Introduction to Machine Learning

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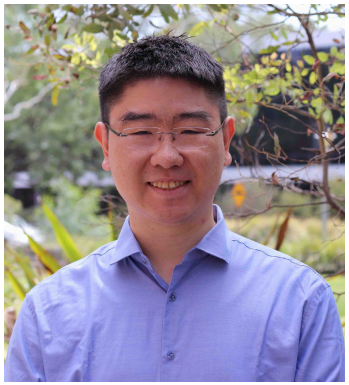
Who Are We?



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Tutors

Nutthadech Banditakkarakul
Xinghao Li
Shi Qiu
Xiaoxiao Sun
Ruiqi Li
Alexander Soen
Ruotian Zhang
Chinh La
Nikunj Sura
Xian Li
Dian Lu
Qingzheng Xu
David Quarel
Cheng Xue
Ruikai Cui

Who Are you?

Undergraduate students

Postgraduate students

Graduate certificate students

Lectures

- 1:30pm – 3:00 Tuesday
- 3:30pm – 5pm Wednesday
- Week 1 to Week 12
- Kambri Manning Clark Hall
- Zoom link: https://anu.zoom.us/j/83859790342?pwd=TWR2UnVlZUREUXVEc2tzeWg3N1NpQT09

- Office hour (online)
- 1pm-2pm Friday
- Same Zoom link as lectures

Evaluation

- Homework (40 pts)
  - 4 assignments, equally weighted
  - Programming and theory
    - Submitted to Wattle
  - Honor Code
    - You can form study groups to work on the homework
    - Write-up solutions on your own
    - List names of anyone you talked to
- Final Exam (60 pts)
  - Assess your understanding of machine learning algorithms
  - You do not need to write codes or pseudo codes

To support hybrid learning

- Live streamed + in-person lectures
- Lecture recordings will be available
- Exercises in each lecture (e.g., last 5 minutes in each lecture)
- I will stay a while (10 - 20 minutes) after each lecture to answer individual questions
- Lab materials / lecture slides will be released as early as possible
- Group discussions in tutorials
- Instant feedback on assignments / exam / lectures on Piazza
- No hurdle
  - We will have self-assessment in Week 2
  - You may choose to drop the course if you feel the self-assessment questions are too difficult for you

How can you support us teaching?

- Try to show up in lectures
- Try to turn your camera on
- Actively participate in your online discussions
- Try to show up in your labs/tutorials
- Be proactive
  - Ask questions before your lab/tutorials
  - Give us feedback during/after class

Class representatives needed!

Assignment dates

Week	Mon	Tue	Wed	Thu	Fri	Sat	Sun
1	Jul 26						
2	Aug 2		Ass1				
3	Aug 9						
4	Aug 16		Ass2				Ddl1
5	Aug 23						
6	Aug 30						Mk1
Break							Ddl2
Break							
7	Sep 20		Ass3				Mk2
8	Sep 27						
9	Oct 4		Ass4				Ddl3
10	Oct 11						
11	Oct 18						Ddl4 Mk3
12	Oct 25						Mk4*

Date when assignment is released

Date when assignment is due

Date when mark is available. Feedback will be uploaded after that.

*Note: Mark release for A4 may be a few days after Week 12 but will be before the exam.

Policy

- Late policy
  - No deadline extension unless
    - accompanied by a doctor's certificate
  - A 100% penalty after the deadline – 0 mark
    - A grace period of 5 minutes: it is fine if you are 5 minutes late.
    - Other than that, your mark will be 0 if you are late by at least 5 min 1 second, as per time on Wattle
  - We will send reminders 7 days, 3 days, 1day before the due date.
  - Test your internet connection & submit as you go
- For each assignment, if you think our marking is incorrect, you need to let us know in 30 days after the feedback is released.
  - Note: after we recheck your assignment, you might have increased/decreased/same marks
- We reserve the right to ask you to orally explain your solutions (see ANU policy on plagiarism http://academichonesty.anu.edu.au/UniPolicy.html)

Plagiarism

- https://services.anu.edu.au/education-support/academic-integrity
- You must
  - Work on your own solution, without taking a single look at others' (you can discuss though).
  - Cite the uni ID of anyone you discussed with.
  - Cite a (web) source when you get your idea from external sources.
  - Work on your own solution even if you get the idea from the web

- Formal process (against plagiarism) will be taken if
  - [Poor academic practice] Your solutions are highly similar to other students
  - [Poor academic practice] Your solutions are highly similar to a webpage (and potentially similar to other students who also use the same webpage as a source)
    - If you have cited the source, i.e., a genuine mistake, the penalty will be lighter
  - [Minor breach] You fail to cite the external reference where you get your idea from (but your solution is sufficiently different from the external reference)
  - [Minor breach] You fail to cite your peer who discussed with you (but your solutions are sufficiently different from your peers')
  - Other cases outlined in the ANU policy (link above).

Textbook

- Deisenroth, Faisal and Ong, "Mathematics for Machine Learning", 2019. https://mml-book.github.io/book/mml-book.pdf

Syllabus

Week	Topic	Week	Topic
1	Intro & Linear algebra	7	Probability and distributions
2	Linear algebra & Analytic geometry	8	Gaussian Mixtures
3	Analytic geometry & models meets data	9	Matrix decomposition
4	Clustering	10	Principal Component Analysis
5	Vector calculus	11	Classification
6	Linear Regression	12	Guest lectures

Machine Learning

What is machine learning?

Task

Performance

Experience

Algorithms that improve their performance
at some task with experience
– Tom Mitchell (1998)

What is machine learning?

- A branch of **artificial intelligence**, concerned with the design and development of algorithms that allow computers to evolve behaviors based on empirical data.

- As intelligence requires knowledge, it is necessary for the computers to acquire knowledge.

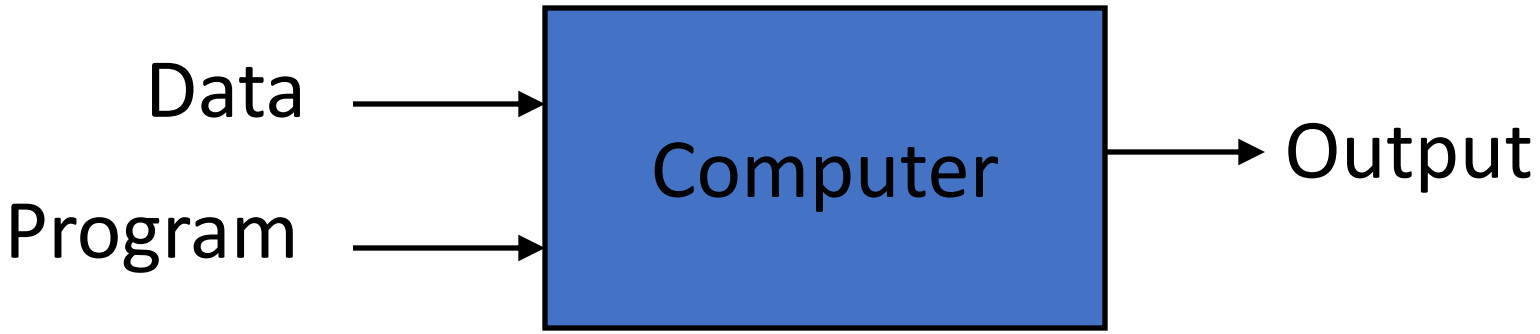
What is machine learning?

