Department of Medical Physics and Biomedical Engineering
Centre for Medical Image Computing (CMIC)
Wellcome / EPSRC Centre for Interventional and Surgical Sciences (WEISS)

Deep Learning

MPHY0041 Machine Learning in Medical Imaging

Yipeng Hu
yipeng.hu@ucl.ac.uk

Introduction | Admin

Content

- Introduction
  - Admin; Background.
- Deep Neural Networks
  - Supervised learning; MLP; Activation functions; Loss functions; Backpropagation.
- Network Architecture
  - Width and depth; Branching, joining and Skipping (Shortcuts, skip layers, ResNet, DenseNet); Convolutional neural networks; Sampling; Examples (U-Net; PointNet; Attention mechanism, vision transformer); Recurrent neural networks.
- Training and Regularisation
  - Optimisation; Constrain parameters (norms, sharing); Augment data; Add randomness; Ensemble; Semi-supervised learning; Multi-task learning
- Selected Research Topics*
  - Multiple instance learning; Adversarial learning and generative models; Domain adaptation; Meta-learning.
- Medical Imaging Applications
  - Classification; segmentation; registration; synthesis.

- Hands-on tutorials

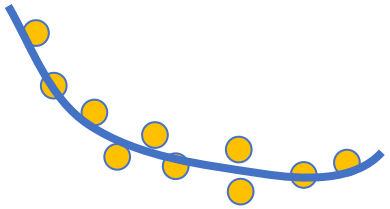
  https://weisslab.cs.ucl.ac.uk/yipenghu/mphy0041
- Learning materials - `mphy0041/docs`
  - Supported development environment
  - Learning materials for TensorFlow and PyTorch
  - Reading list
- Objectives
  - Basic deep learning knowledge
  - Hands-on experience with supervised convolutional neural networks
- Prerequisites
  - Machine learning basics
  - Maths: linear algebra, calculus, probability and statistics
  - Programming: Python, TensorFlow/PyTorch

- Live sessions
  - 12:00-13:00 on Tuesdays
  - 10:00-11:00 on Fridays
- Lecture videos
  - Organised by topics, posted at the “weekly tabs”
- Flexible office hours
  - Emails or message teams (yipeng.hu@ucl.ac.uk)
  - Book a time (15-30 min) with me or one of the tutors within a week time
- Formative assessment
  - Associated with hands-on tutorials
  - Feedback are available but not compulsory
- Coursework (groupwork)
  - Programming - TensorFlow 2 / PyTorch
  - Solve real-world clinical problems
  - Submit code in Git repository
  - Report results in the form of a scientific paper

