COMS21202: An Introduction to Doing Things with Data

[based on Dima Damen lecture notes]

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What is Data?

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- Data: Symbols, Patterns and Signals
  - Numeric (measurements, finances, ...)

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  - Signals (GPS signals, neuronal activity, ...)

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  - 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

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  - storing, shuffling, searching

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  - sending

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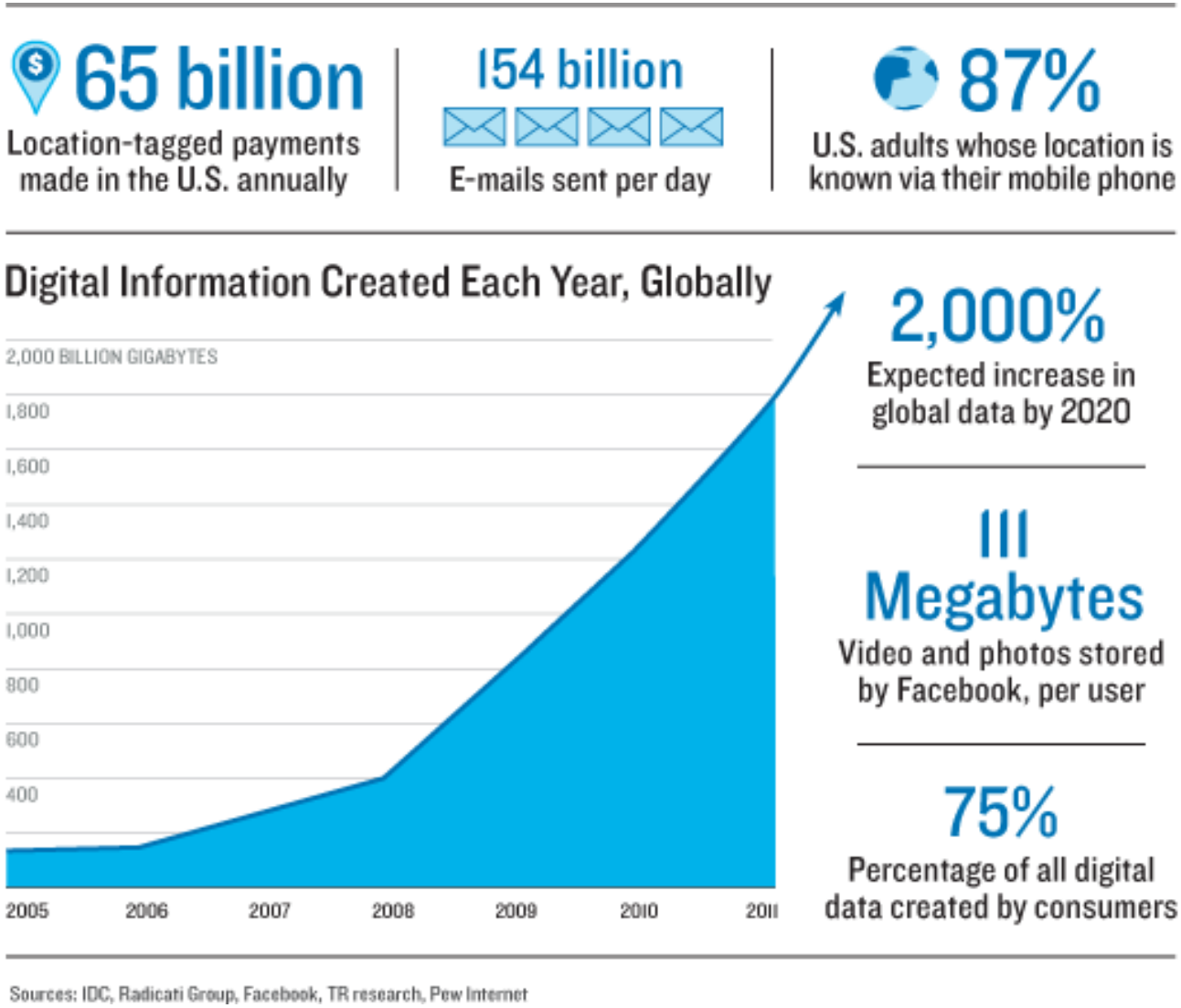
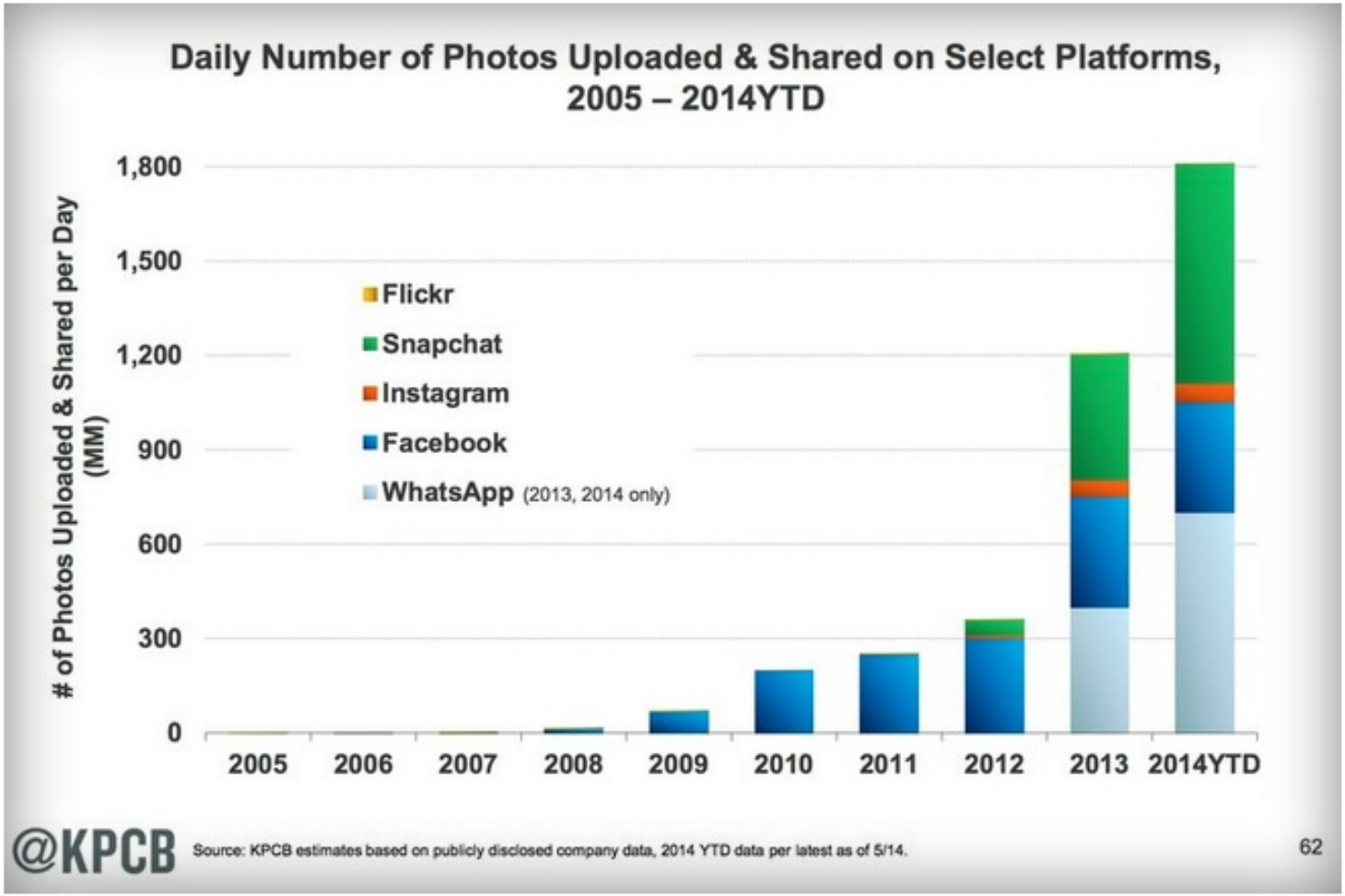
  - storing, shuffling, searching (Data Structures and Algorithms)
  - sending (Networking)
  - compressing or encrypting (Crypto I and Crypto II)
- This unit is about:
  - extracting knowledge from data
  - generating data and making predictions
  - making decisions based on data
  - ... often referred to as: Data Science