Hard-Coded

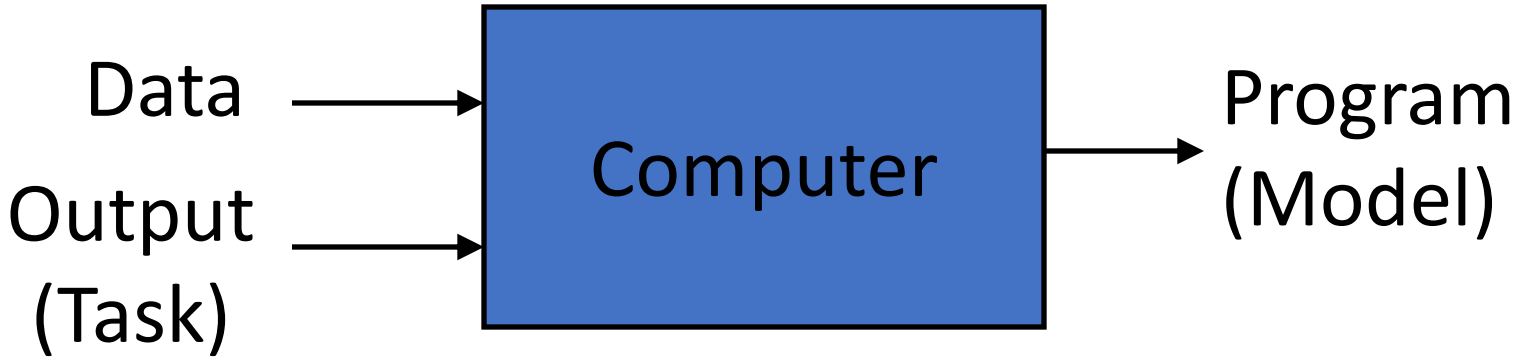
Trained

Giving computers the ability to learn without being explicitly programmed – Arthur Samuel (1959)

Traditional Programming



Machine Learning



What is machine learning?

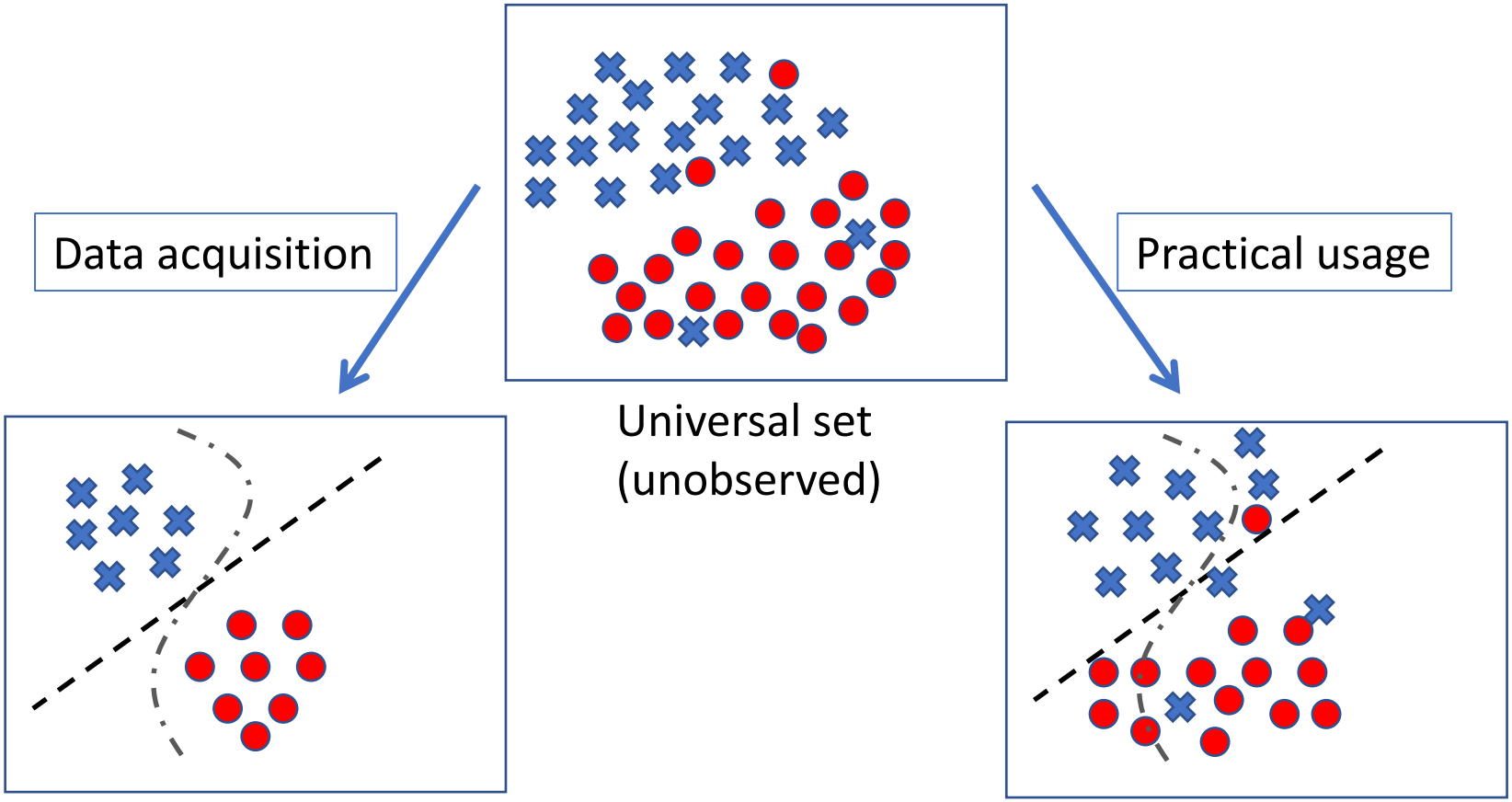
- We have a model
- We predict
  - Given input
- Image classification

input

model

Dog
Building
Cat ✓
Human
Car

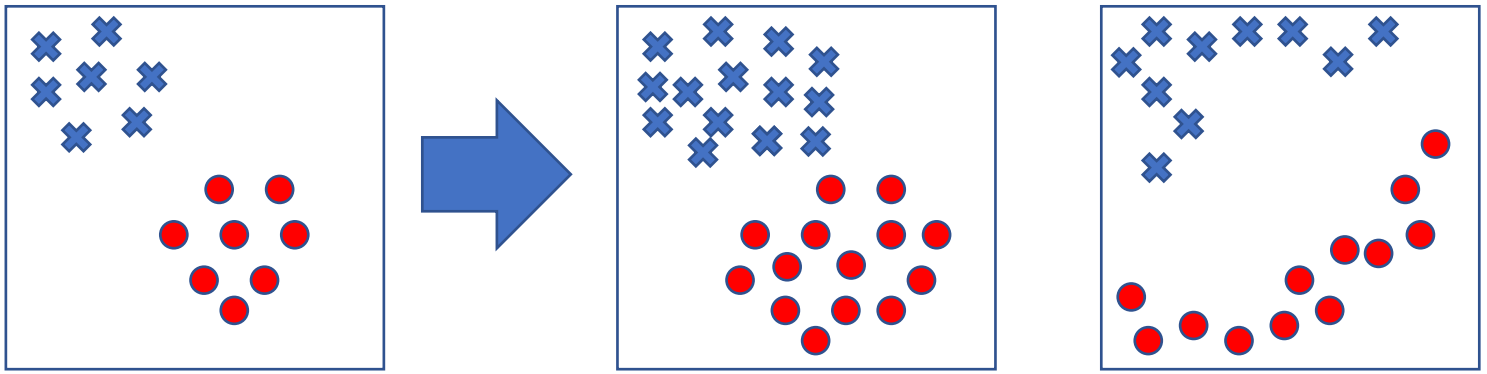
Training and testing



Training and testing

- Training is the process of making the system able to learn.