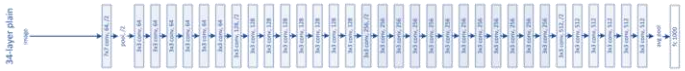
Introduction | Background

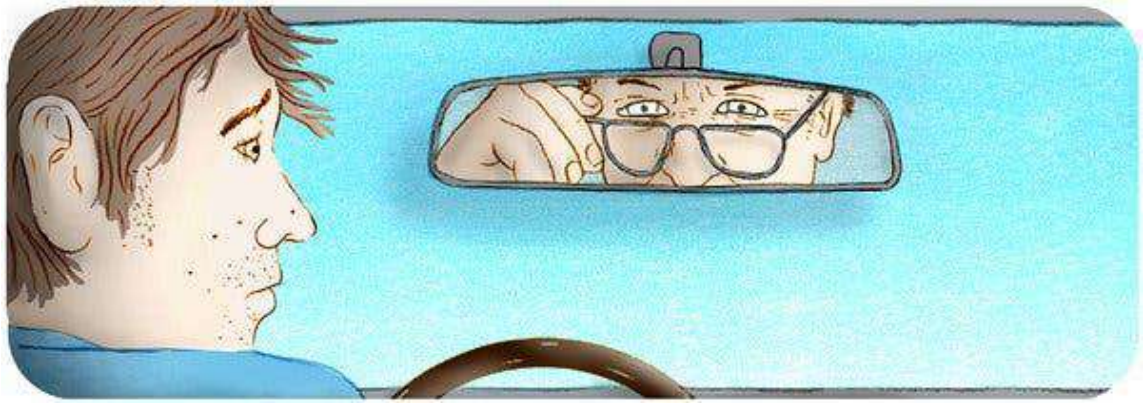
Artificial Intelligence

Machine Learning

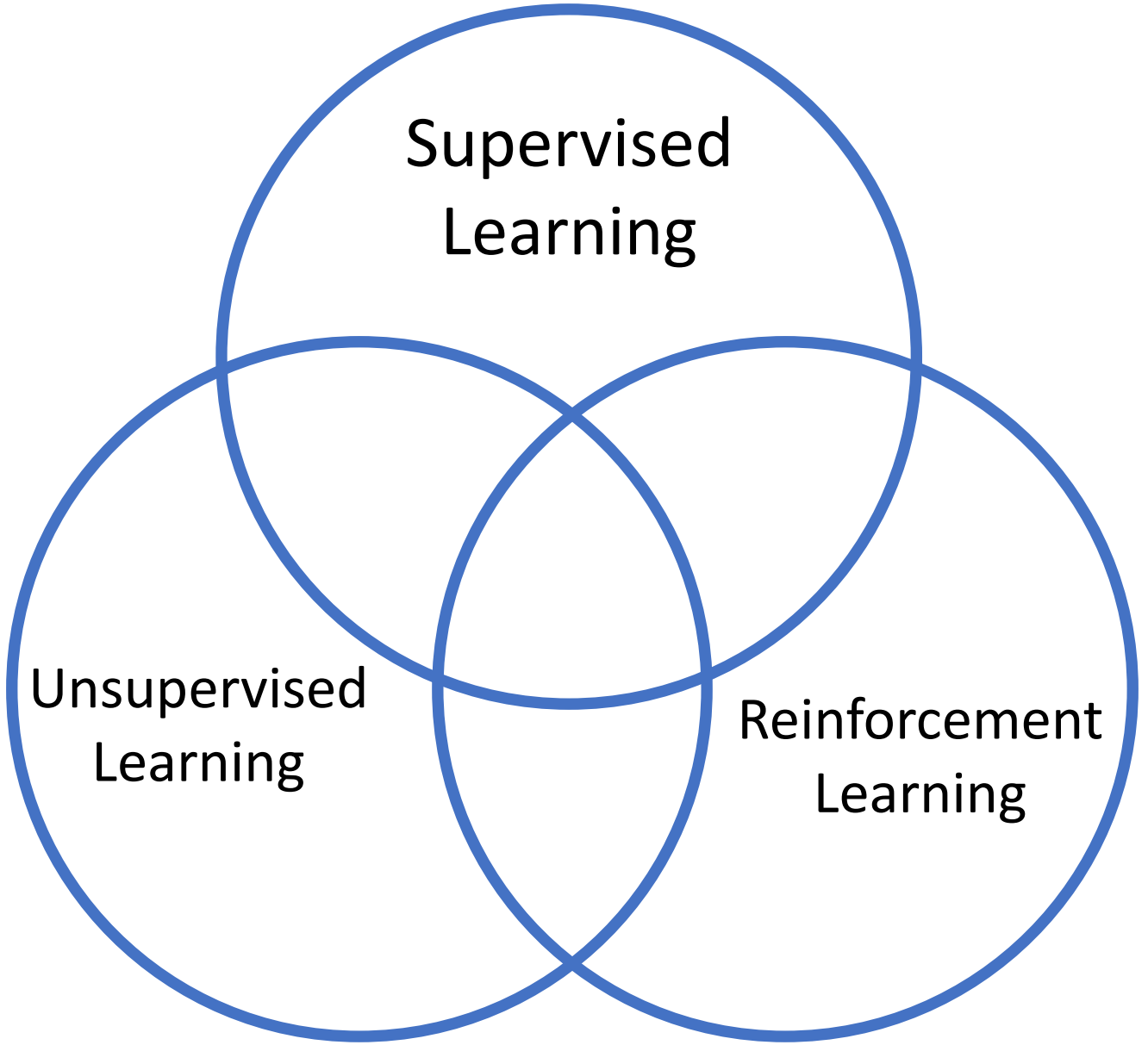


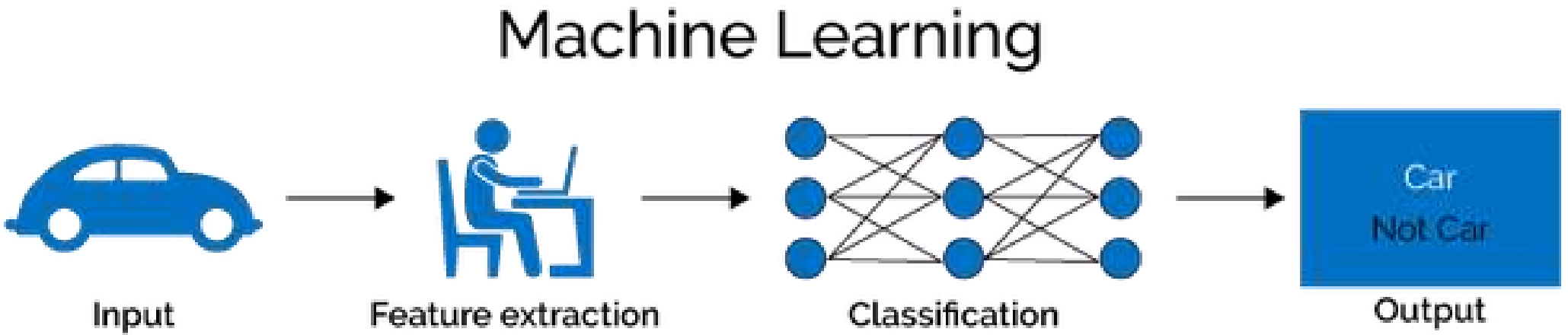
Deep Learning

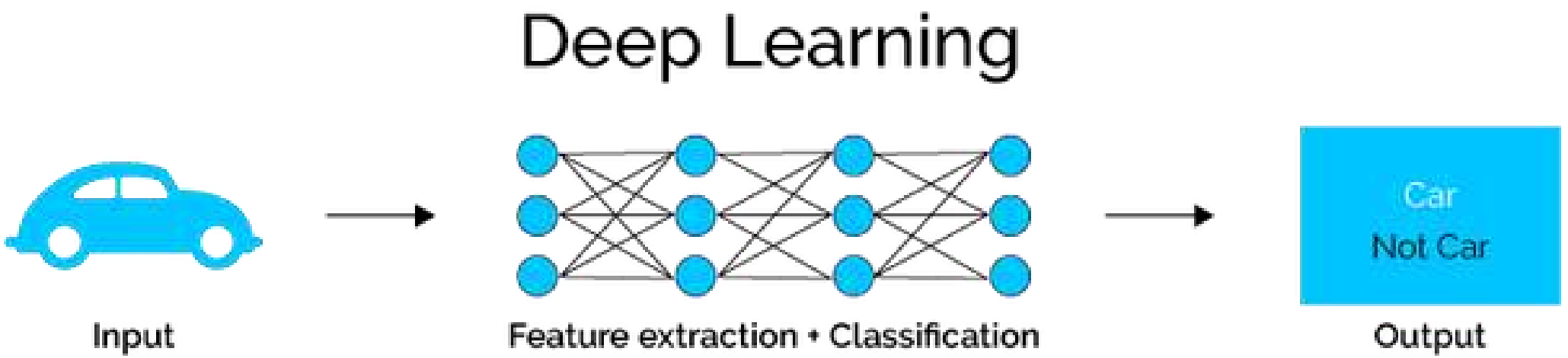