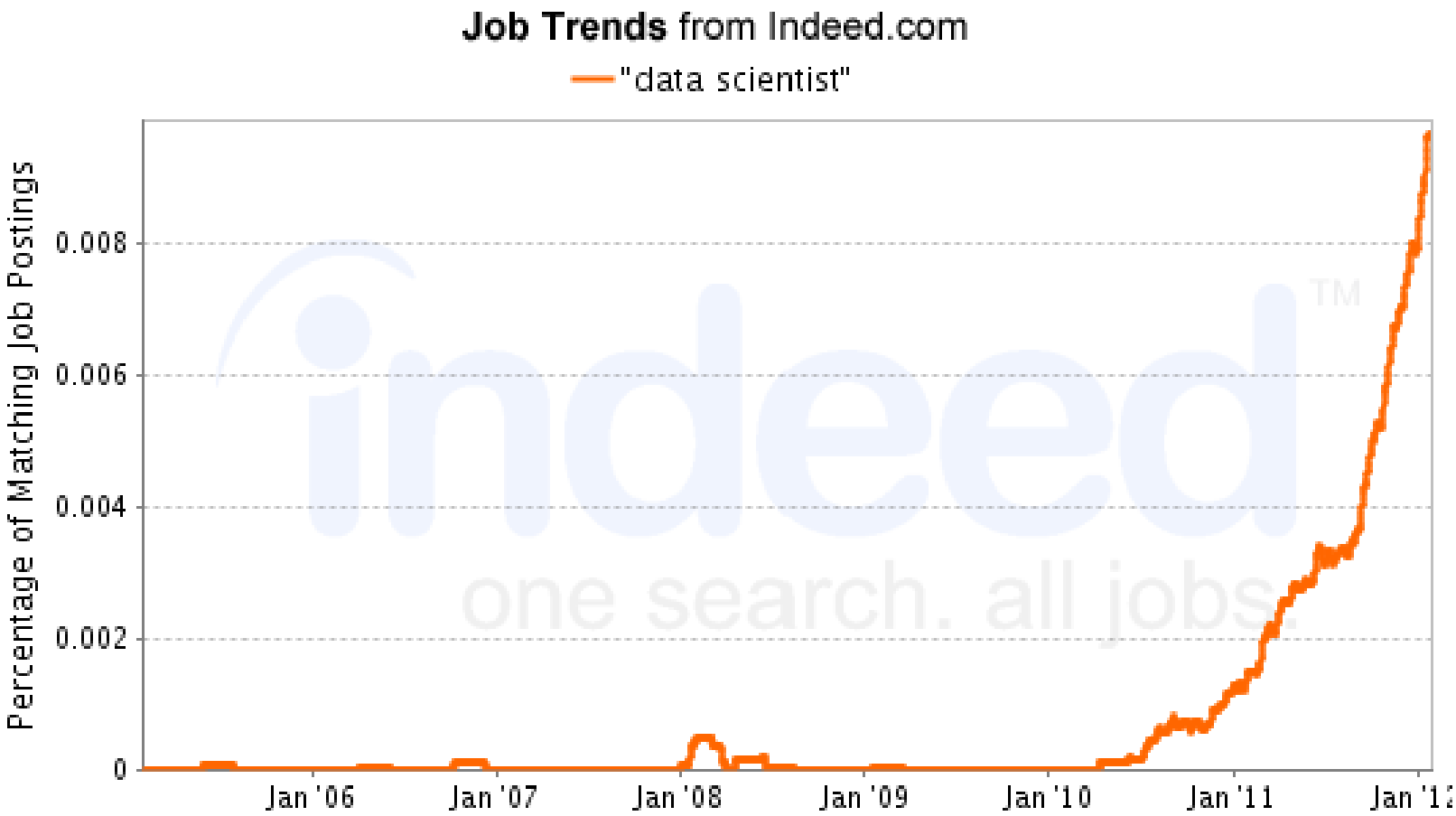
This Unit


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


Daily Number of Photos Uploaded & Shared on Select Platforms, 2005 – 2014YTD
# of Photos Uploaded & Shared per Day (MM)
1,800
1,500
1,200
900
600
300
0
Flickr
Snapchat
Instagram
Facebook
WhatsApp (2013, 2014 only)
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014YTD
@KPCB
Source: KPCB estimates based on publicly disclosed company data, 2014 YTD data per latest as of 5/14.
62