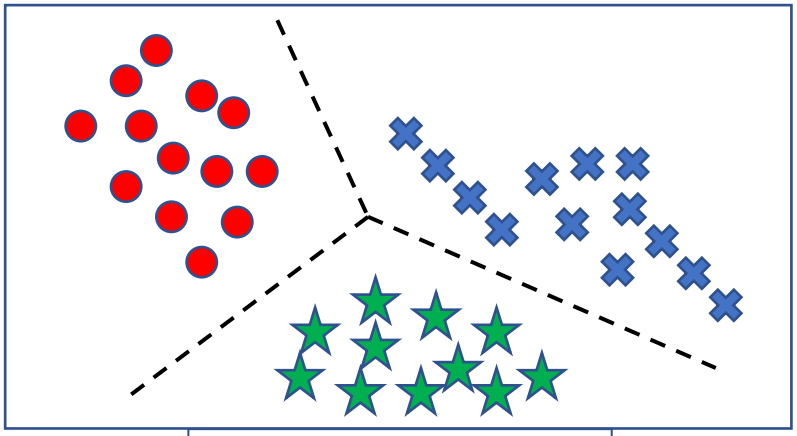
- No free lunch rule: a model that explains a certain situation well may fail in another situation.
  - Training set and testing set come from the same distribution
  - Before applying a model, check the assumptions!



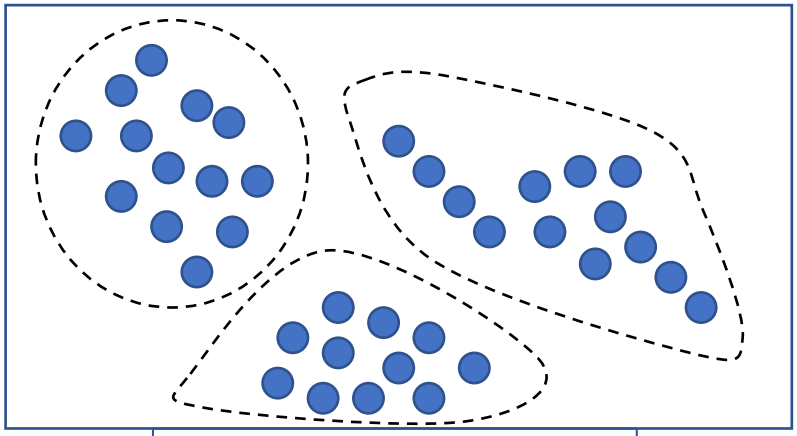
Training data

Testing data

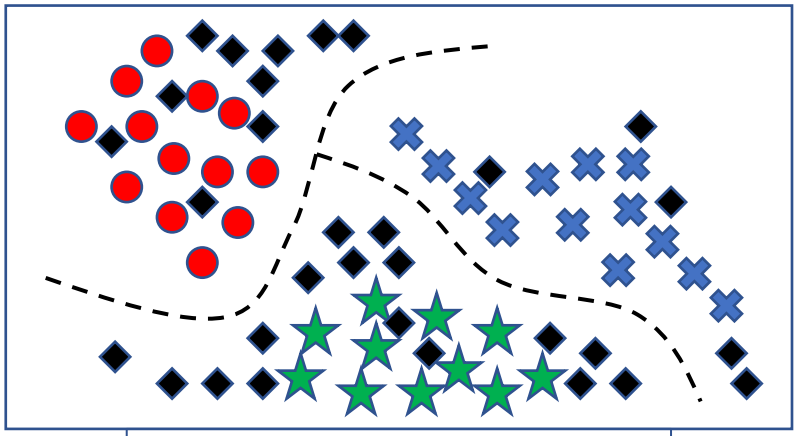
Types of machine learning



Supervised learning



Unsupervised learning



Semi-supervised learning

Supervised Learning

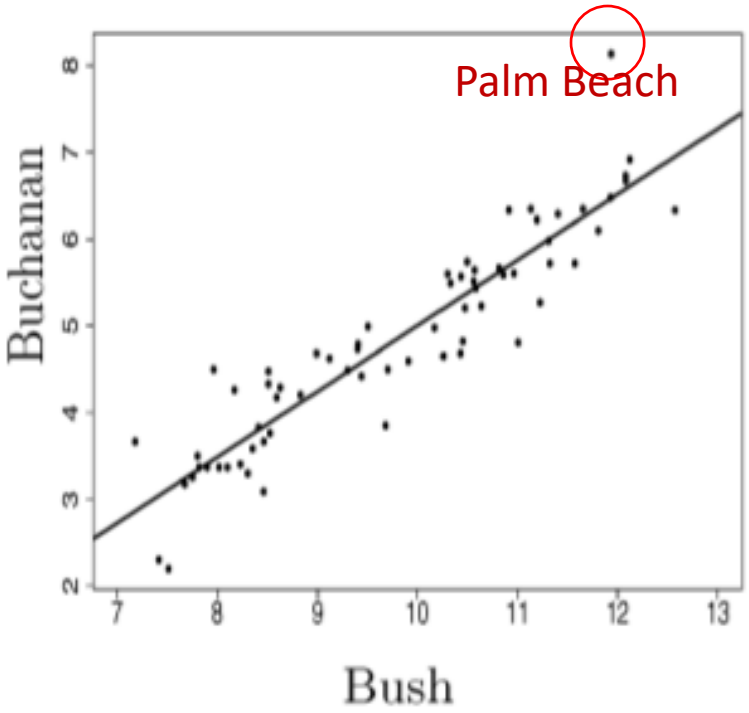
Learning a function

$y = f(x)$

$x \in \mathbb{R}$

$y \in \mathbb{R}$

Regression (Linear)



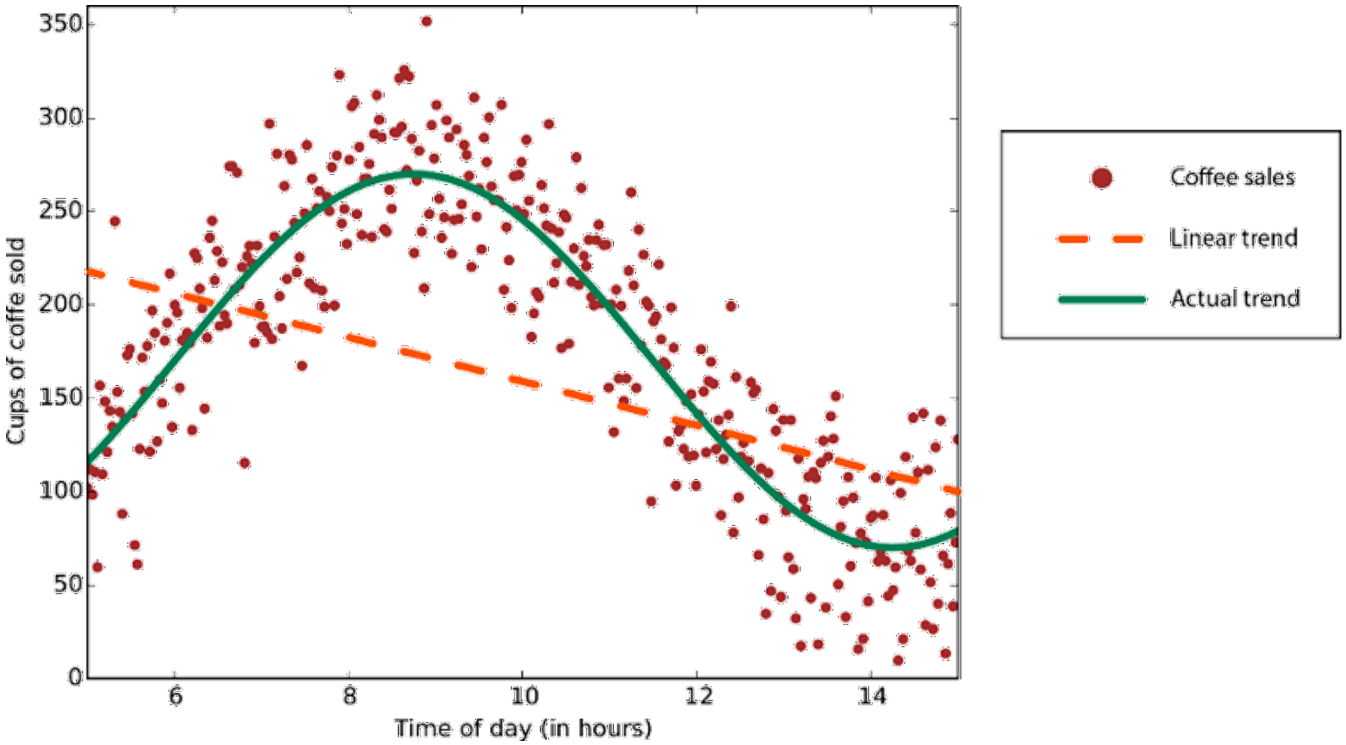
2000 USA Presidential Elections.

