Introduction to Machine Learning

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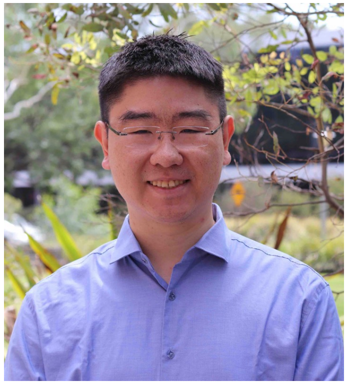
Who Are We?



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Tutors

Belona Sonna
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Yanjun Liu
Yao Ni
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Fazeleh Sadat Kazemian
David Quarel
Qinyu Zhao
Jiyang Zheng
Junming Zhao
Qingzheng Xu
Jiahao Zhang
Dian Lu
Jingyang You
Xinyu Tian
Xian Li
Xinghao Li
Haiqing Zhu
Alexander Yang

Who Are you?

Undergraduate students

Postgraduate students

Graduate certificate students

Lectures

- 16:00pm-17:30pm, Tuesday at Copland Lecture Theatre
- 15:00pm-16:30pm, Friday at Kambri Cinema
- Week 1 to Week 12
- Zoom link: https://anu.zoom.us/j/85047332371?pwd=RDNOTnAvaG9VQnBDNzdGcnBlNWpWZz09

  Meeting ID: 850 4733 2371
  Password: 634639
- Labs/tutorials run from Week 2 to Week 10.
- We use Piazza for Q&A

Evaluation

- Homework (40 pts)
    - 4 assignments, equally weighted
    - Programming and theory
        - Submitted to Wattle
    - Honor Code
        - You are allowed but not encouraged to form study groups to work on the homework
        - You must 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
- Quick 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 25						
2	Aug 1		A1				
3	Aug 8						
4	Aug 15		A2				
5	Aug 22						Ddl1
6	Aug 29						
Break							Mk1
Break							Ddl2
7	Sep 19		A3				
8	Sep 26						Mk2
9	Oct 3		A4				Ddl3
10	Oct 10						
11	Oct 17						Ddl4 Mk3
12	Oct 24						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.
  - It's OK to get your idea from external sources, but you must cite this (web) source.
  - Work on your own solution no matter where you get the idea

Plagiarism

- https://services.anu.edu.au/education-support/academic-integrity
- Formal process (against plagiarism) will be taken if
  - Your solutions are highly similar to other students’
  - Your solutions are highly similar to a webpage (and potentially similar to other students’ who also referred the same webpage)
    - 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.

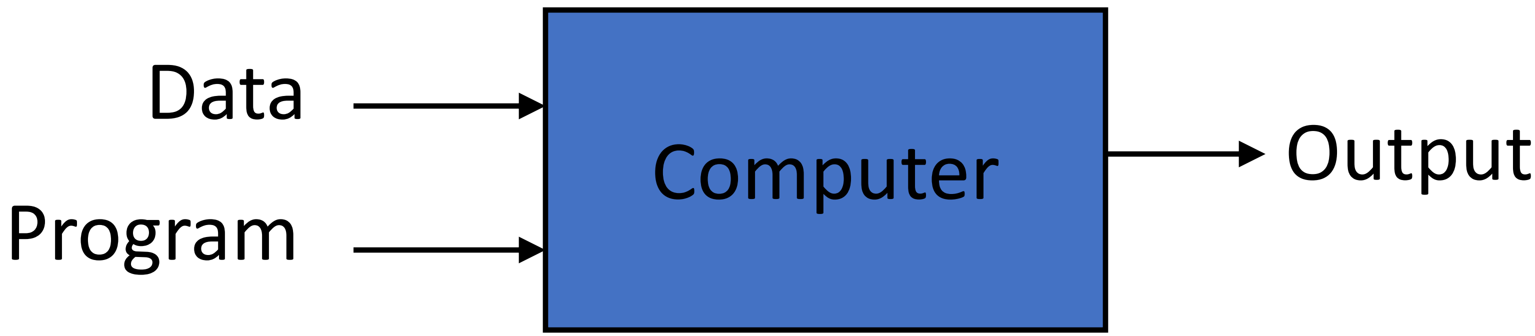
What is machine learning?

Hard-Coded

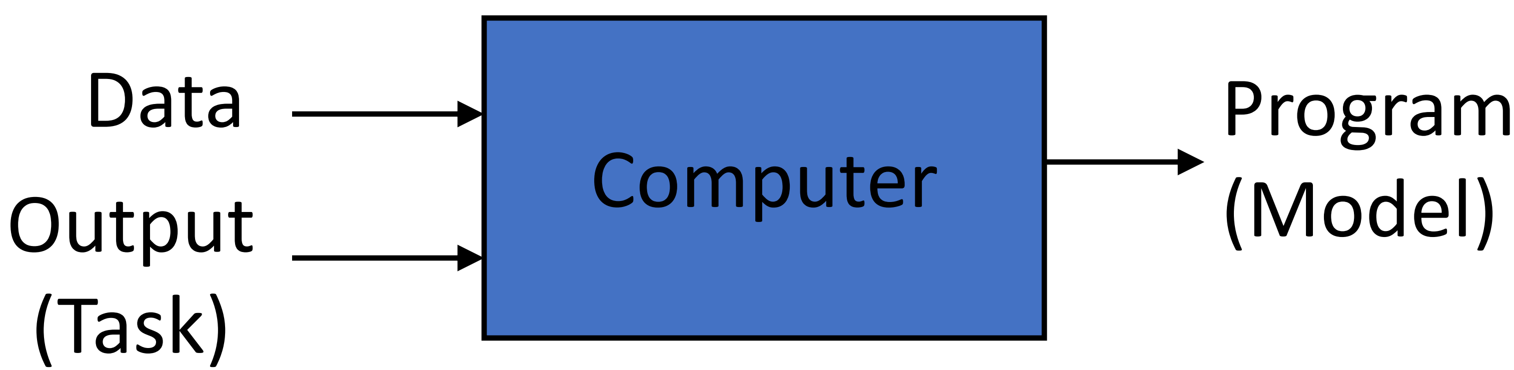
Trained

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

Traditional Programming

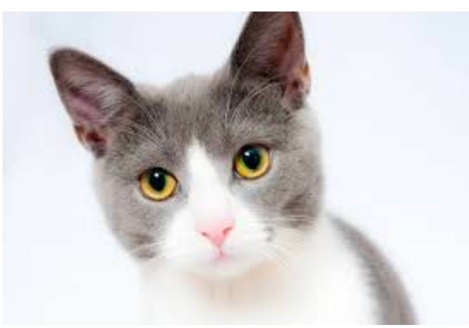


Machine Learning



What is machine learning?

