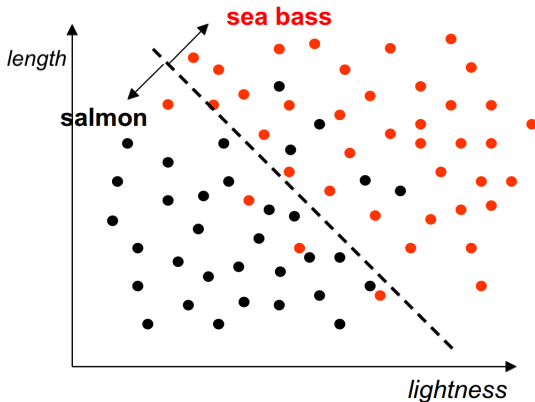
E.g.:

1. Pre-processing e.g. Rotate and align, Segment fish from background
2. Feature Selection e.g. measure length or brightness
3. Classification e.g. find a threshold



Fishing for a Solution

Multiple features could be selected, resulting in a multi-dimensional feature vector.



Ex2. Speech Recognition

Data: analogue speech signals (time series numerical data)

Aim: convert audio into text

Steps:

1. Pre-processing Digitisation
2. Feature Selection Wave amplitude
3. Inference Hidden Markov Models (Viterbi algorithm) [or Deep learning]

Ex3. Spam Filter

Data: email texts (text data)

Aim: determine whether the email is spam

Steps:

1. Pre-processing **Normalise words**(e.g. vector encoding)
2. Feature Selection **Presence of words**
3. Classification **Naive Bayes classifier**

Select subset of words w_i and determine $P(w_i|spam)$ and $P(w_i|\neg spam)$ from frequencies in training data.

For an email that contains w_1, w_2, \dots, w_n of the subset of words, assume

$$P(email|spam) = P(w_1|spam)P(w_2|spam) \dots P(w_n|spam) \quad (1)$$

and

$$P(email|\neg spam) = P(w_1|\neg spam)P(w_2|\neg spam) \dots P(w_n|\neg spam) \quad (2)$$

Email is spam if

$$P(email|spam) > P(email|\neg spam) \quad (3)$$

Ex4. Autonomous Helicopter ¹

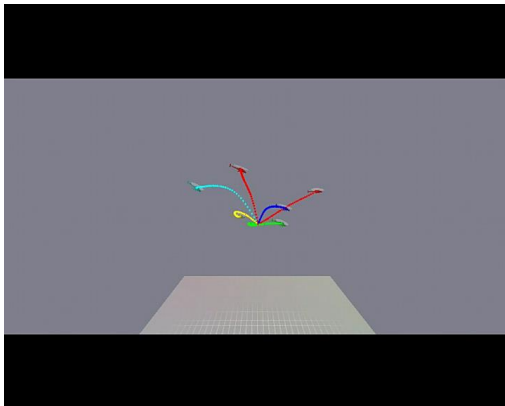


¹Stanford University [<http://heli.stanford.edu/>]

Ex4. Autonomous Helicopter

Data: expert demonstration

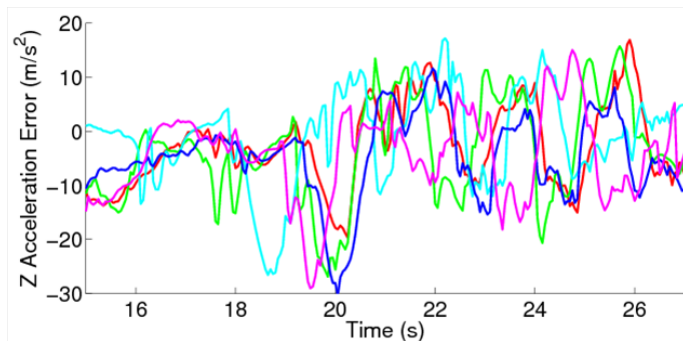
Aim: fly an autonomous helicopter



Ex4. Autonomous Helicopter

Steps:

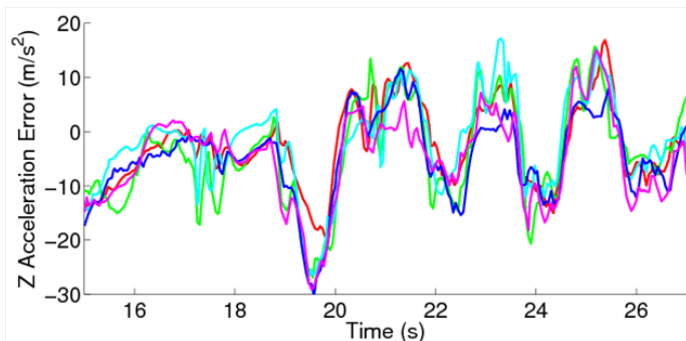
1. Pre-processing align temporal sequences
2. Feature Selection
3. Model Building



Ex4. Autonomous Helicopter

Steps:

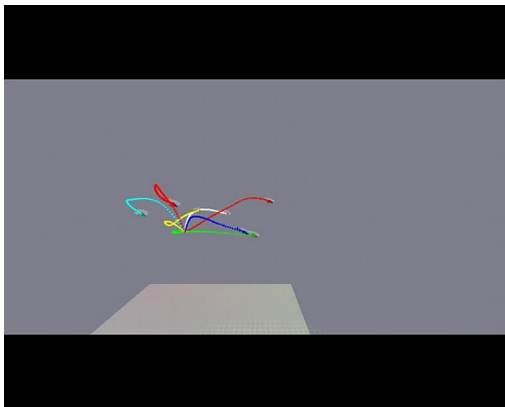
1. Pre-processing align temporal sequences
2. Feature Selection control: acceleration, height, ...
3. Model Building



Ex4. Autonomous Helicopter

Steps:

1. Pre-processing align temporal sequences
2. Feature Selection control: acceleration, height, ...
3. Model Building autonomous controller



Ex4. A modern version (autonomous drone flying)

Skydio 2: <https://youtu.be/imt2qZ7uw1s>

Unit Outline

<https://uob-coms21202.github.io/COMS21202.github.io/>

Weeks	Monday Lecture	Wednesday Lecture	Labs	Thursday Lecture	Assessments
13	Data, Data Modelling and Estimation (I)	Data, Data Modelling and Estimation (II)	Intro to Jupiter Notebook I	Problem Class - Data Acquisition	-
14	Data Modelling and Estimation (III)	Problem Class - Deterministic Data Modelling	Intro to Jupiter Notebook II	Data, Data Modelling and Estimation (IV)	-
15	Data, Data Modelling and Estimation (V)	Problem Class - Probabilistic Data Modelling	Least Squares	Review part I	CW1 (set)
16	Classification I	Classification II	Maximum Likelihood	Clustering	-
17	Problem Class	Gaussian Mixture Methods	Fitting	Evaluation Methods	-
18	Computer Science Explore Week				-
19	Problem class	Problem Class	Classification	Review part II	-
20	Features	Features	-	Features	-
21	Features	Problem Class	-	Features	CW1 (deadline)
Easter Break					
22	Features	Features	-	Problem Class	CW2 (formative)
23	Review part I (Rui)	Review part II (Laurence)	-	Review Part III (Majid)	-
24	Review week				

Assessments

- ▶ CW1: One individual course work: report + code (40%)
weeks 15-21 [submission in week 21]
- ▶ Discuss with others, but submissions are individual
- ▶ Assessment for course work is marked in the form of a report - **it's what you have understood about the data that matters**
- ▶ CW2: Formative course work (i.e. not assessed)

- ▶ Exam (60%)

- ▶ Unit Averages
 - ▶ 2018/2019 Avg: 66
 - ▶ 2016/2017 Avg: 60
 - ▶ 2015/2016 Avg: 56

Labs

- ▶ Tuesdays 13:00 - 15:00 [by timetable]: Group 2
- ▶ Thursday 09:00 - 11:00 [by timetable]: Group 1
- ▶ Lab Environment [Jupyter + Python]



- ▶ **Lab Work:**
 - ▶ Do the labs in pairs

Labs: Important!!

- ▶ Main source of 1:1 support will be from the TAs in the labs!
- ▶ Labs are essential for the coursework!
- ▶ Attendance will be taken.

Tasks

- ▶ Next Lab (Week 13): Introduction to Jupyter Notebook I
- ▶ Sheet on unit web page
- ▶ Next Problem Class (Thur 1-2): Data Acquisition
- ▶ Prepare your answers in advance [available online]