Votes for Buchanan and Bush in counties of Florida on a log scale.

https://en.wikipedia.org/wiki/United_States_presidential_election_in_Florida,_2000
http://andrys.com/flballot.html

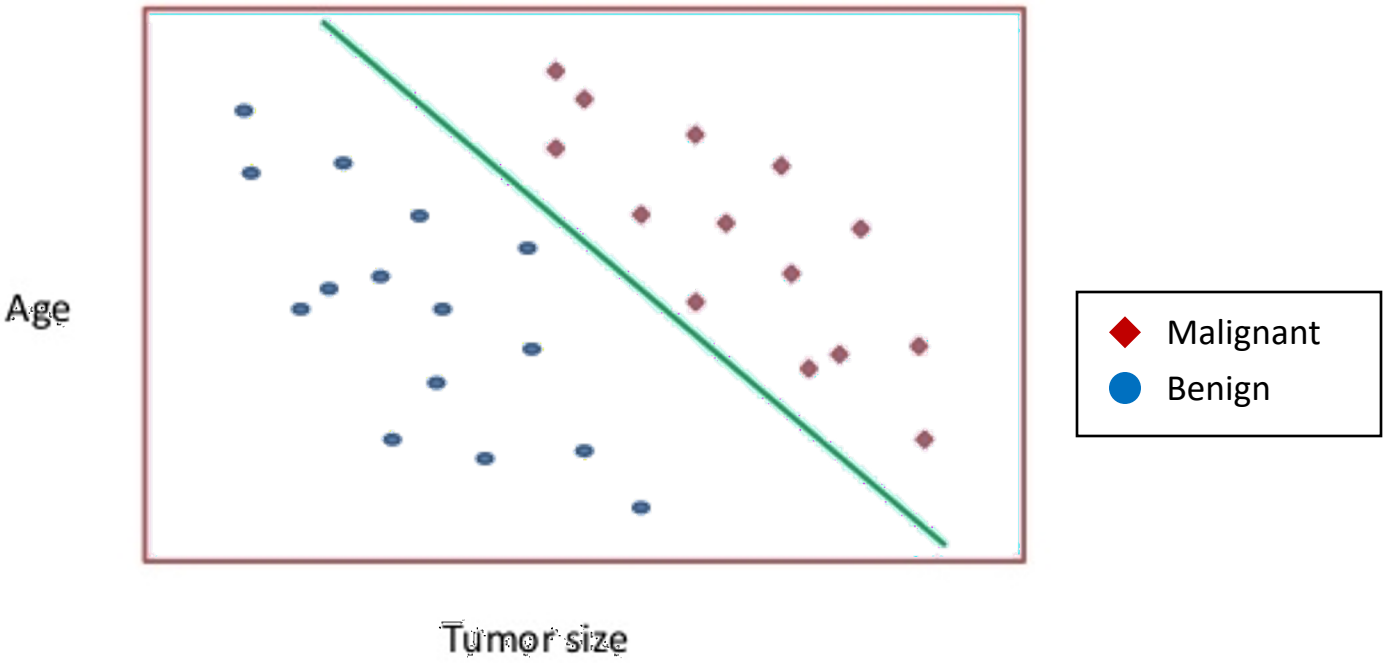
Supervised Learning

Regression (Non-linear)



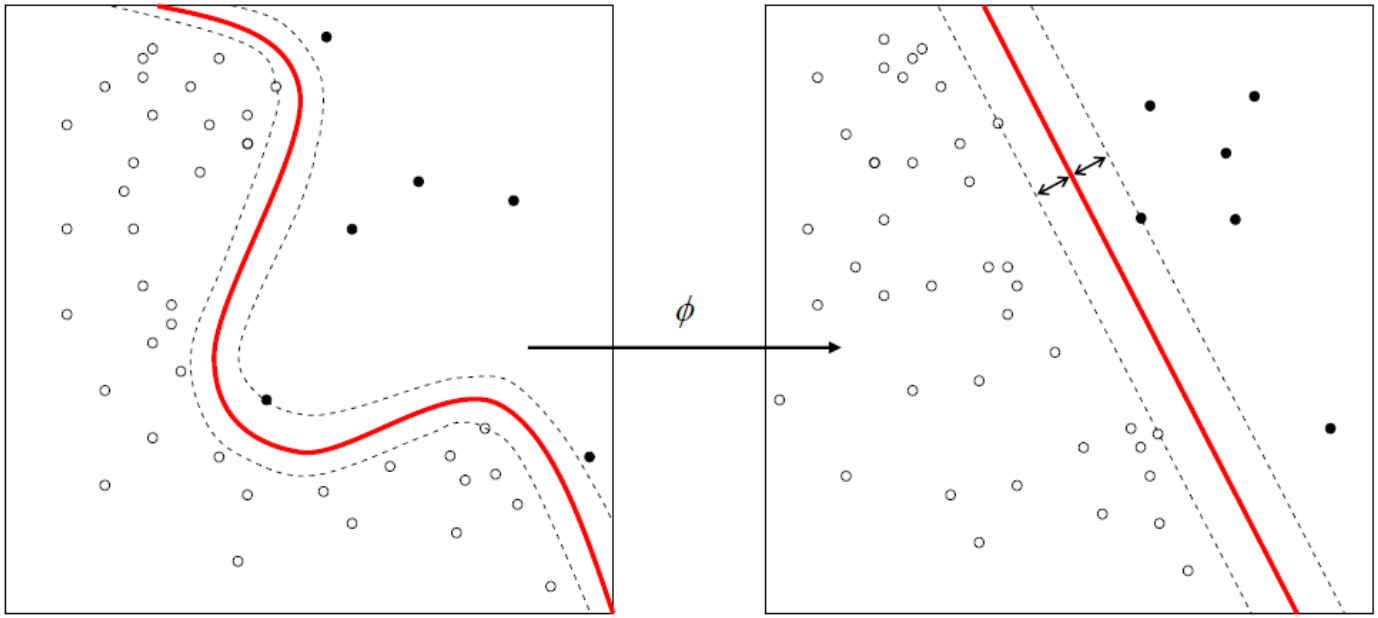
Supervised Learning

Classification (Linear)



Supervised Learning

Classification (Non-linear)