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

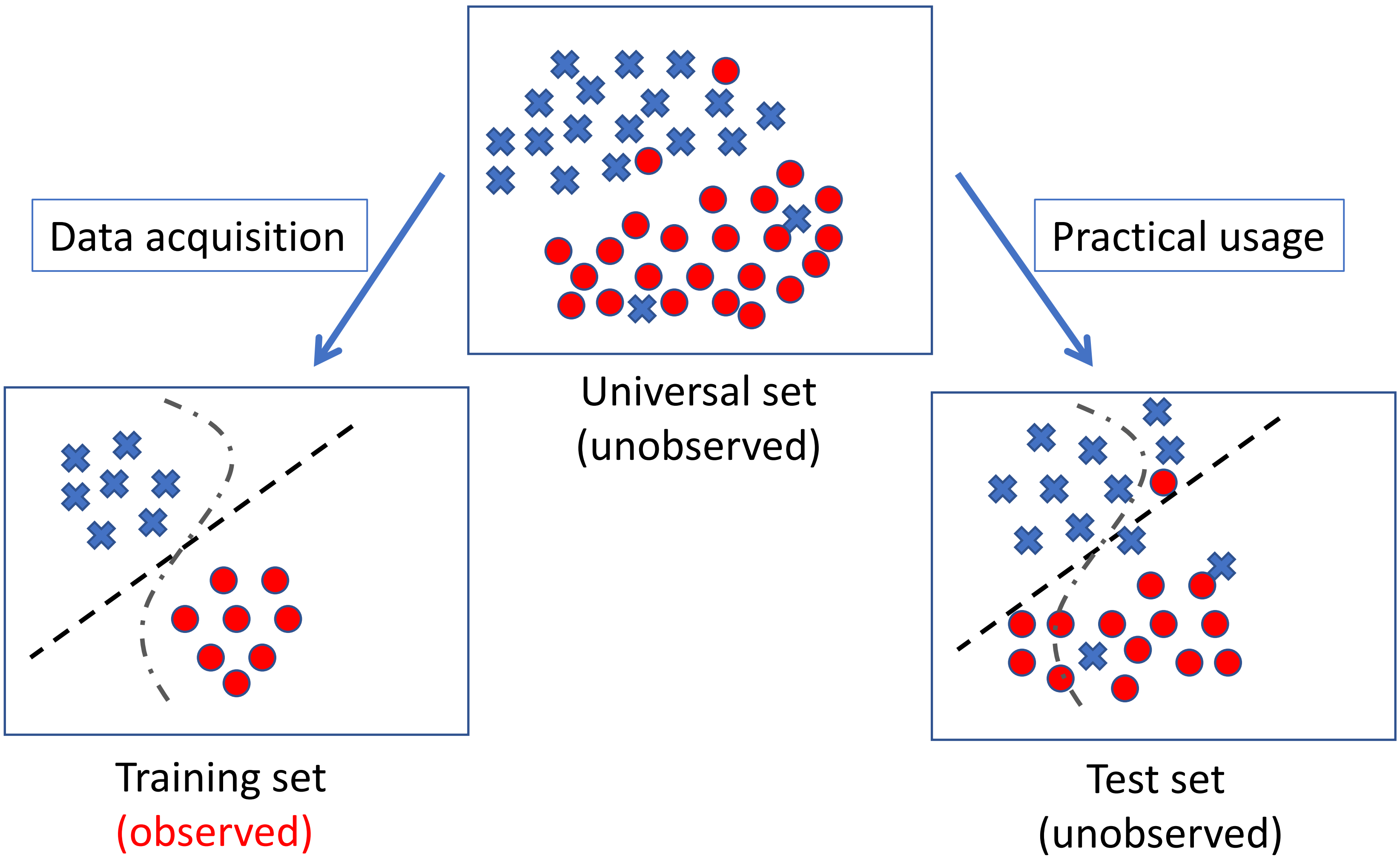


input

model

Dog
Building
Cat
Human
Car

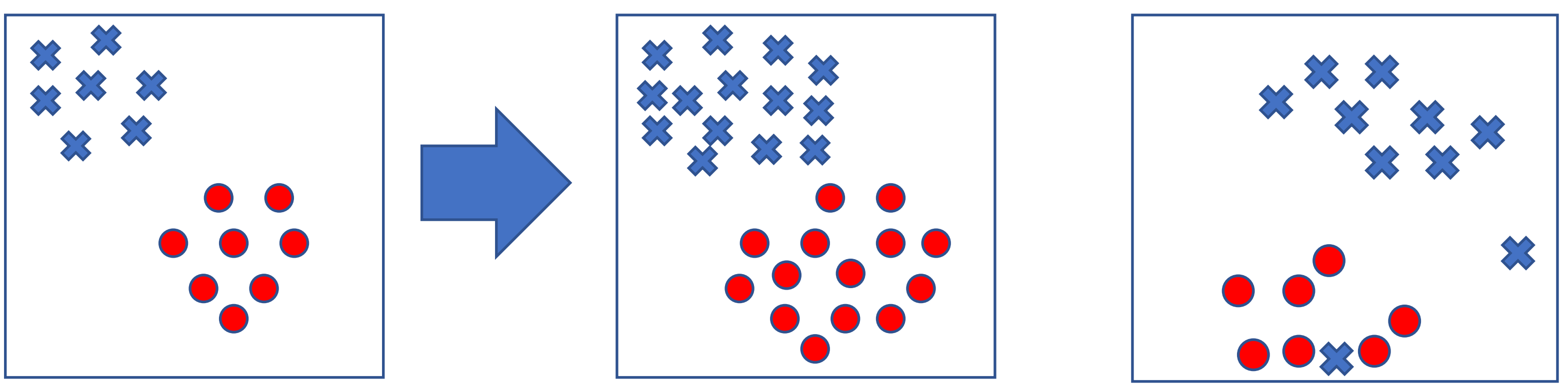
Training and testing



Training and testing

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

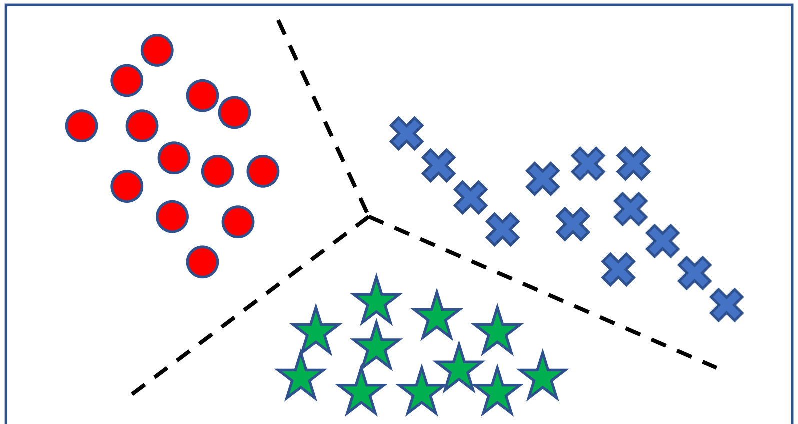
- A model that explains a certain situation well may fail in another situation.
  - Training set and test set come from the same distribution (in-distribution vs. out of distribution)
  - Before applying a model, check the assumptions!



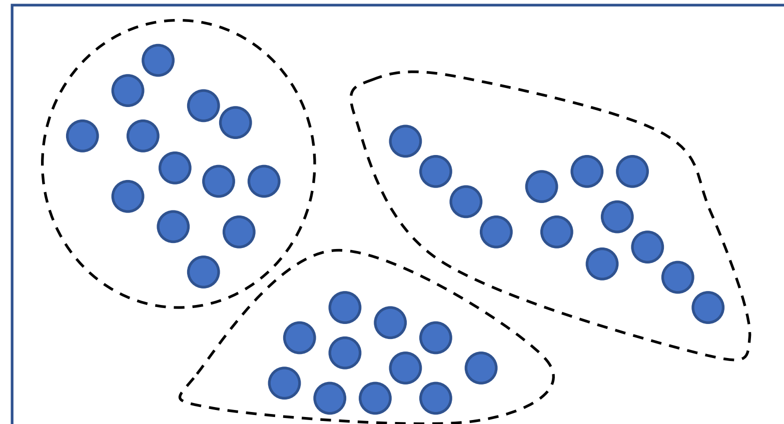
Training data

Test data

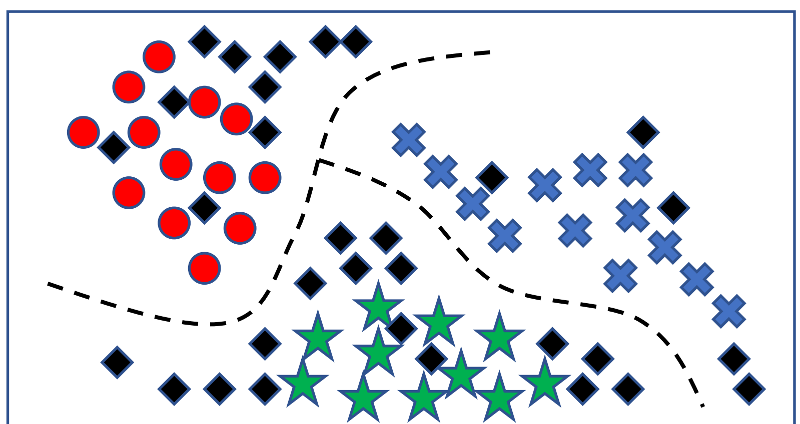
Types of machine learning



Supervised learning



Unsupervised learning

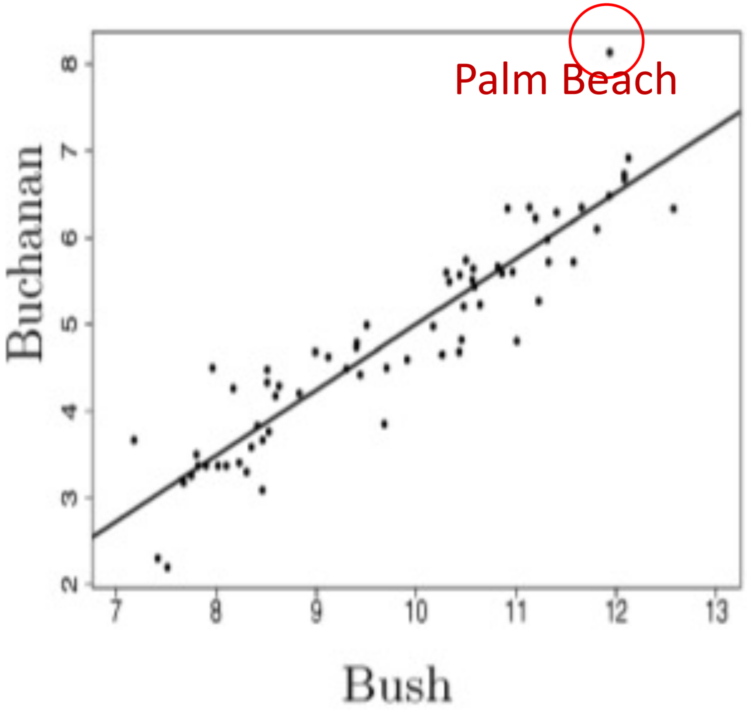


Semi-supervised learning

Supervised Learning

Learning a function
$y = f(x)$
$x \in \mathbb{R}$
$y \in \mathbb{R}$

Regression (Linear)