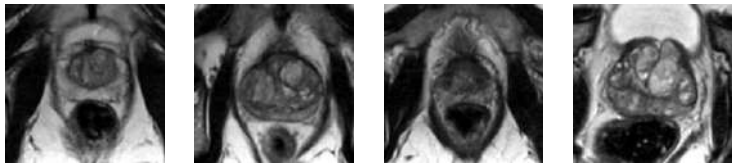



LEARNER


Supervised Learning
Unsupervised Learning
Reinforcement Learning

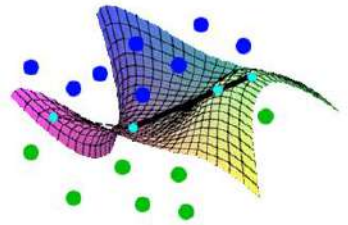

Machine Learning
Input
Feature extraction
Classification
Car
Not Car
Output


Deep Learning
Input
Feature extraction + Classification
Car
Not Car
Output



1	0	1	1
0	0	1	0
0	1	0	0
0	1	0	0
1	1	0	0
1	0	1	1
1	1	0	1

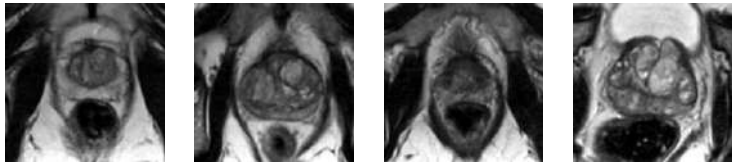
Features Vectors



Classifier

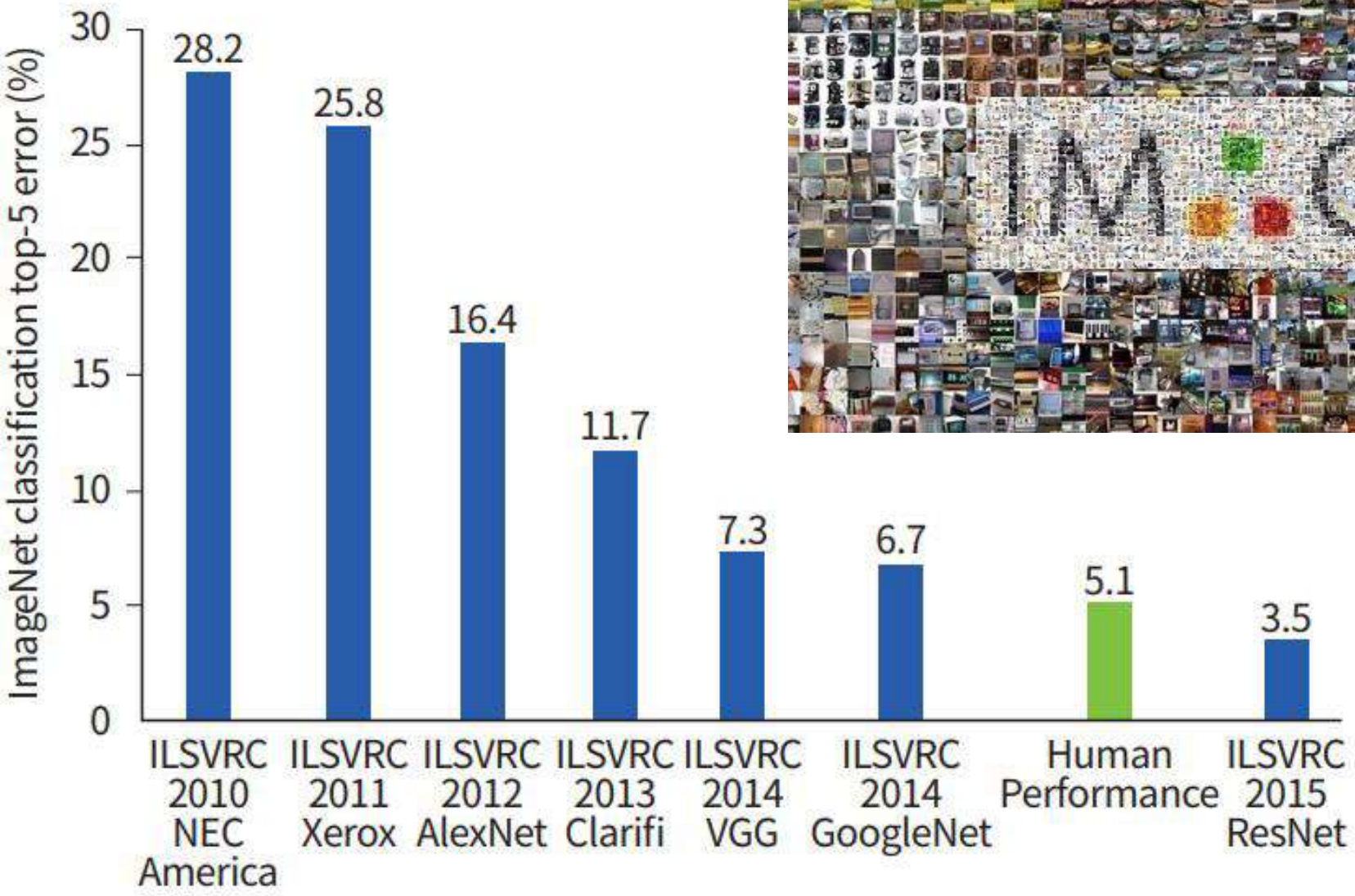
- Benign
- Malignant

Deep Representation Learning