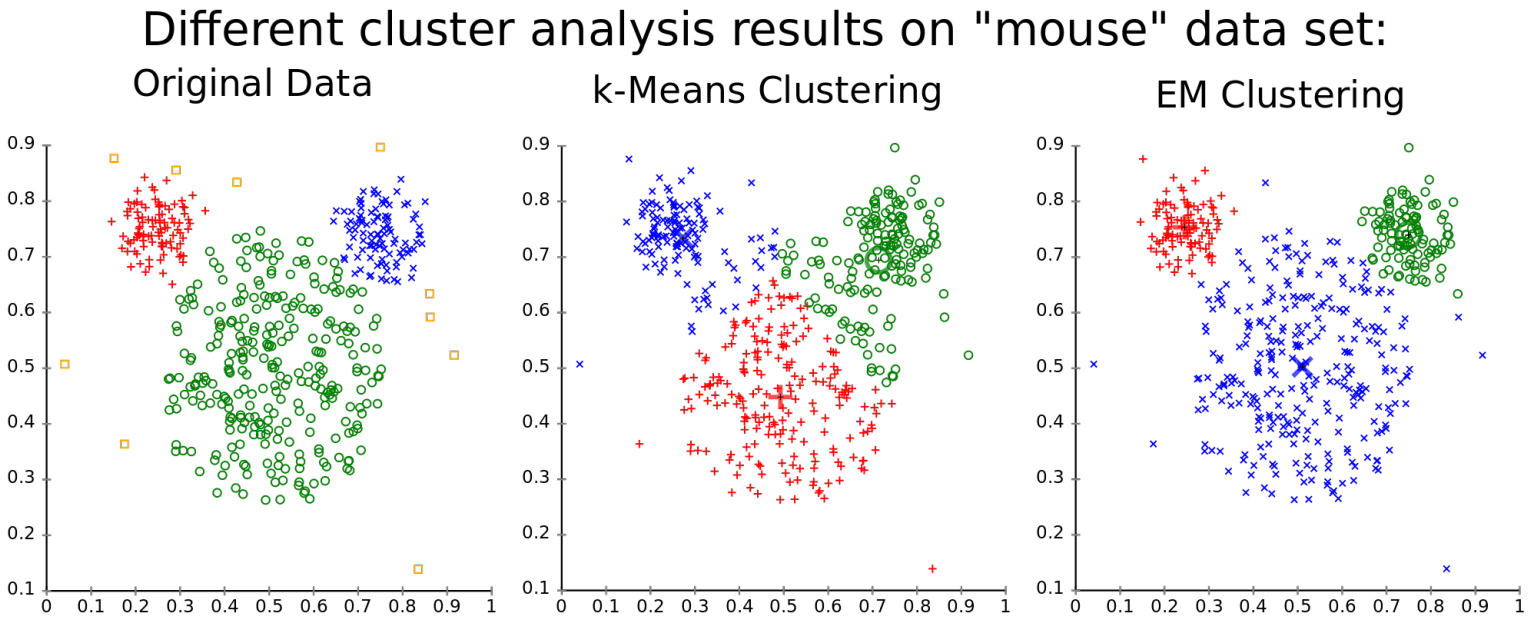


Spam Filters

Bayesian Networks

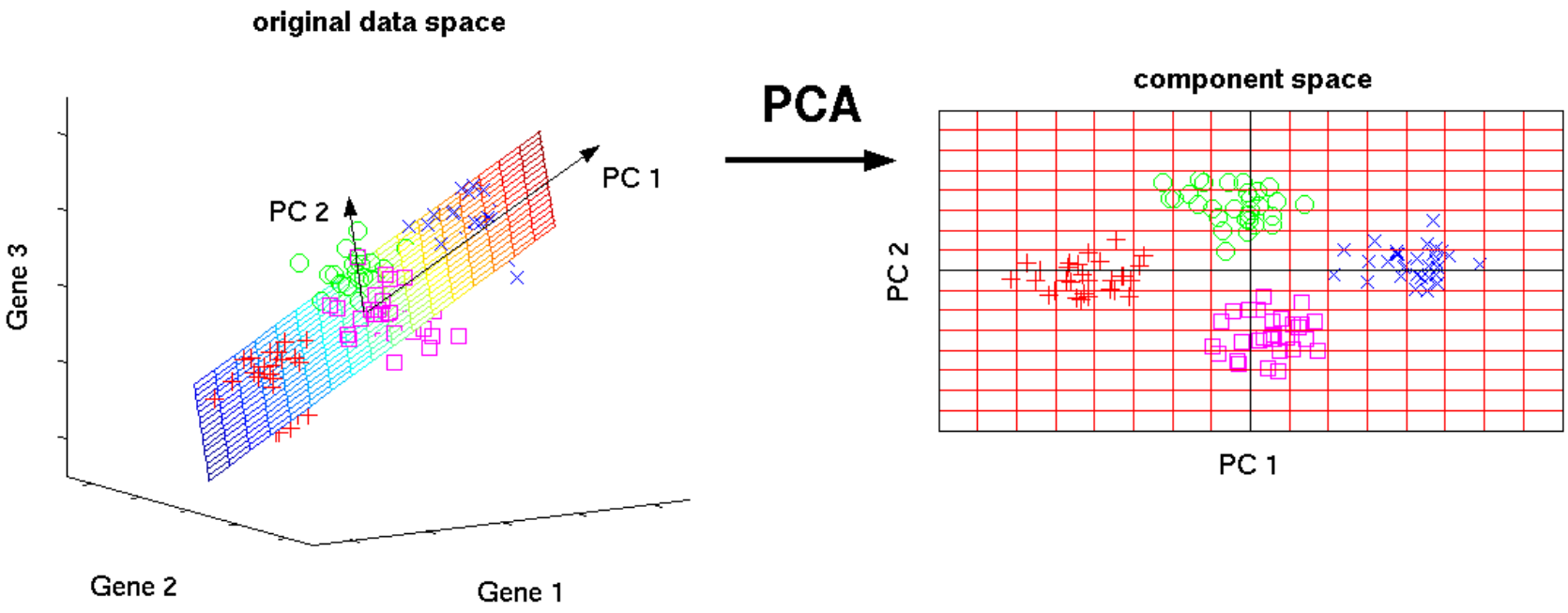
Unsupervised Learning

Clustering



Unsupervised Learning

Dimensionality Reduction: Subspace Learning



Deep Learning

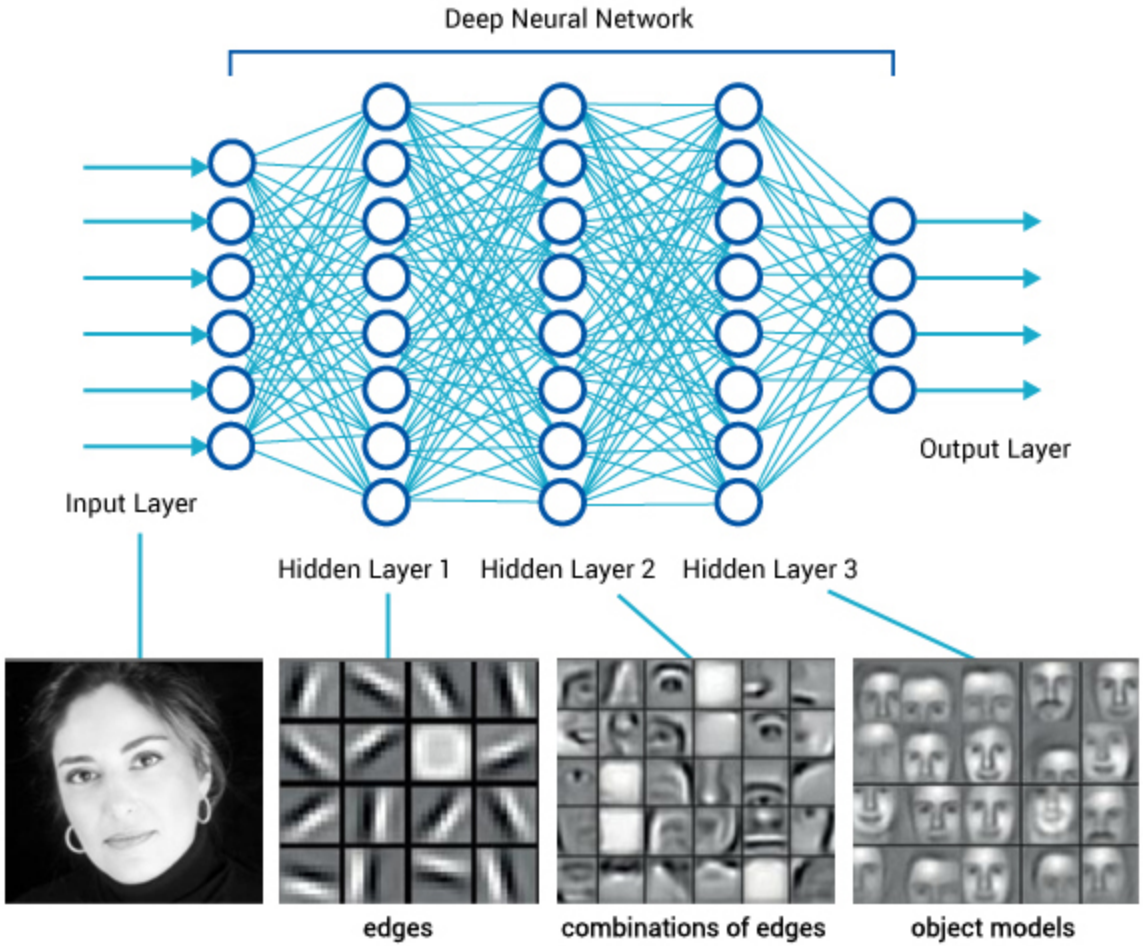


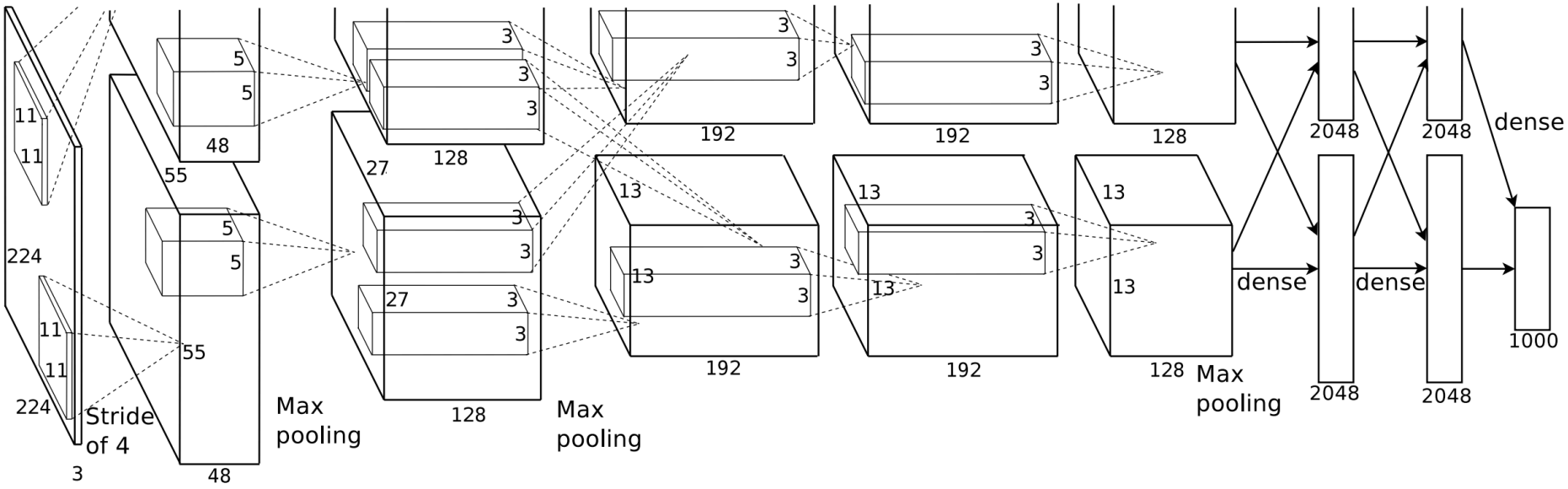
Image Classification

ImageNet dataset: 1,000 classes, 1.2 million images for training, 50k images for testing

Method	**Year**	**Top-1 error (%)**	**Top-5 error (%)**
Sparse coding	2010	47.1	28.2
SIFT + FV	2011	45.7	25.7