This Unit


Job Trends from Indeed.com
"data scientist"
Percentage of Matching Job Postings
0.008
0.006
0.004
0.002
0
Jan '06
Jan '07
Jan '08
Jan '09
Jan '10
Jan '11
Jan '12
indeed™
one search. all jobs.

This Unit


Job Trends from Indeed.com
"Data Scientist"
Percentage of Matching Job Postings
0.04
0.02
0
Jan '06
Jan '07
Jan '08
Jan '09
Jan '10
Jan '11
Jan '12
Jan '13
Jan '14
Jan '15
indeed
one search. all jobs.

This Unit is an introduction to.....

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

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

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.

311 50 0 4 365 Email

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

telegraph.co.uk

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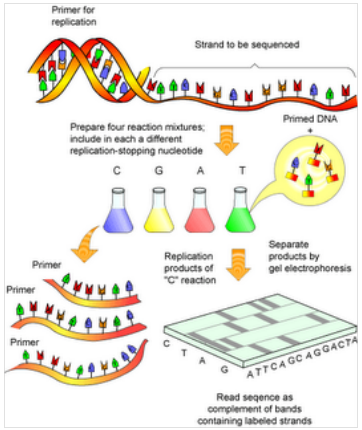
Correlation **does not** imply causation! telegraph.co.uk

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.