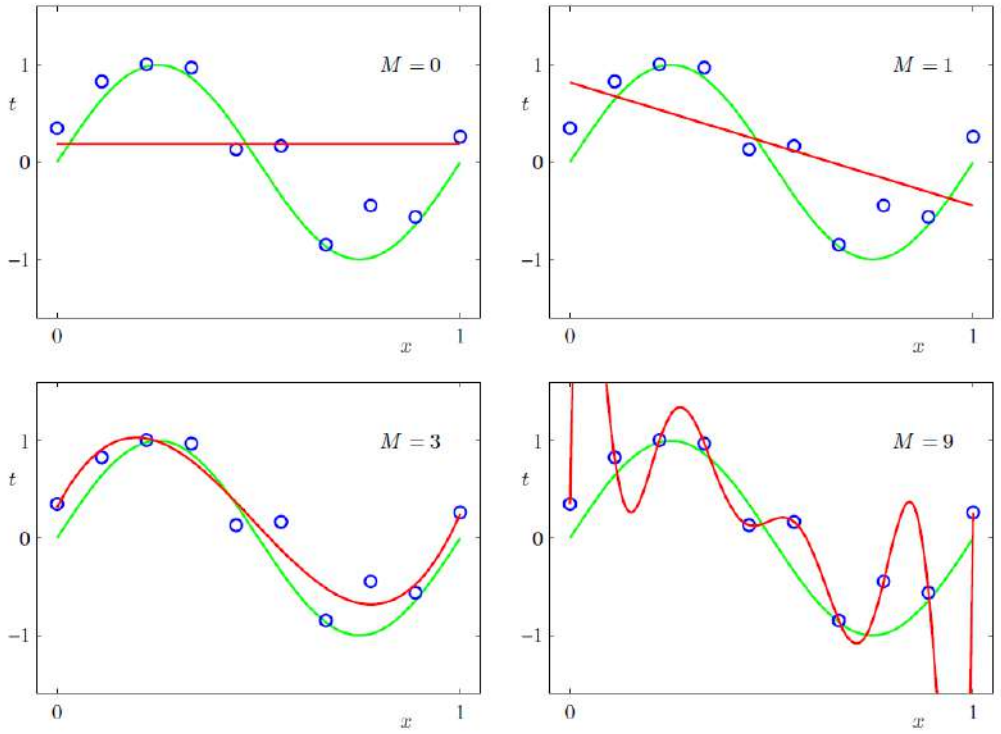


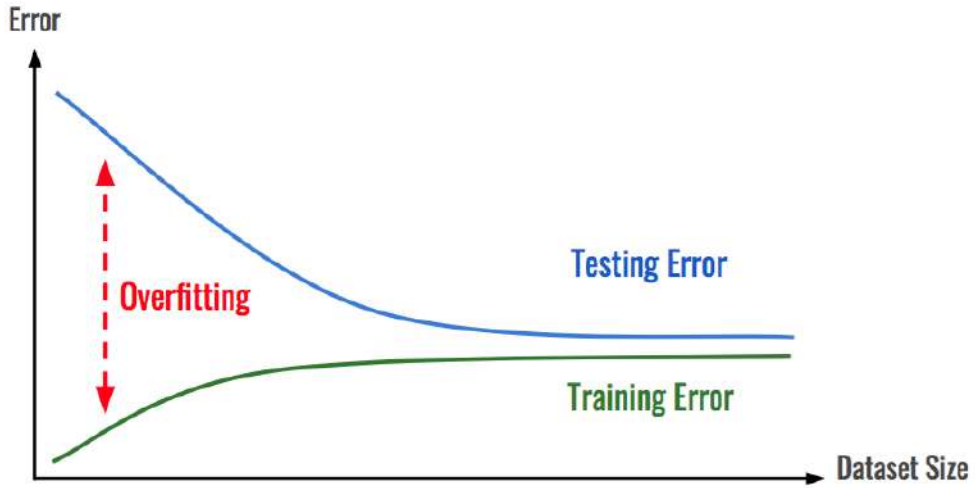
- Benign
- Malignant


IMAGENET

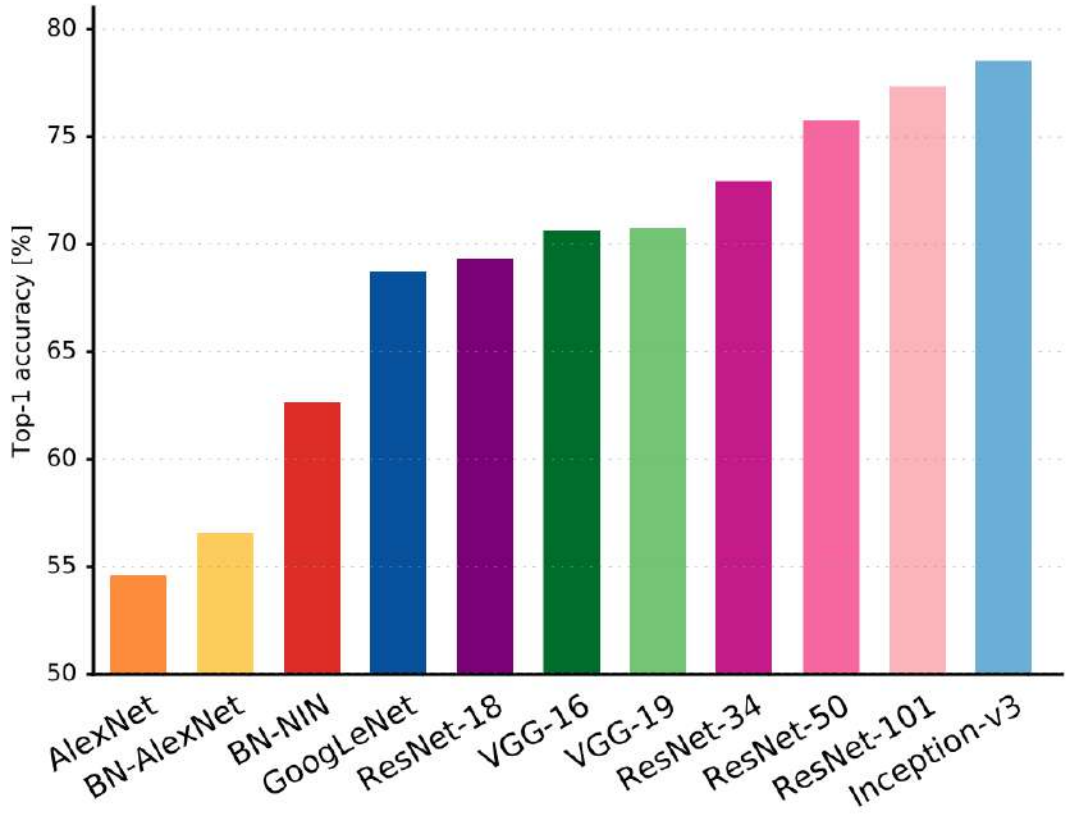

ImageNet classification top-5 error (%)
30
25
20
15
10
5
0
28.2
25.8
16.4
11.7
7.3
6.7
5.1
3.5
ILSVRC 2010 NEC America
ILSVRC 2011 Xerox