AlexNet	2012	37.5	17.0
VGGNet	2014	23.7	6.8
GoogleNet	2014	21.99	4.82
ResNet	2016	19.38	3.57

Human: 5.1%

Alexnet



Alex Krizhevsky, Ilya Sutskever, and Geoffrey E. Hinton. "Imagenet classification with deep convolutional neural networks." In Advances in neural information processing systems, pp. 1097-1105. 2012.

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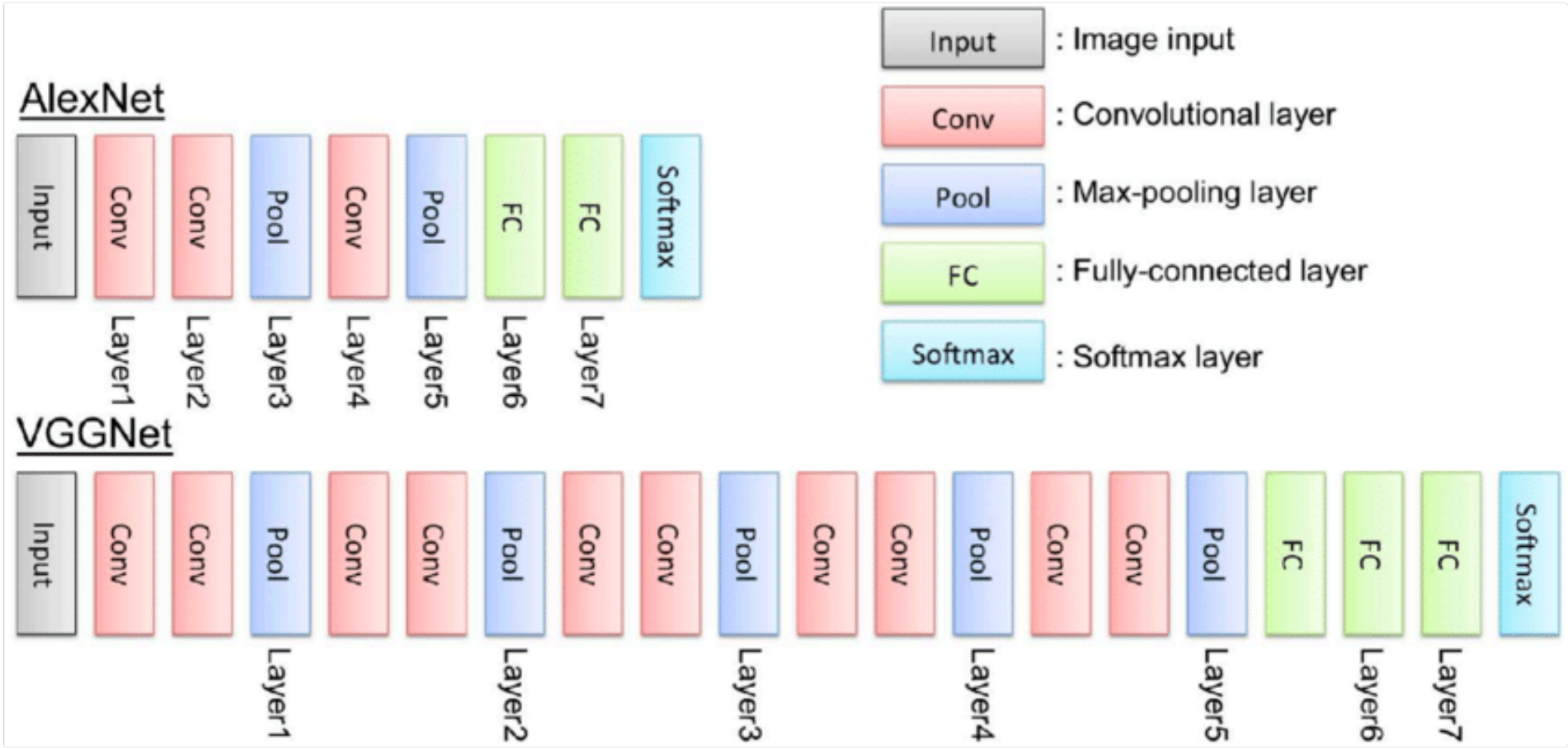
VGGNet

Karen Simonyan, and Andrew Zisserman. “Very deep convolutional networks for large-scale image recognition.” *ICLR 2015*.