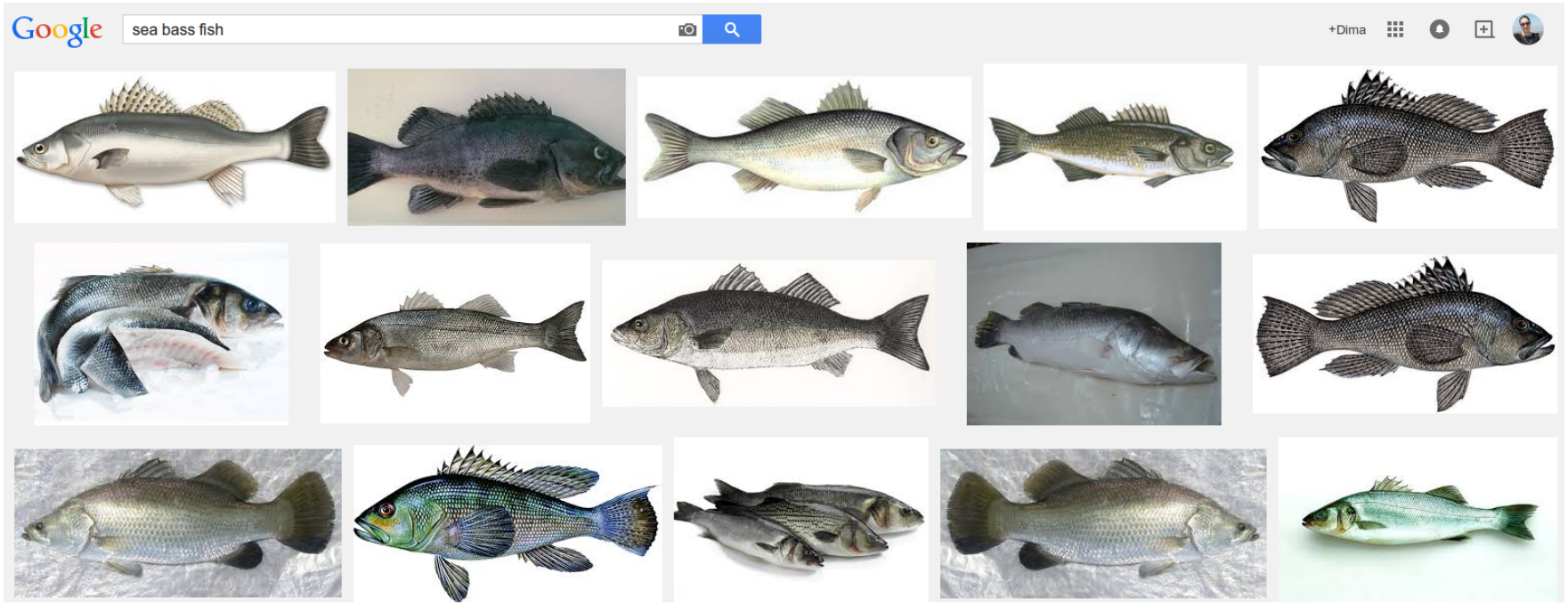
Ex1. A Fishy Problem

From: Pattern Classification by Duda, Hart and Stork

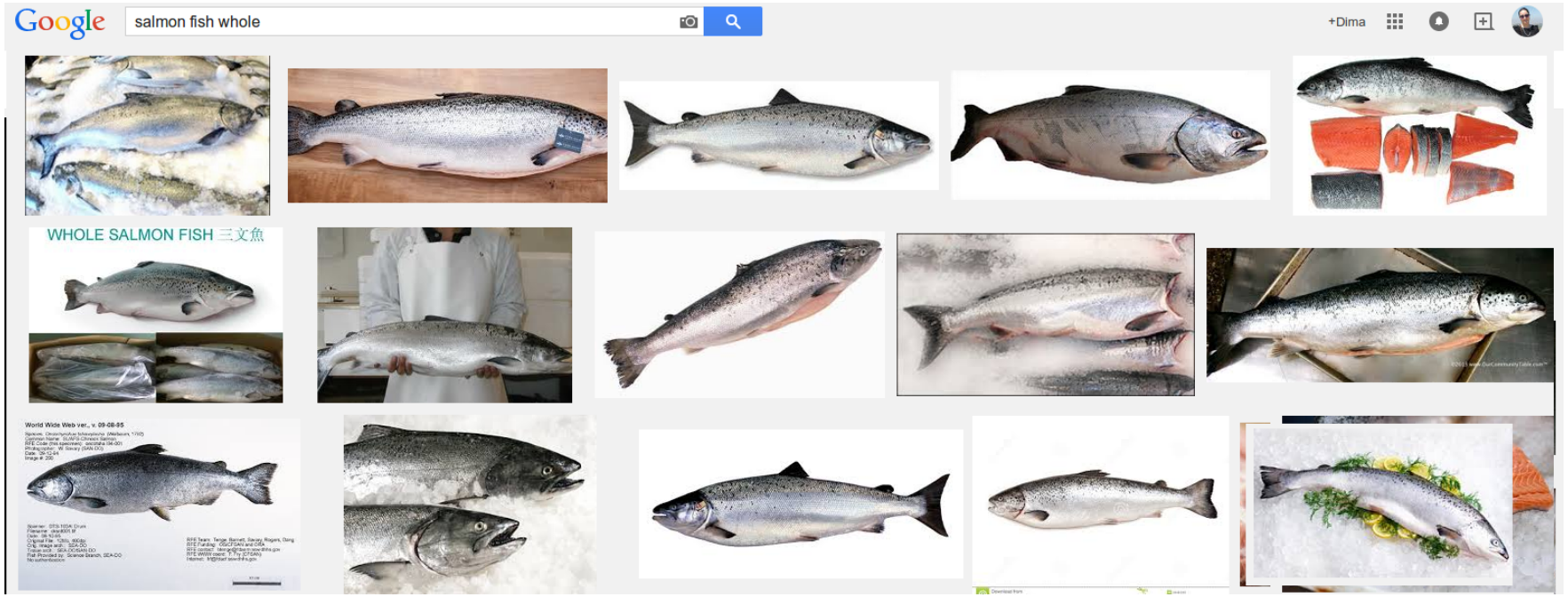
Data: images of fish

Aim: distinguish between sea bass and salmon

Ex1. A Fishy Problem



Ex1. A Fishy Problem



Ex1. A Fishy Problem

Steps:

Ex1. A Fishy Problem

Steps:

1. Pre-processing

Ex1. A Fishy Problem

Steps:

1. Pre-processing
2. Feature Selection

Ex1. A Fishy Problem

Steps:

1. Pre-processing
2. Feature Selection
3. Classification

Ex1. A Fishy Problem

Steps:

1. Pre-processing [Unit - Part 1]» Rui Ponte Costa
2. Feature Selection
3. Classification

Ex1. A Fishy Problem

Steps:

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

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
2. Feature Selection
3. Classification

Fishing for a Solution

E.g.:

1. Pre-processing e.g. Rotate and align, Segment fish from background
2. Feature Selection
3. Classification

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
3. Classification

Fishing for a Solution

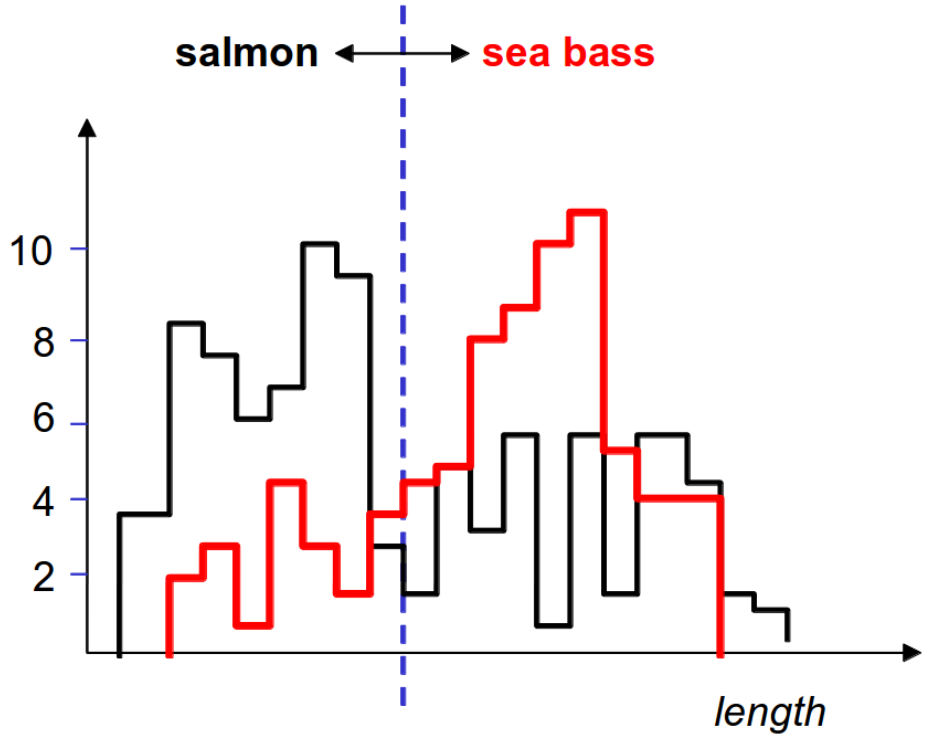
E.g.:

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

Fishing for a Solution

E.g.:

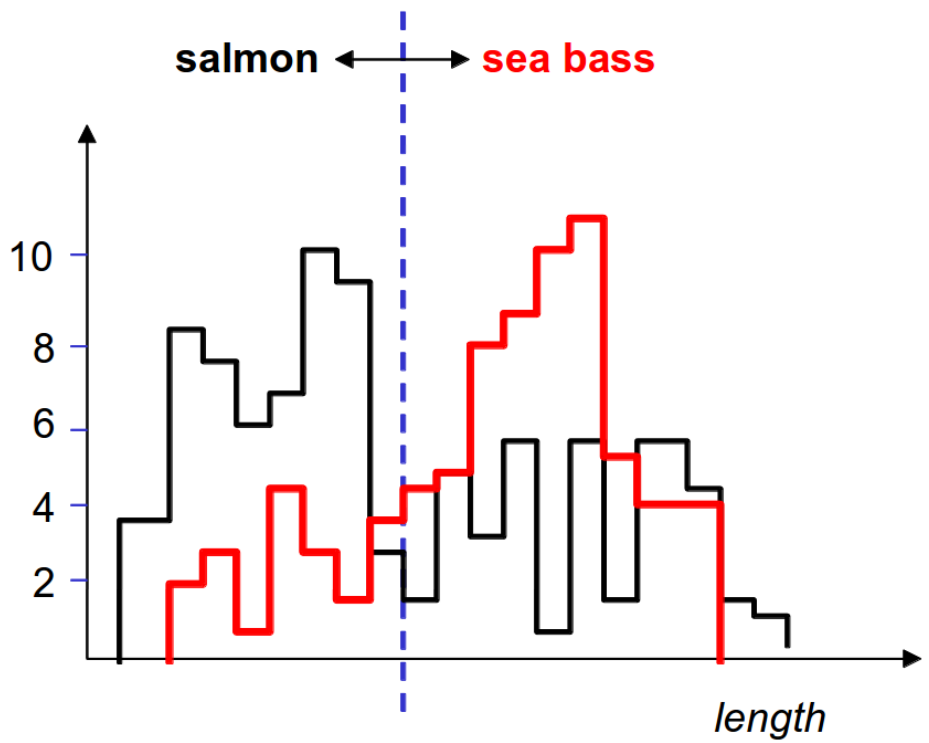
1. Pre-processing e.g. Rotate and align, Segment fish from background
2. Feature Selection e.g. measure length
3. Classification e.g. find a threshold

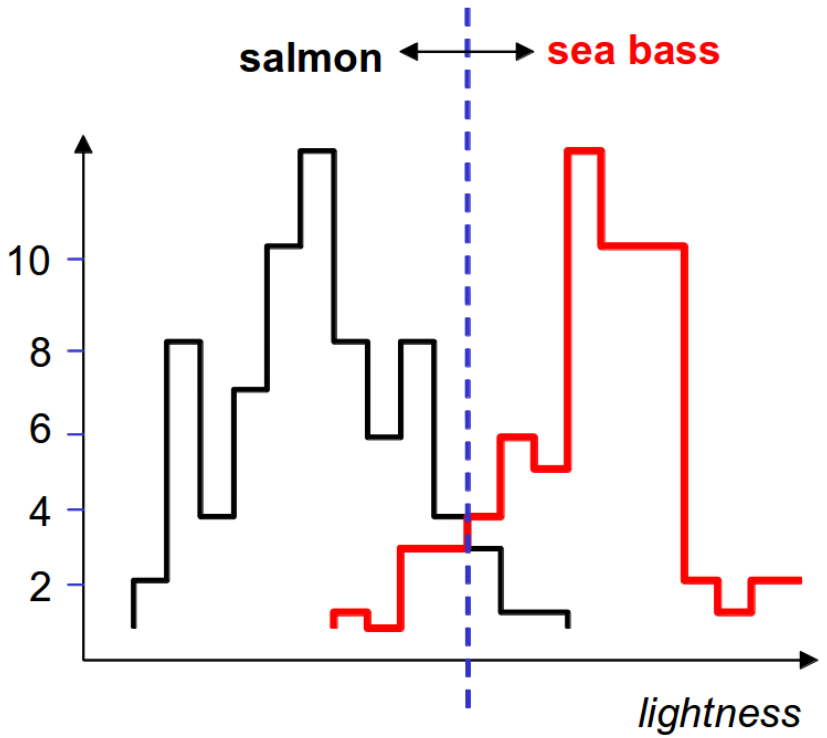


Fishing for a Solution

E.g.:

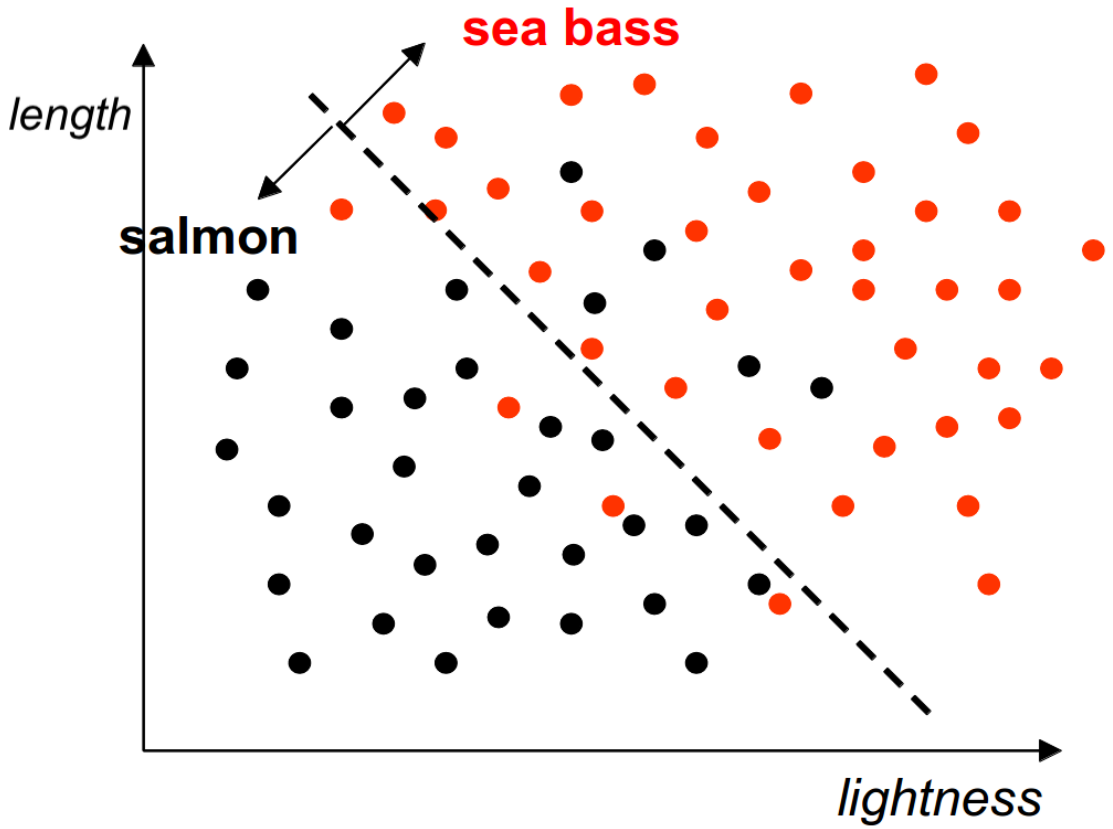
1. Pre-processing e.g. Rotate and align, Segment fish from background
2. Feature Selection e.g. measure length or brightness
3. Classification e.g. find a threshold