ILSVRC 2012 AlexNet
ILSVRC 2013 Clarifi
ILSVRC 2014 VGG
ILSVRC 2014 GoogleNet
Human Performance
ILSVRC 2015 ResNet

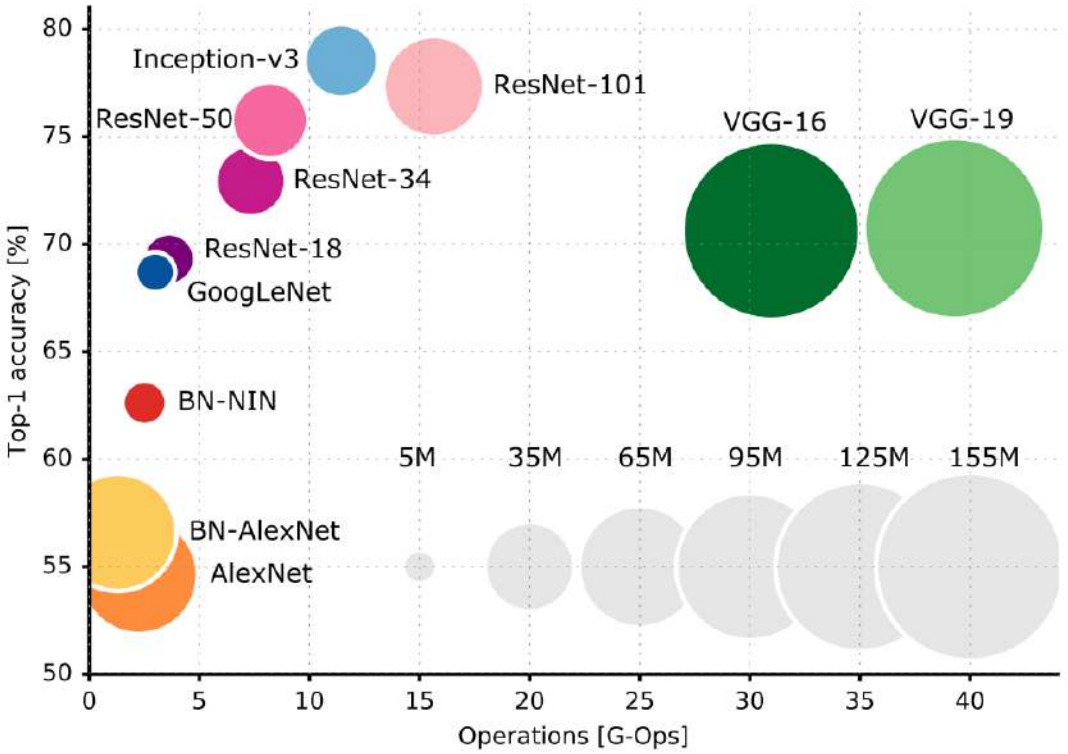
- Over-parameterisation and generalisation
- Architecture / training and regularisation / selected research topics