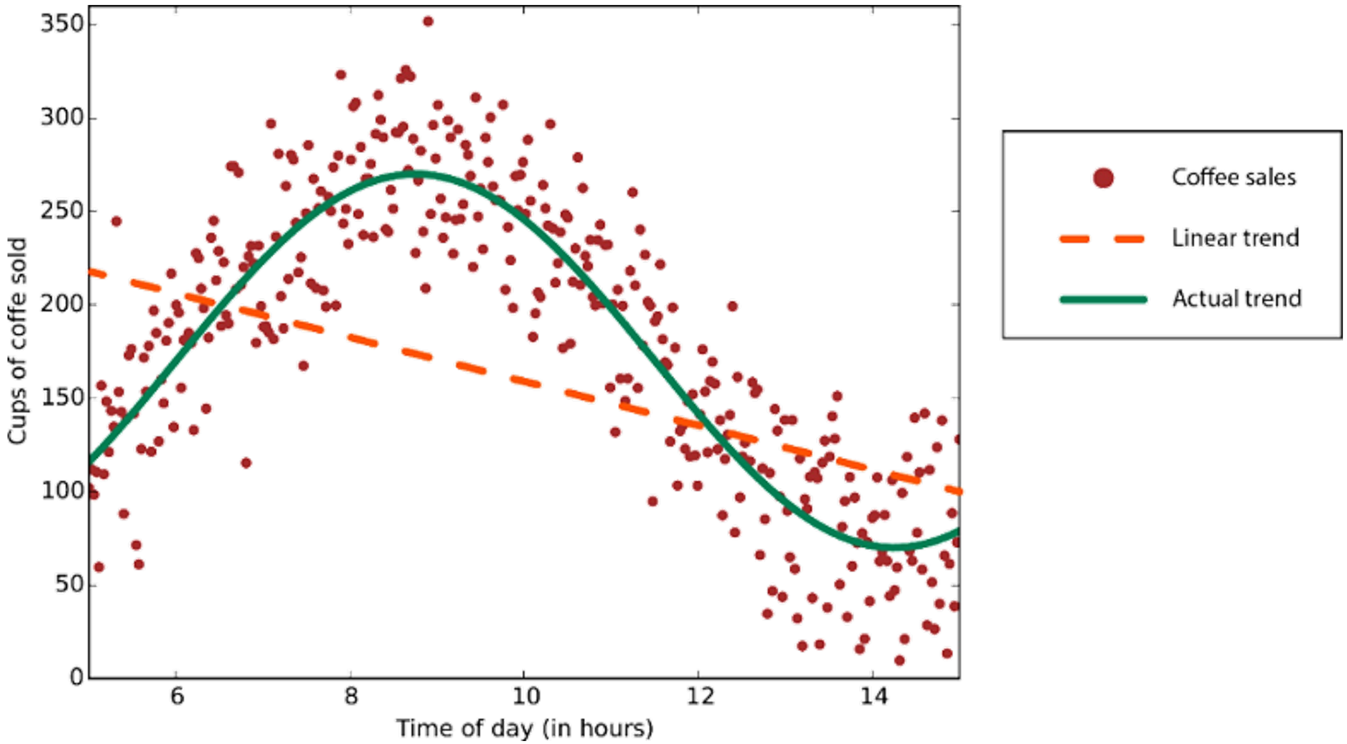
2000 USA Presidential Elections.

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

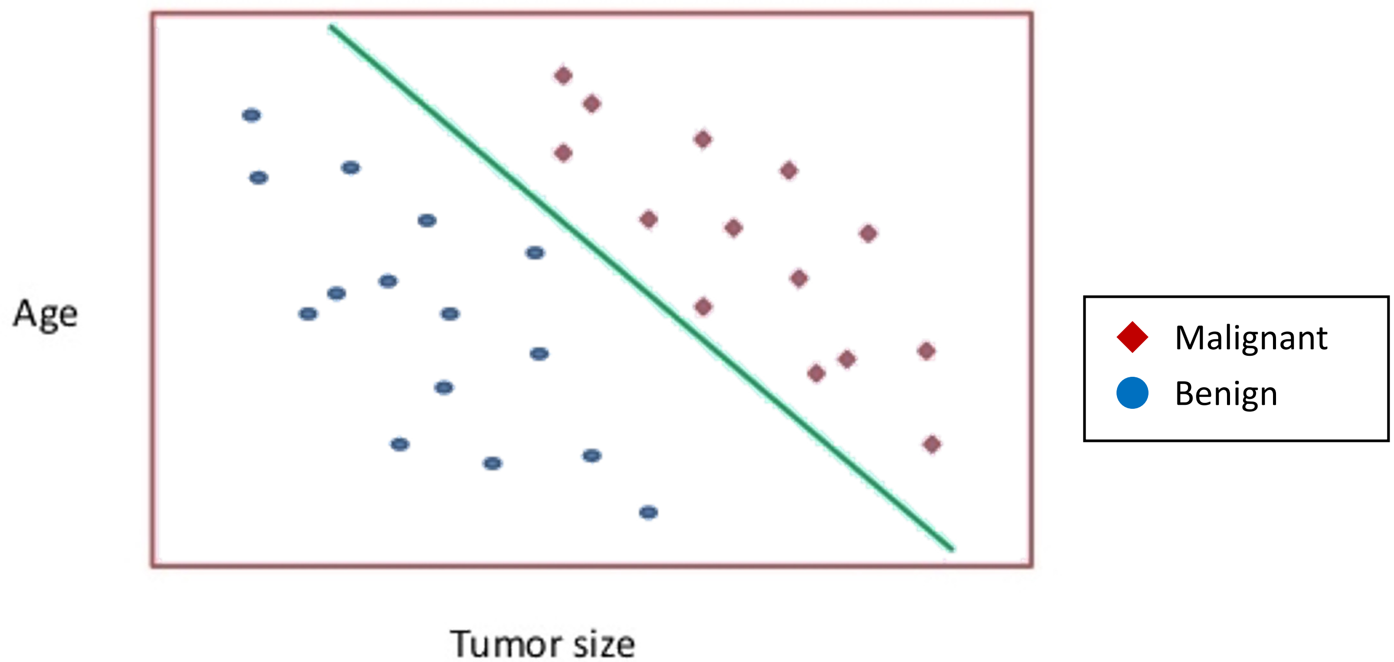
Supervised Learning

Regression (Non-linear)



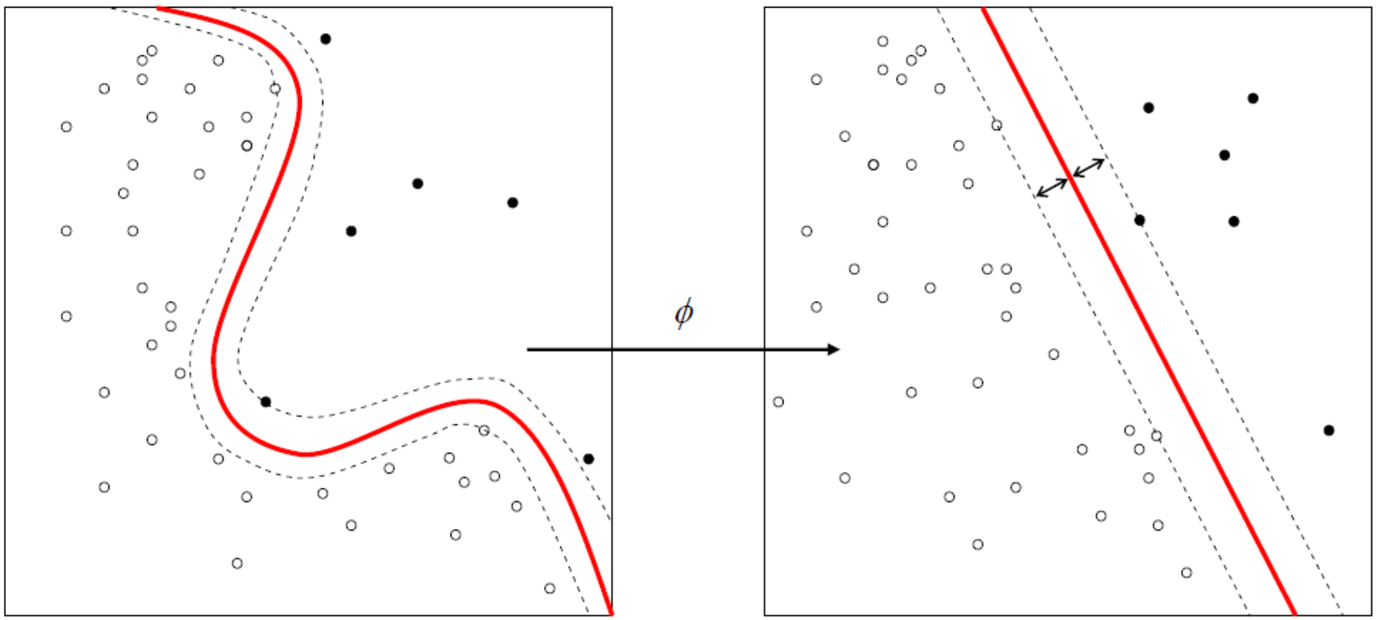
Supervised Learning

Classification (Linear)