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
2. Feature Selection
3. Inference

Ex2. Speech Recognition

Data: analogue speech signals (time series numerical data)

Aim: convert audio into text

Steps:

1. Pre-processing Digitisation
2. Feature Selection
3. Inference

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

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
2. Feature Selection
3. Classification

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
3. Classification

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

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

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 $w_1, w_2, .., w_n$ of the subset of words, assume

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

and

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

Email is spam if

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

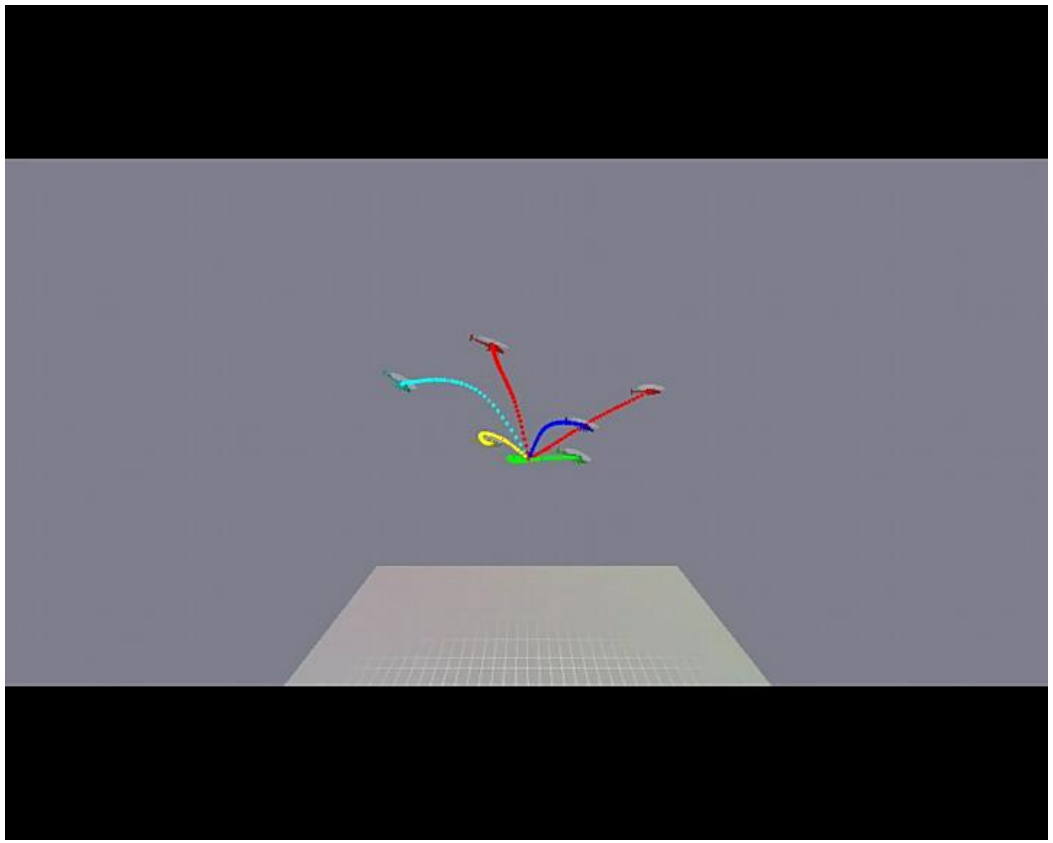
Ex4. Autonomous Helicopter [1]