VGGNet


Input : Image input
Conv : Convolutional layer
Pool : Max-pooling layer
FC : Fully-connected layer
Softmax : Softmax layer
AlexNet
Input
Conv
Layer1
Conv
Layer2
Pool
Layer3
Conv
Layer4
Pool
Layer5
FC
Layer6
FC
Layer7
Softmax
VGGNet
Input
Conv
Conv
Pool
Layer1
Conv
Conv
Pool
Layer2
Conv
Conv
Pool
Layer3
Conv
Conv
Pool
Layer4
Conv
Conv
Pool
Layer5
FC
FC
Layer6
FC
Layer7
Softmax

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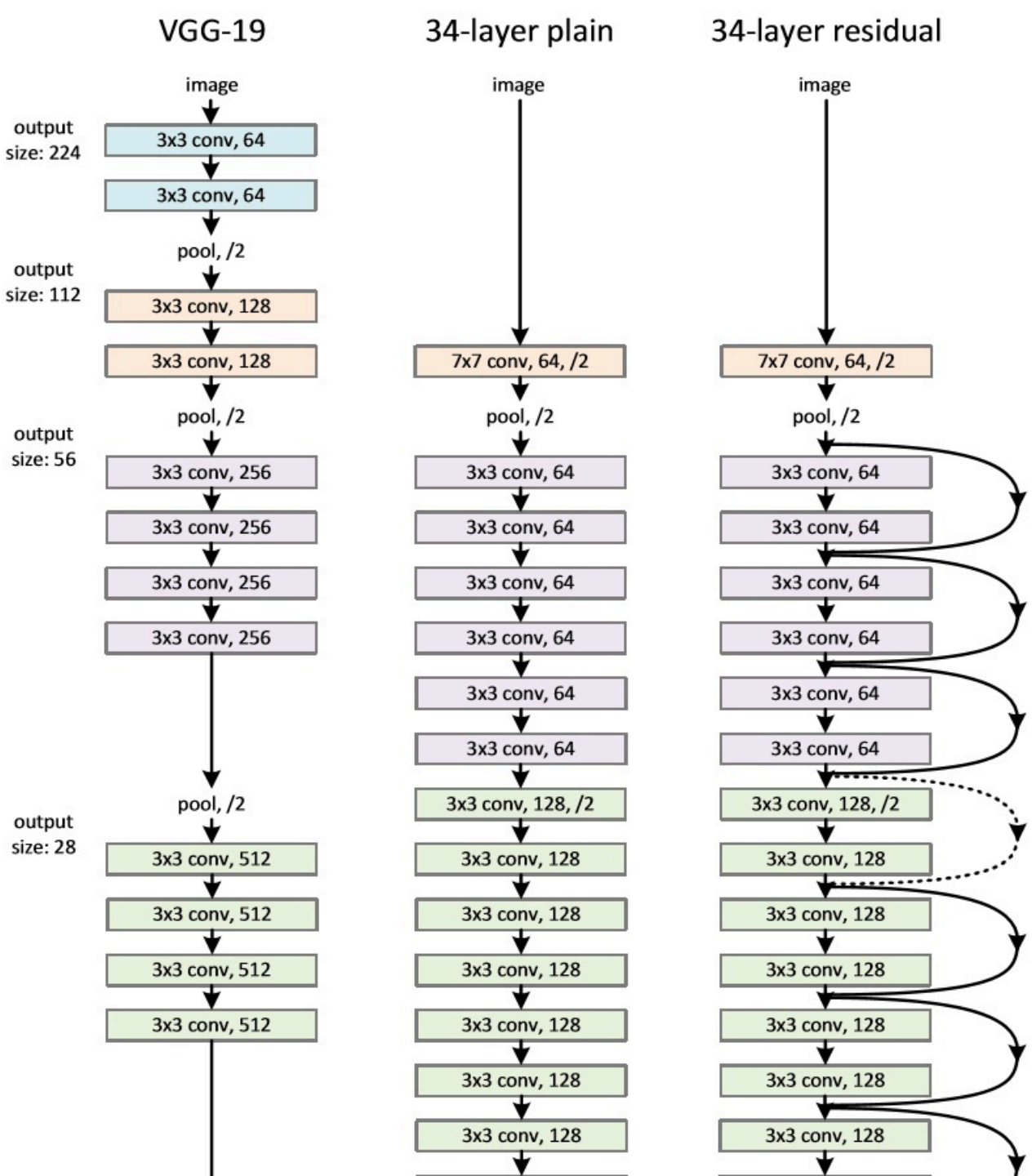
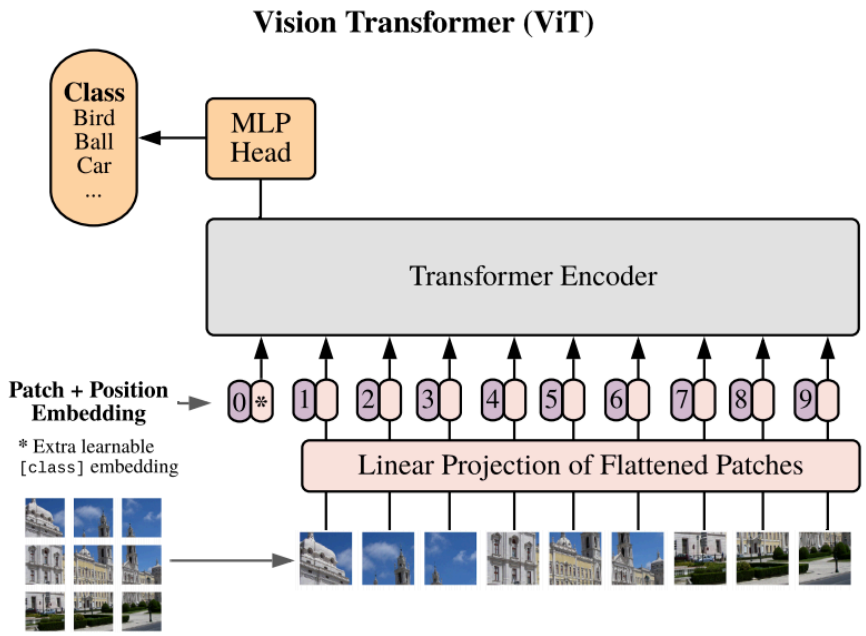
Human: 5.1%

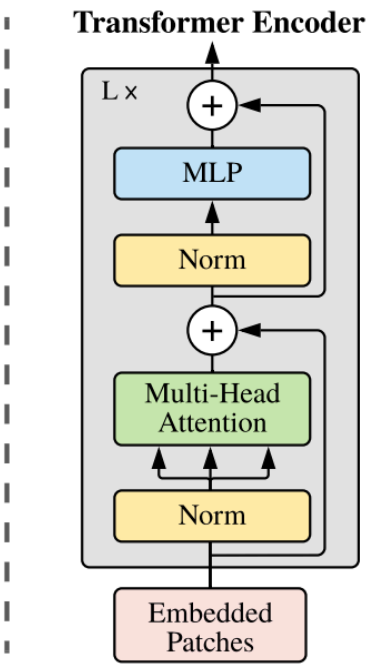
ResNet

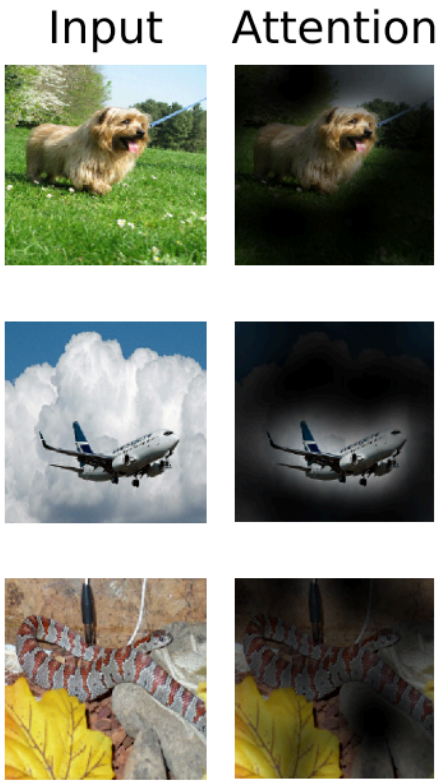
Kaiming He, Xiangyu Zhang, Shaoqing Ren, and Jian Sun. "Deep residual learning for image recognition." In *Proceedings of the IEEE conference on computer vision and pattern recognition*, pp. 770-778. 2016.