Supervised Learning

Classification (Non-linear)



Spam Filters

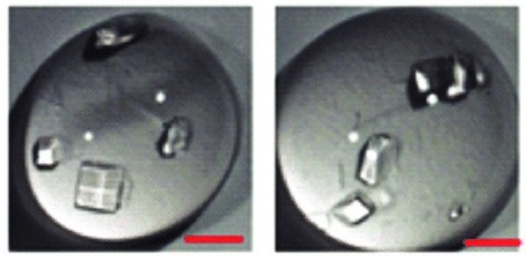
Bayesian Networks

AlphaFold2

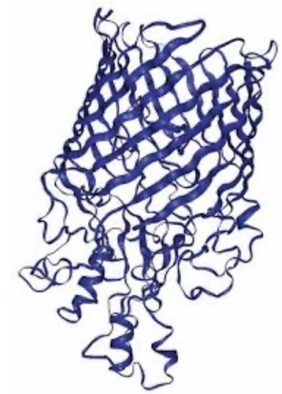
- Protein is a chain of amino acids and has complex 3D structures.

What structural biologists do:

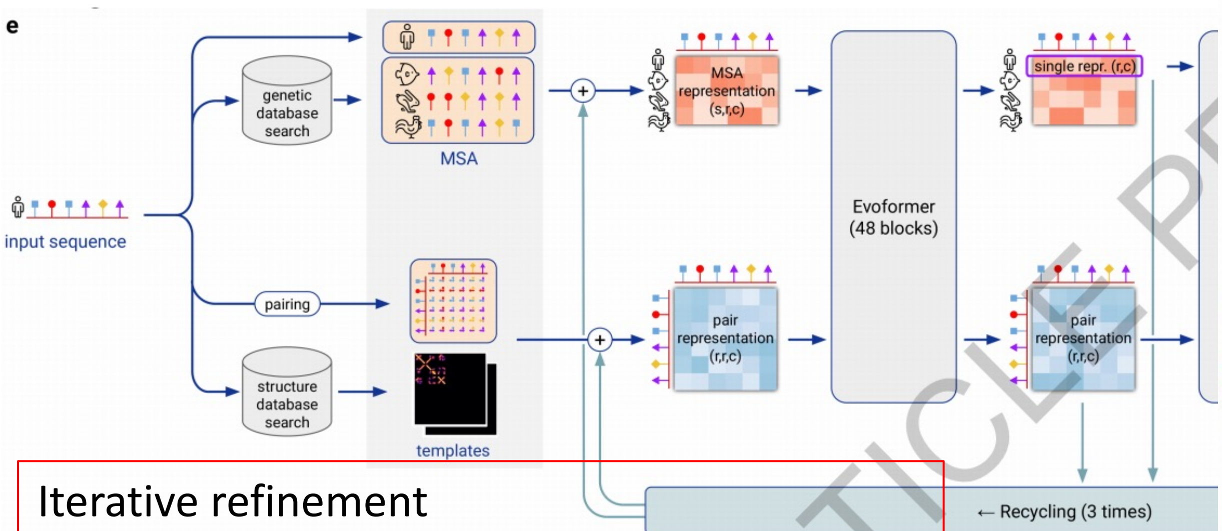
Working hard to find a crystallization condition

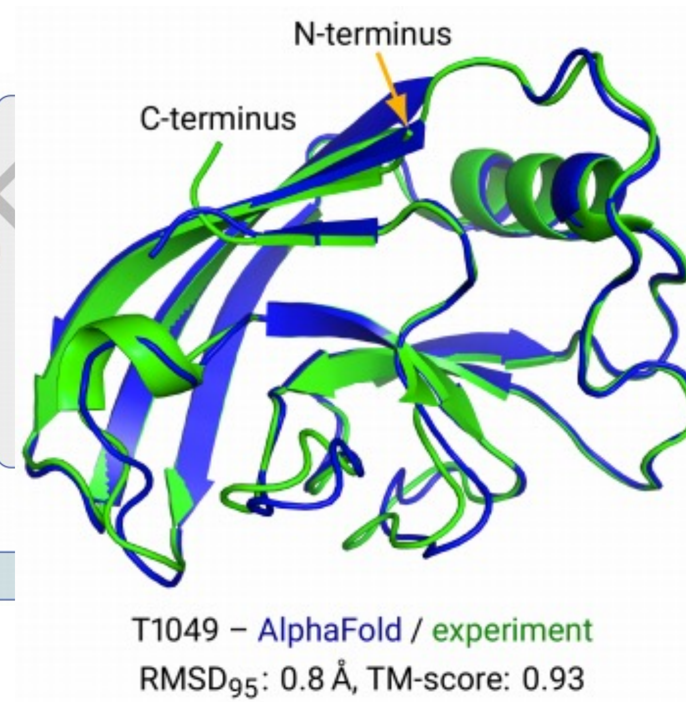


Cryogenic electron microscopy



What AlphaFold2 does:



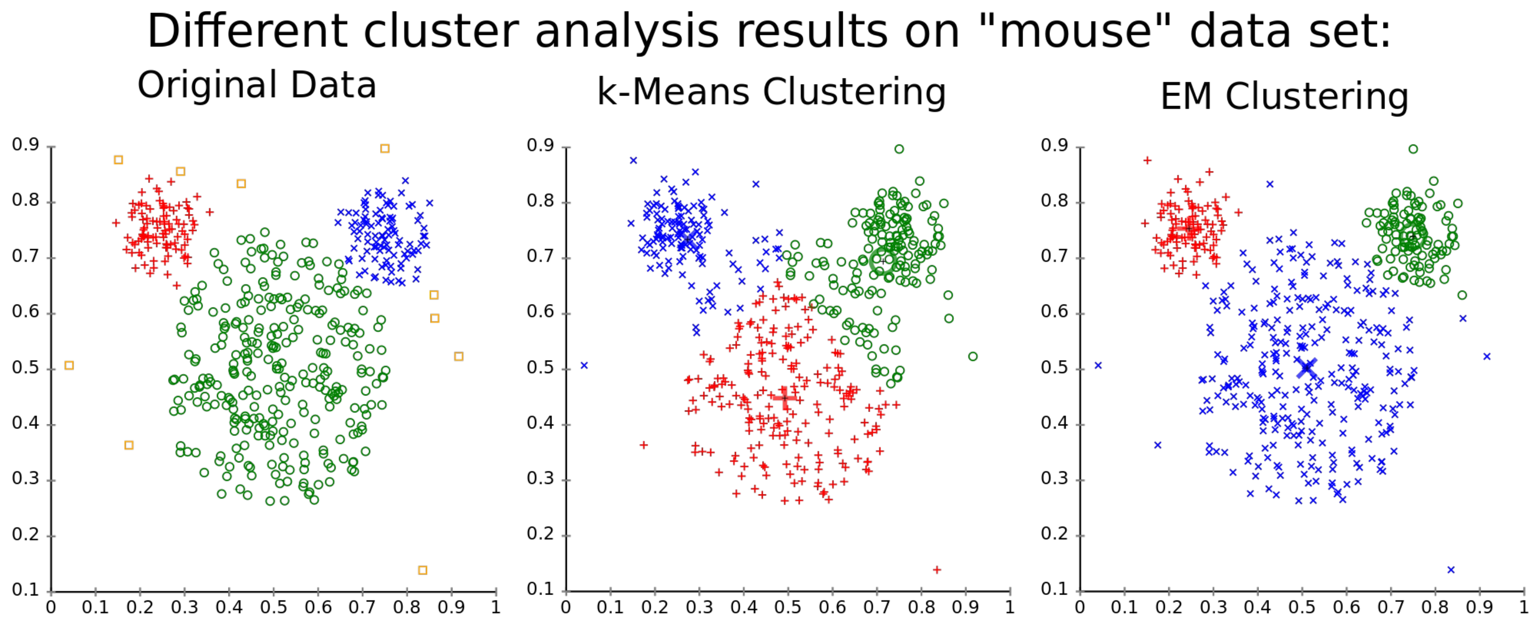


Iterative refinement
Widely used attention
Noise student training
Noise added to input – robust model training