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

Ex4. Autonomous Helicopter

Data: expert demonstration

Aim: fly an autonomous helicopter



Ex4. Autonomous Helicopter

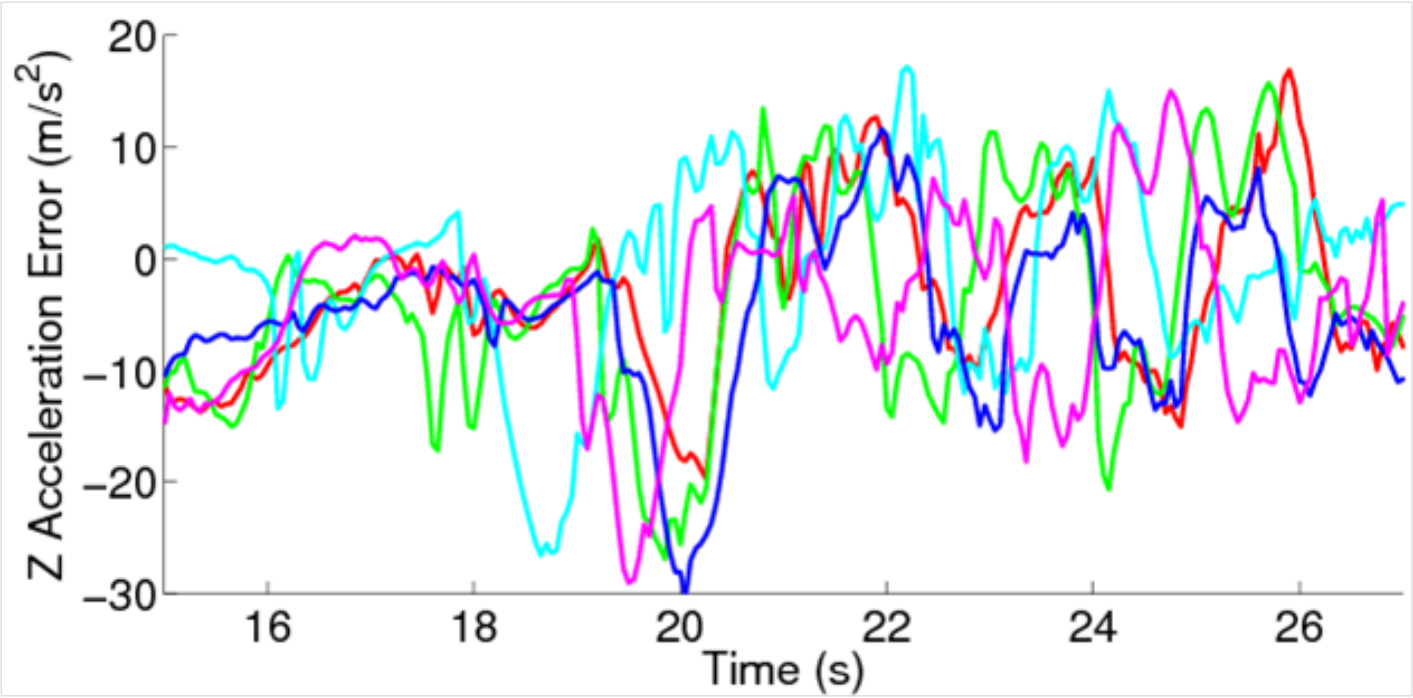
Steps:

1. Pre-processing
2. Feature Selection
3. Model Building

Ex4. Autonomous Helicopter

Steps:

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



Ex4. Autonomous Helicopter

Steps:

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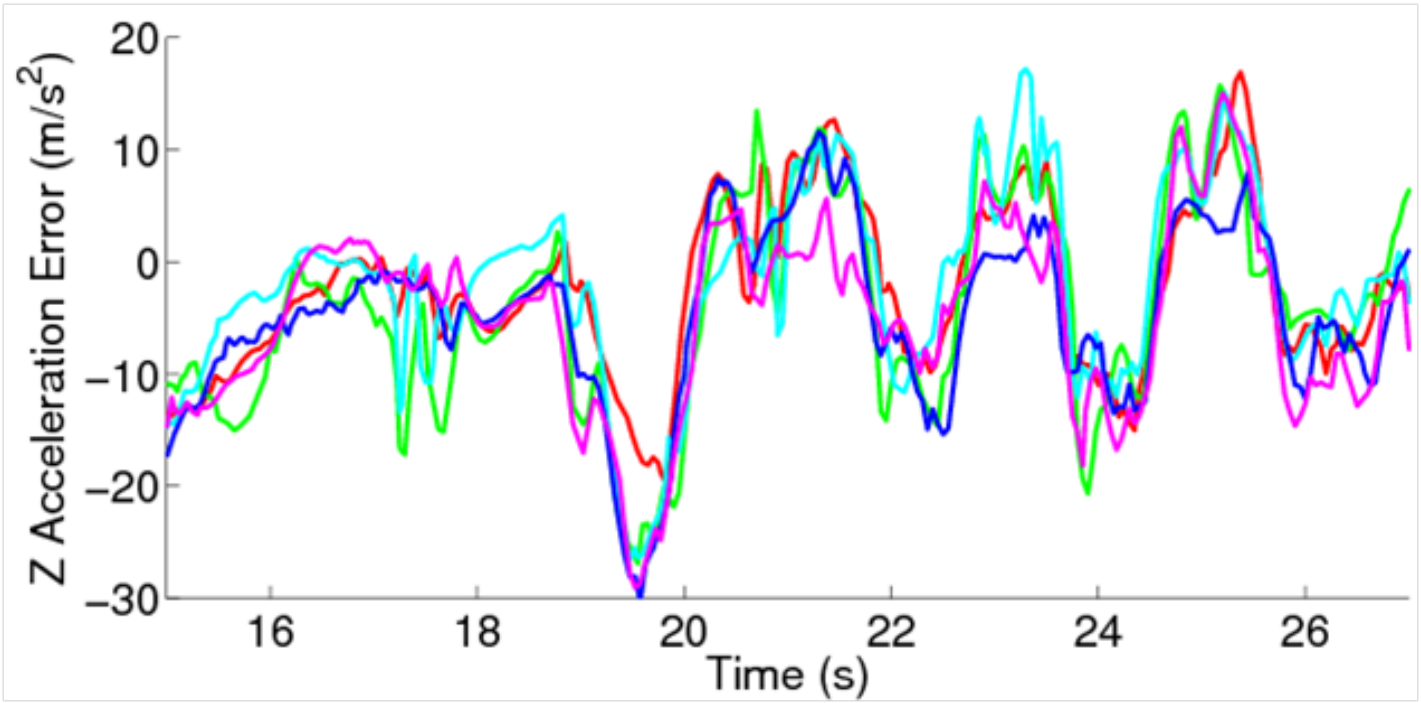
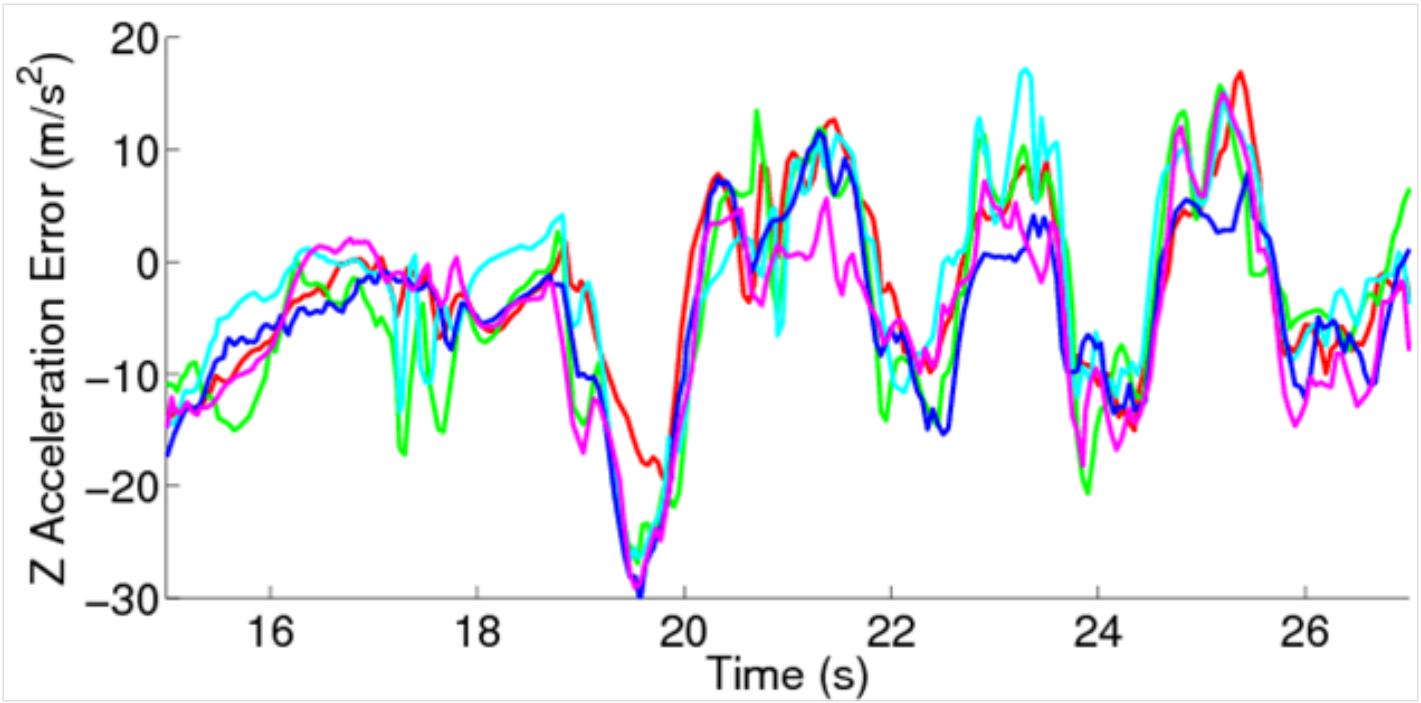
2. Feature Selection
3. Model Building