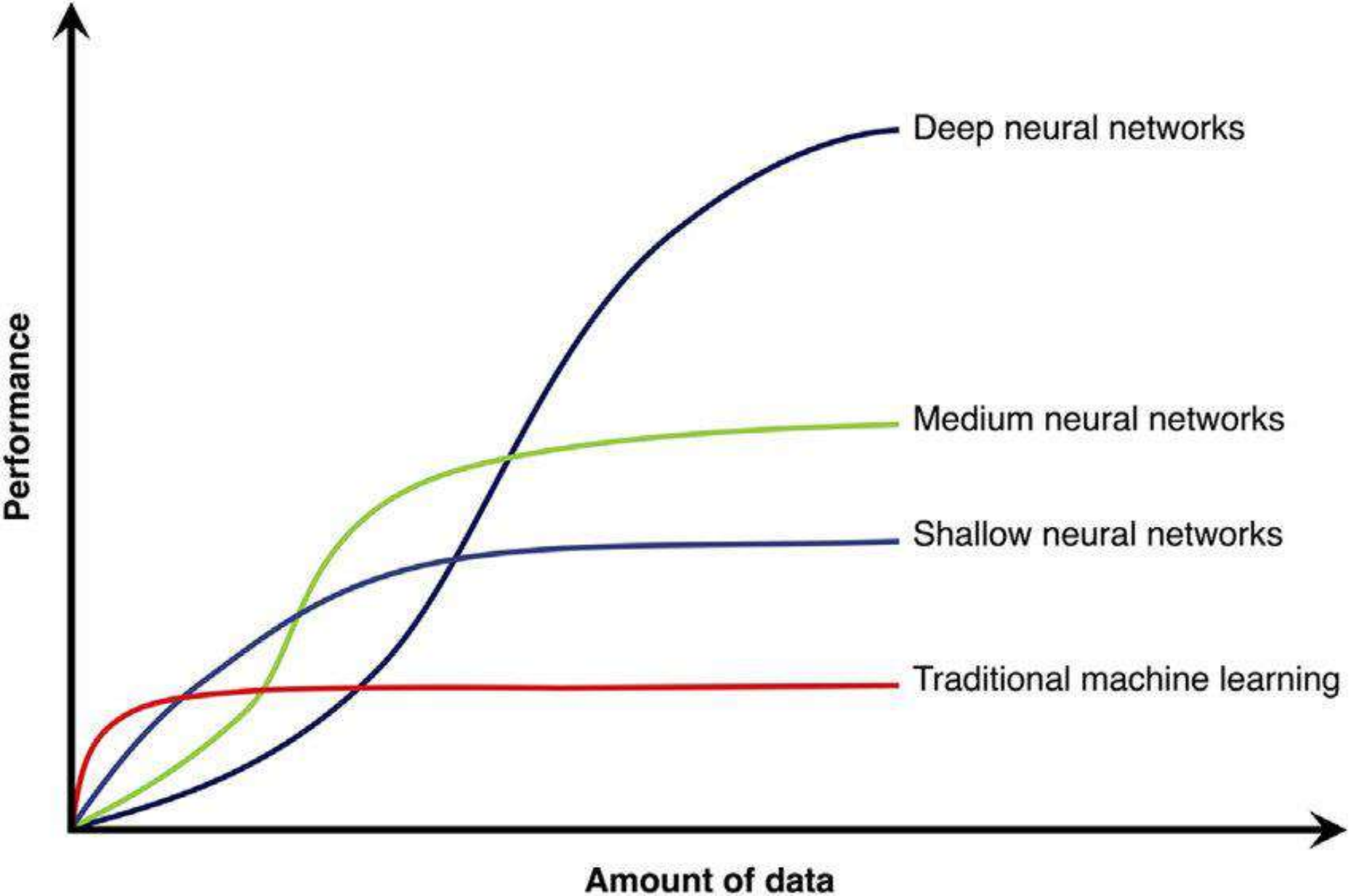




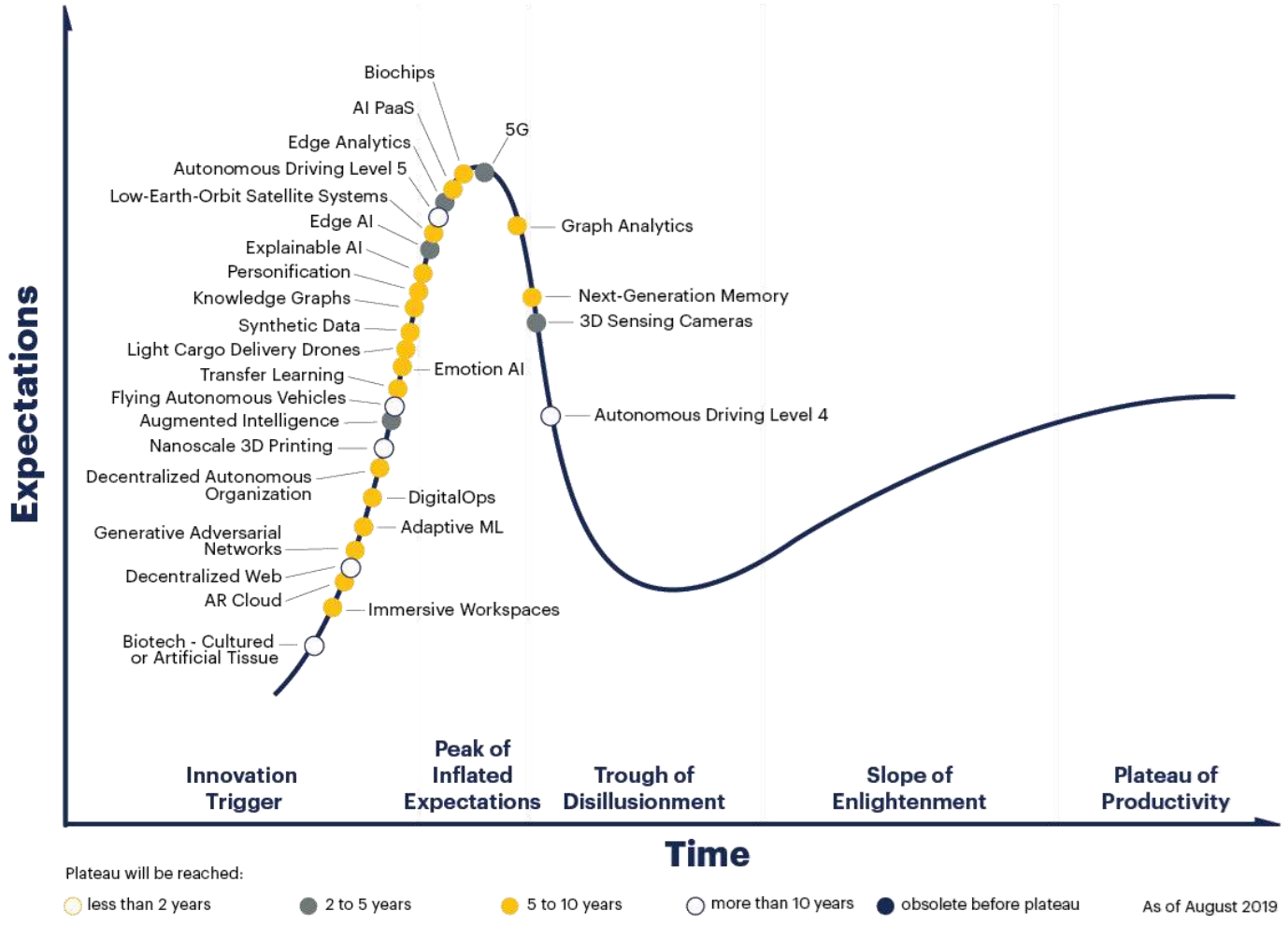
Introduction | Background






Deep neural networks
Medium neural networks
Shallow neural networks
Traditional machine learning
Performance
Amount of data

Gartner Hype Cycle for Emerging Technologies, 2019



Classic machine learning methods (first part of the module)

- Linear regression
- Support vector machine
- Random forest

Tools

- Deep neural networks
- Computer vision and natural language processing
- Supervised learning with quality labeled data

Research

- Advanced learning and generative modelling
- Domain adaptation and meta-learning
- Unsupervised learning, reinforcement learning, Monte Carlo, approximate inference, model interpretation, auto-ML...

Development environment

- OS
  - Ubuntu, Debian
  - MacOS
  - Windows Subsystem for Linux
  - Linux on Chrome OS
- Python and NumPy
- TensorFlow and PyTorch
- Jupyter Notebook
- Cloud computing, e.g. Google Colab
- Git
- GPU computing