Jumper et al., Highly accurate protein structure prediction with AlphaFold, Nature, 2021

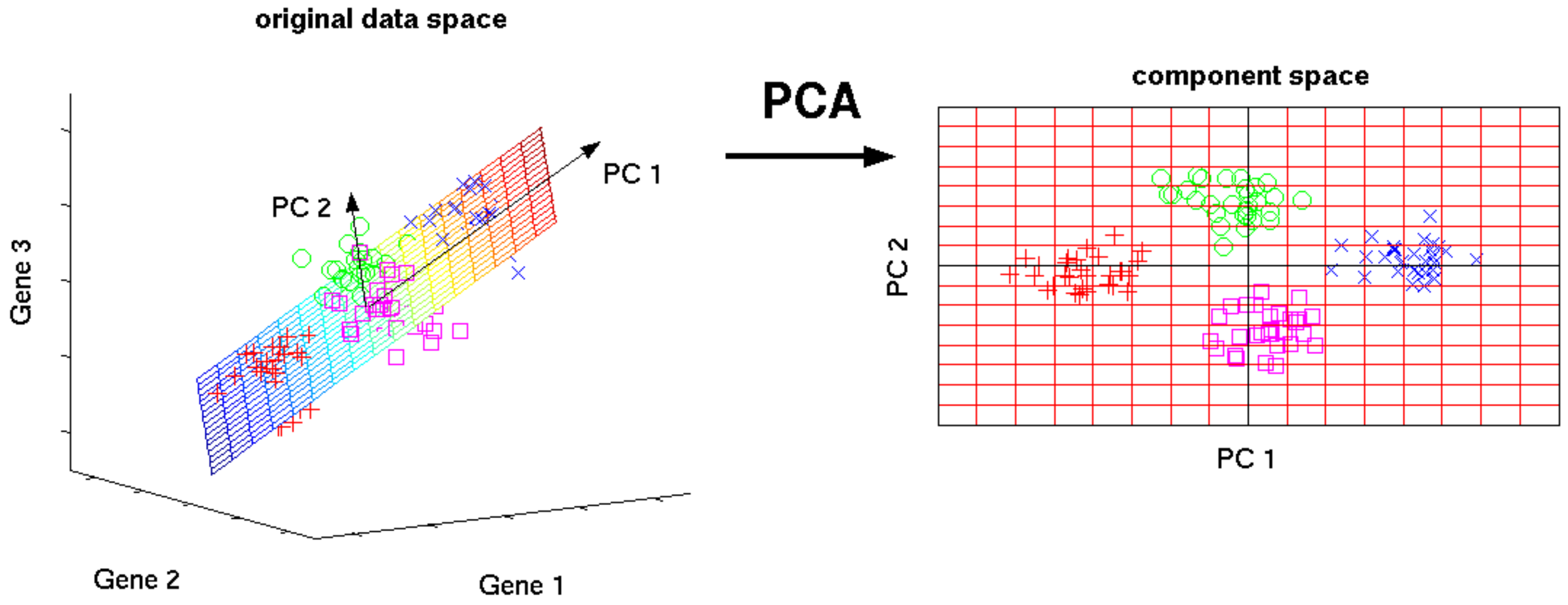
Unsupervised Learning

Clustering

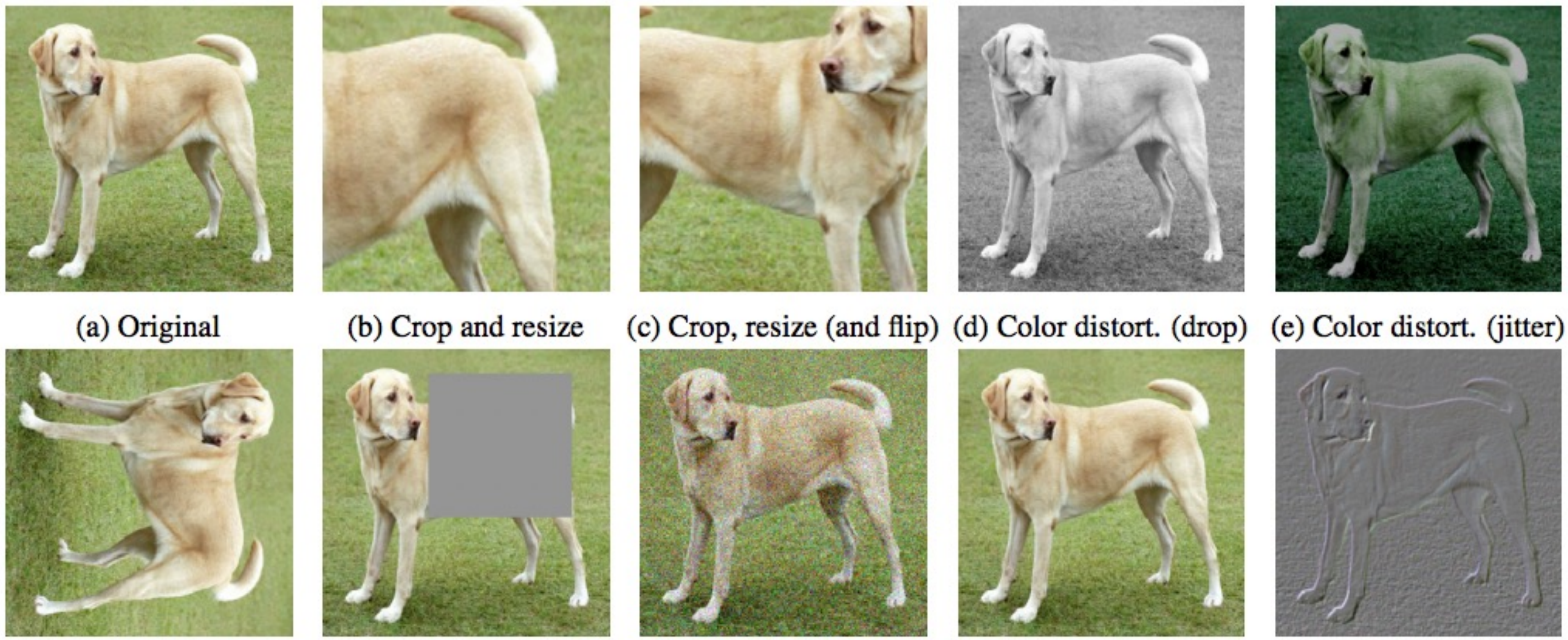


Unsupervised Learning

Dimensionality Reduction: Subspace Learning



Self-supervised learning T. Chen et al., ICML 2020



(a) Original (b) Crop and resize (c) Crop, resize (and flip) (d) Color distort. (drop) (e) Color distort. (jitter)

(f) Rotate {90°, 180°, 270°} (g) Cutout (h) Gaussian noise (i) Gaussian blur (j) Sobel filtering

We apply various transformations to the original image. The resulting images should share the same label.