Ex4. Autonomous Helicopter

Steps:

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



Ex4. Autonomous Helicopter

Steps:

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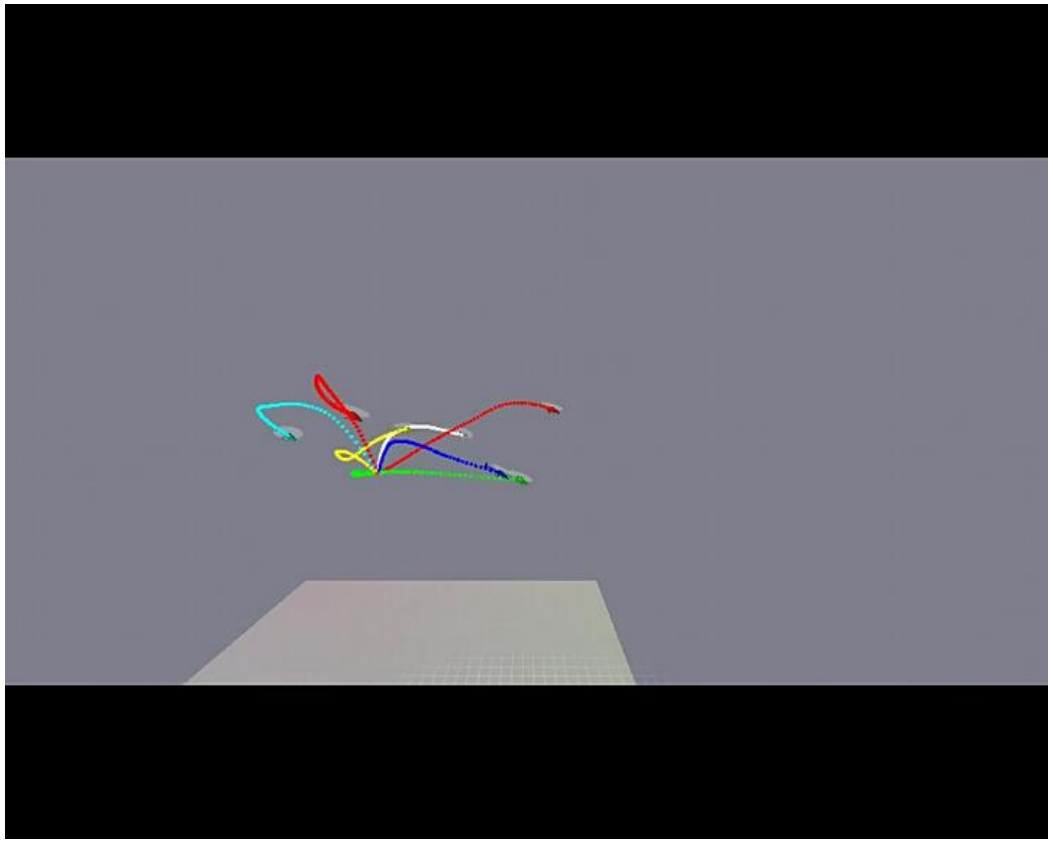
3. Model Building autonomous controller



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

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- Exam (60%)

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- 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

Labs

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- 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]