VGG-19
34-layer plain
34-layer residual
image
output size: 224
3x3 conv, 64
3x3 conv, 64
pool, /2
output size: 112
3x3 conv, 128
3x3 conv, 128
pool, /2
output size: 56
3x3 conv, 256
3x3 conv, 256
3x3 conv, 256
3x3 conv, 256
pool, /2
output size: 28
3x3 conv, 512
3x3 conv, 512
3x3 conv, 512
7x7 conv, 64, /2
pool, /2
3x3 conv, 64
3x3 conv, 128, /2
3x3 conv, 128

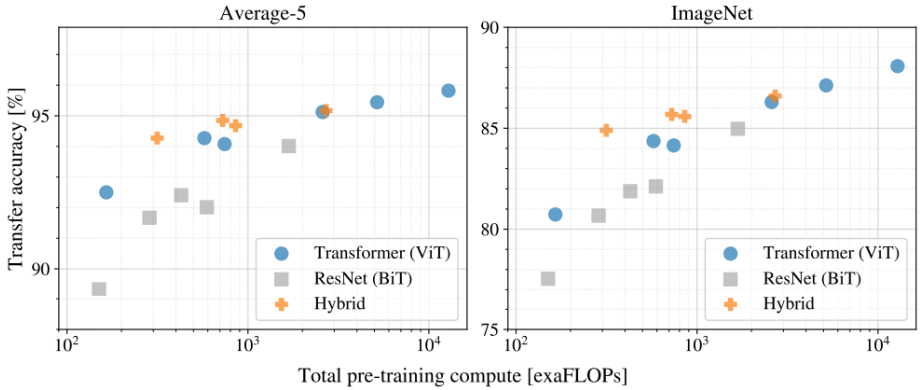
Vision Transformer, ICLR 2021







	Ours (ViT-H/14)	Ours (ViT-L/16)	BiT-L (ResNet152x4)	Noisy Student (EfficientNet-L2)
ImageNet	88.36	87.61 ± 0.03	87.54 ± 0.02	$88.4/\mathbf{88.5}^{*}$
ImageNet ReaL	**90.77**	90.24 ± 0.03	90.54	90.55
CIFAR-10	$\mathbf{99.50} \pm 0.06$	99.42 ± 0.03	99.37 ± 0.06	–
CIFAR-100	$\mathbf{94.55} \pm 0.04$	93.90 ± 0.05	93.51 ± 0.08	–
Oxford-IIIT Pets	$\mathbf{97.56} \pm 0.03$	97.32 ± 0.11	96.62 ± 0.23	–
Oxford Flowers-102	99.68 ± 0.02	$\mathbf{99.74} \pm 0.00$	99.63 ± 0.03	–
VTAB (19 tasks)	$\mathbf{77.16} \pm 0.29$	75.91 ± 0.18	76.29 ± 1.70	–
TPUv3-days	2.5k	0.68k	9.9k	12.3k



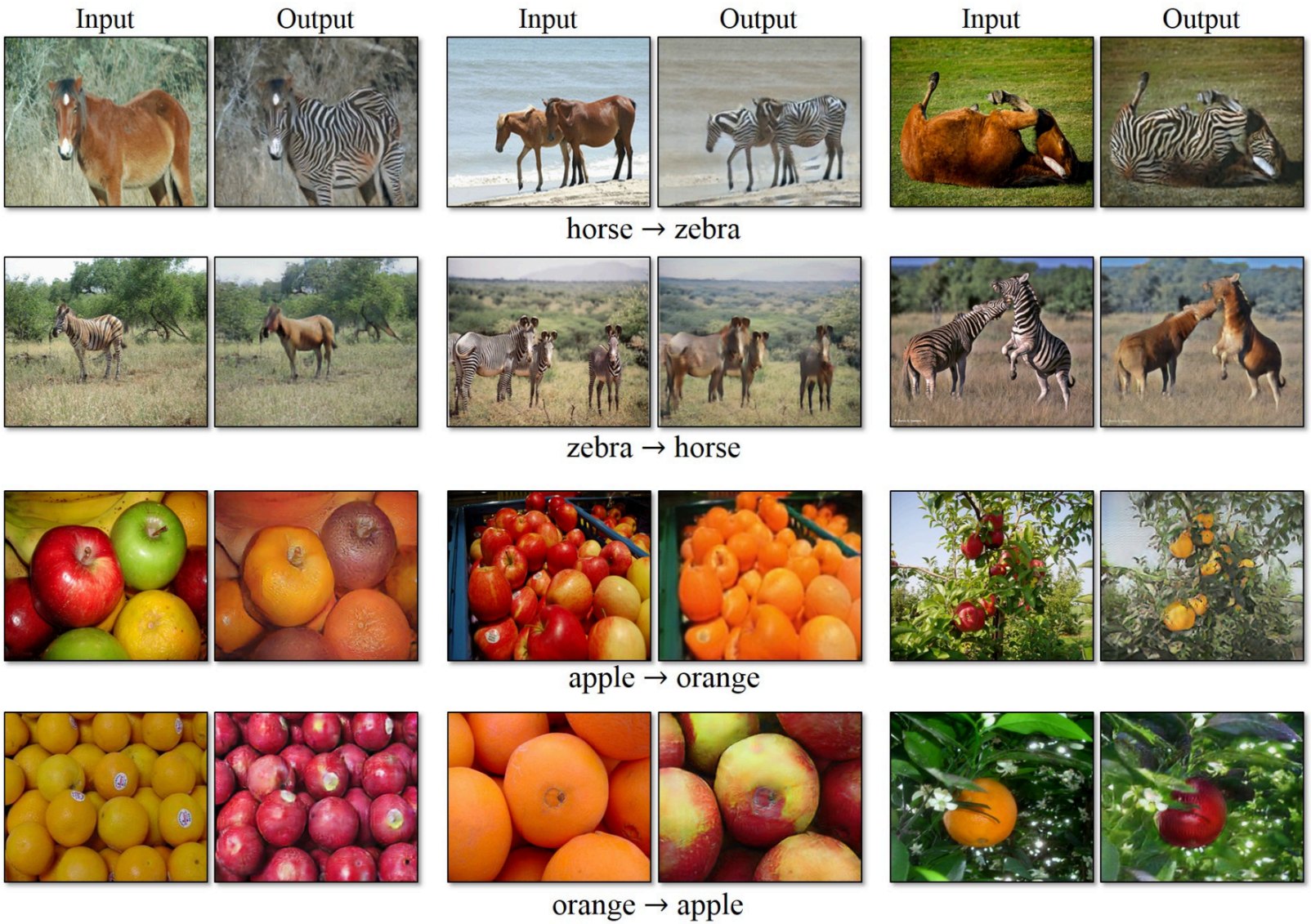
Object Detection

Generative Models

Collection Style Transfer

Generative Models

Object Transfiguration



Exercises (unrelated to your mark)

- Which of the followings are machine learning applications?

  (A) Timetabling at ANU

  (B) Face recognition at airports

  (C) Write machine learning assignment

  (D) Use a camera to detect car speeding

  (E) Use a GPS to track a player in a match.

  (F) Crop a face from an image using photoshop

  (G) automatically send alarm when water level is above a threshold

  (H) Google translation (e.g., English -> French)

  (I) Recommendation system in Facebook/Netflix