Deep Learning

2018 Turing Award

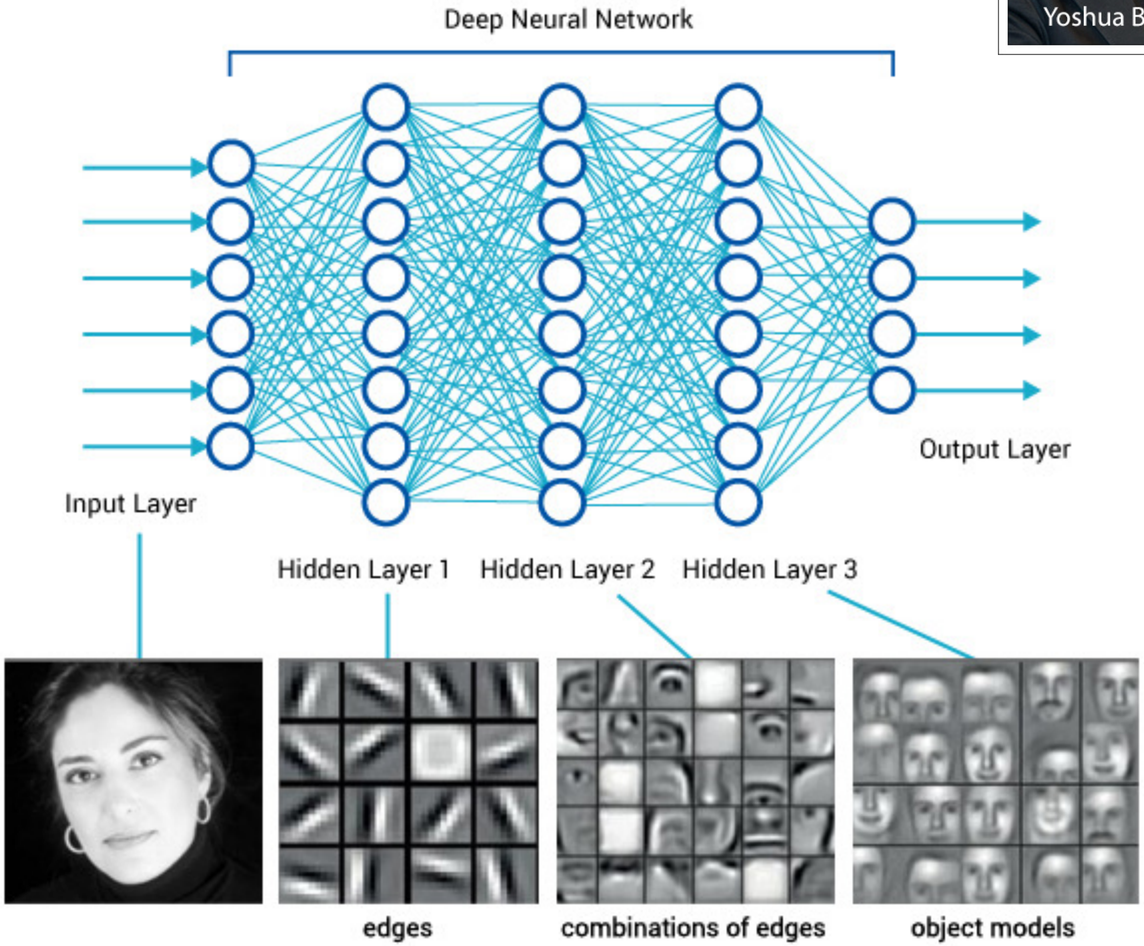


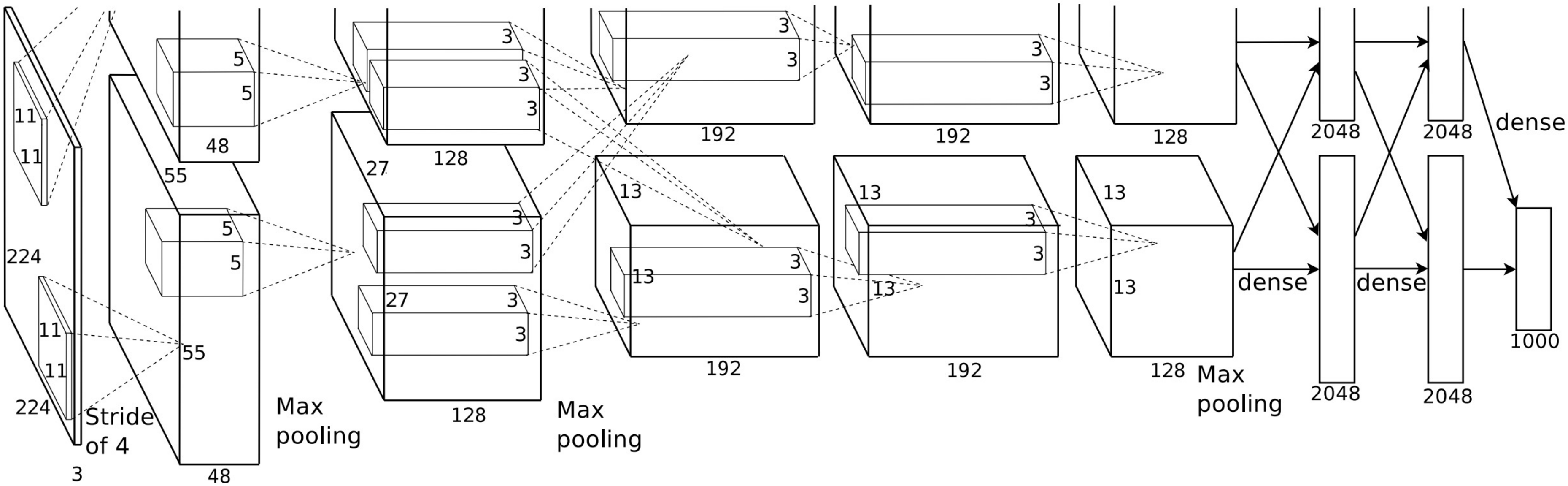
Image Classification

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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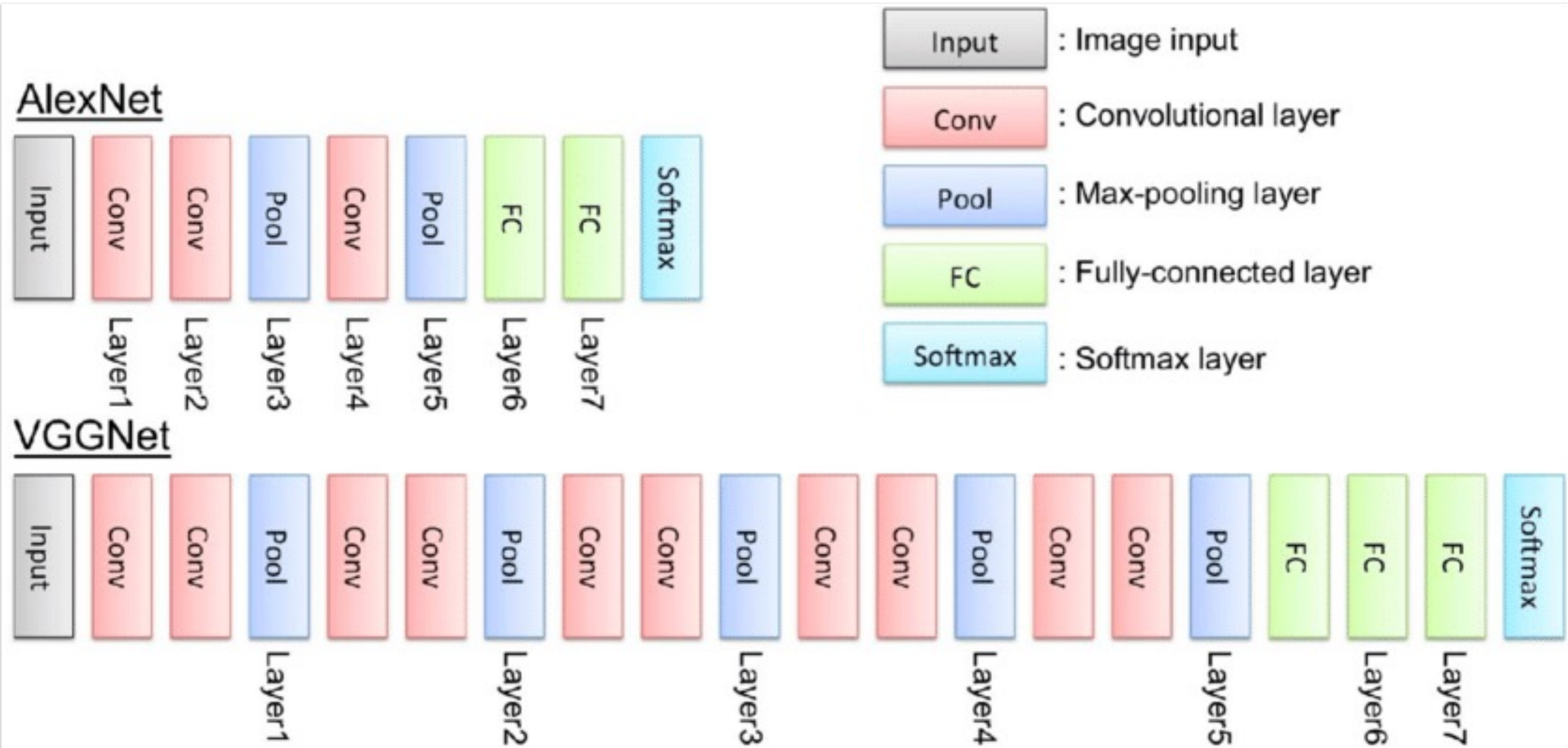
VGGNet

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

VGGNet


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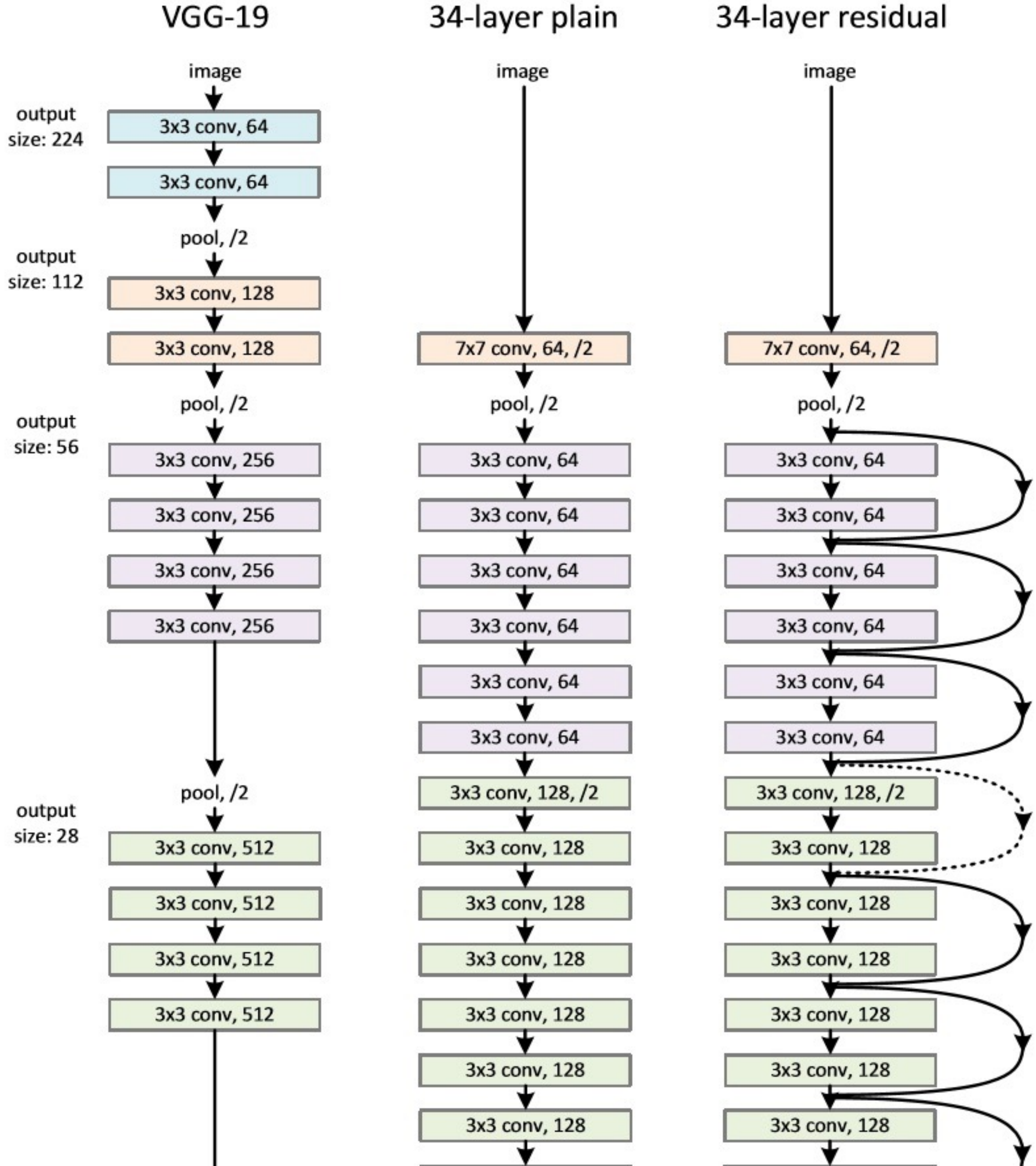
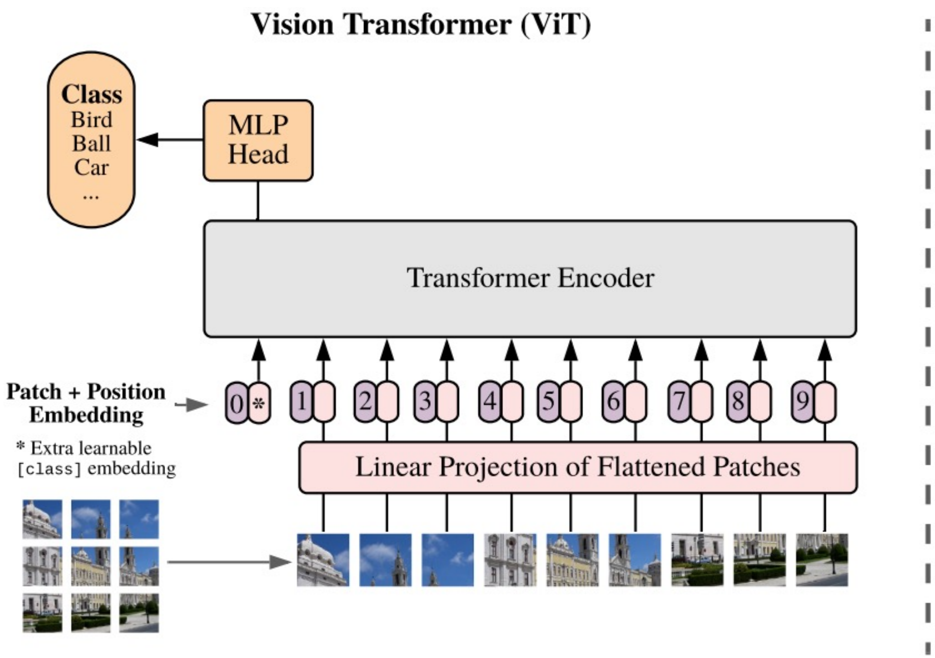
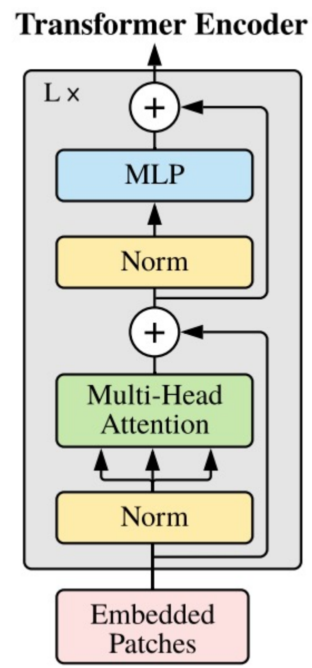
ResNet

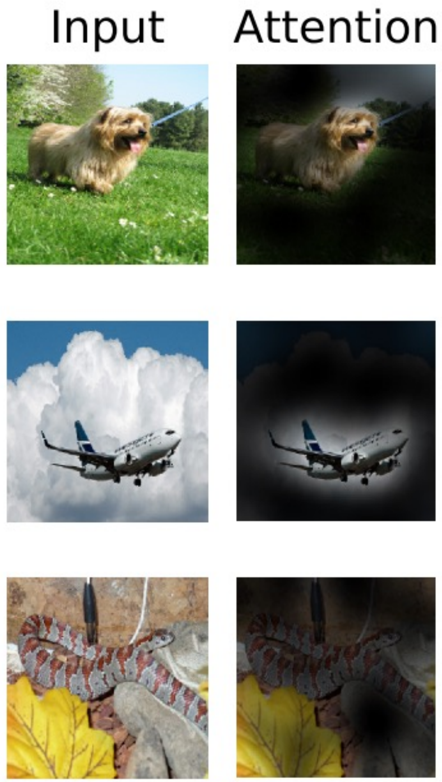
Kaiming He, Xiangyu Zhang, Shaoqing Ren, and Jian Sun. "Deep residual learning for image recognition." In *Proceedings of the IEEE conference on computer vision and pattern recognition*, pp. 770-778. 2016.


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
3x3 conv, 512
image
7x7 conv, 64, /2
pool, /2
3x3 conv, 64
3x3 conv, 64
3x3 conv, 64
3x3 conv, 64
3x3 conv, 64
3x3 conv, 64
3x3 conv, 128, /2
3x3 conv, 128
3x3 conv, 128
3x3 conv, 128
3x3 conv, 128
3x3 conv, 128
3x3 conv, 128
image
7x7 conv, 64, /2
pool, /2
3x3 conv, 64
3x3 conv, 64
3x3 conv, 64
3x3 conv, 64
3x3 conv, 64
3x3 conv, 64
3x3 conv, 128, /2
3x3 conv, 128
3x3 conv, 128
3x3 conv, 128
3x3 conv, 128
3x3 conv, 128

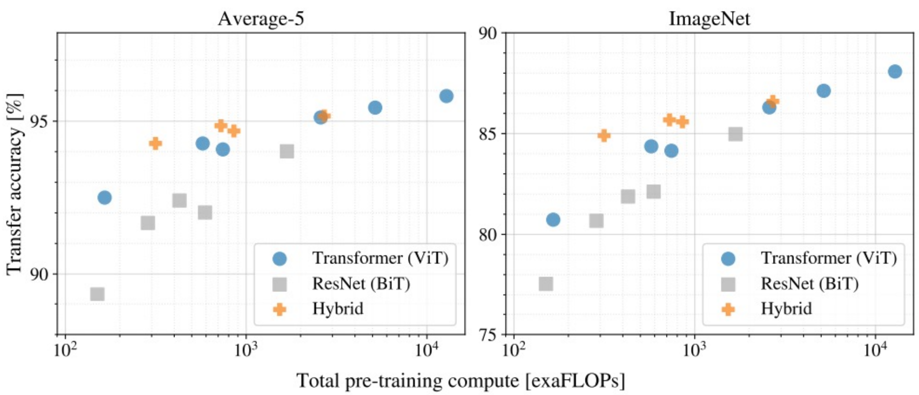
Vision Transformer, ICLR 2021







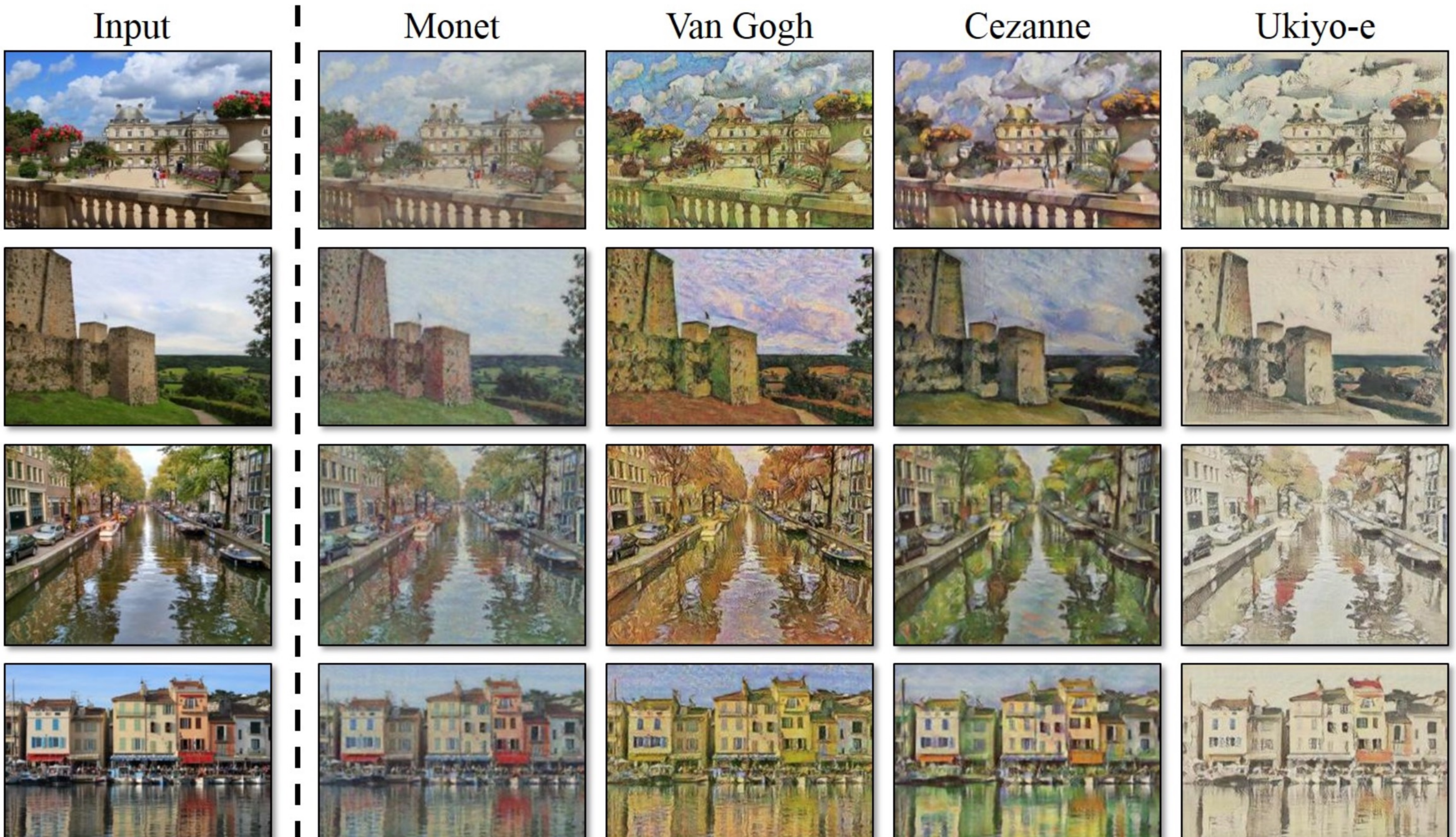
	Ours (ViT-H/14)	Ours (ViT-L/16)	BiT-L (ResNet152x4)	Noisy Student (EfficientNet-L2)
ImageNet	88.36	87.61 ± 0.03	87.54 ± 0.02	88.4/**88.5***
ImageNet ReaL	**90.77**	90.24 ± 0.03	90.54	90.55
CIFAR-10	**99.50** ± 0.06	99.42 ± 0.03	99.37 ± 0.06	–
CIFAR-100	**94.55** ± 0.04	93.90 ± 0.05	93.51 ± 0.08	–
Oxford-IIIT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



Object Detection

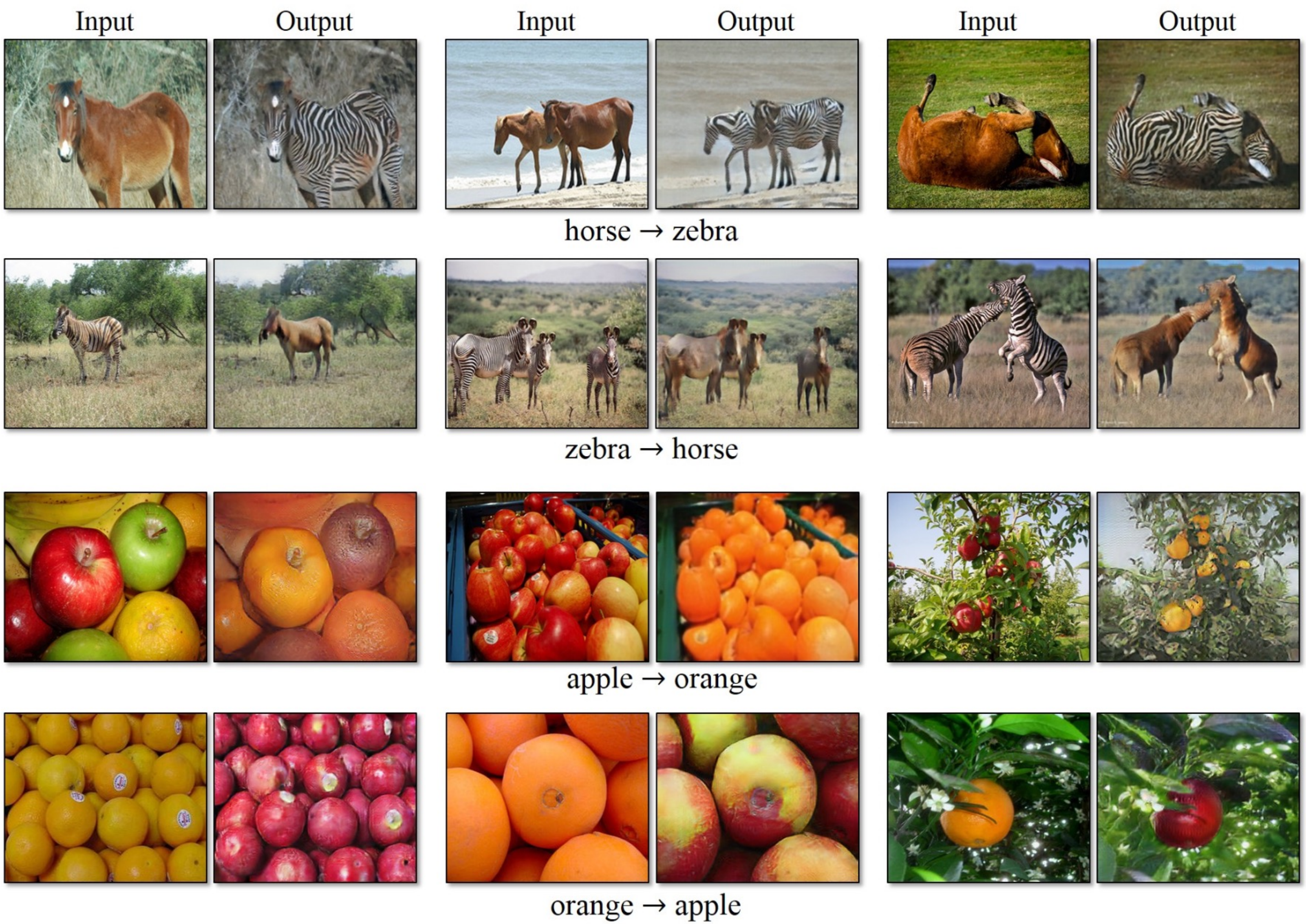
Generative Models

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) You write machine learning assignment

(D) Use an RGB camera to detect car speeding

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

(F) You crop a face from an image using photoshop

(G) Vegetable/fruit name suggestion at Woolworths (by an RGB camera)

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

(I) Recommendation system in Facebook/Netflix