Part 1

Lecture 2 Different Types of ML

1

Who I am…

Pascal Tyrrell, PhD *Associate Professor*

Department of Medical Imaging, Faculty of Medicine

Institute of Medical Science, Faculty of Medicine

Department of Statistical Sciences, Faculty of Arts and Science

Computational power has grown to the point of instant calculations and the ability to evaluate new data, according to previously assessed data, in real time.

AI can potentially look at millions of scans in a short period of time with accuracy

ML Definition

Machine learning - the ability of a computer to learn from experience, i.e. to modify its processing on the basis of newly acquired information.

This process can be based on a simple decision-making tree such as: if-then, which leads to a conclusion, or using deep learning algorithms which imitate the human brain in processing several types of data and creating patterns for use in decision making through neural networks.

Types of algorithms

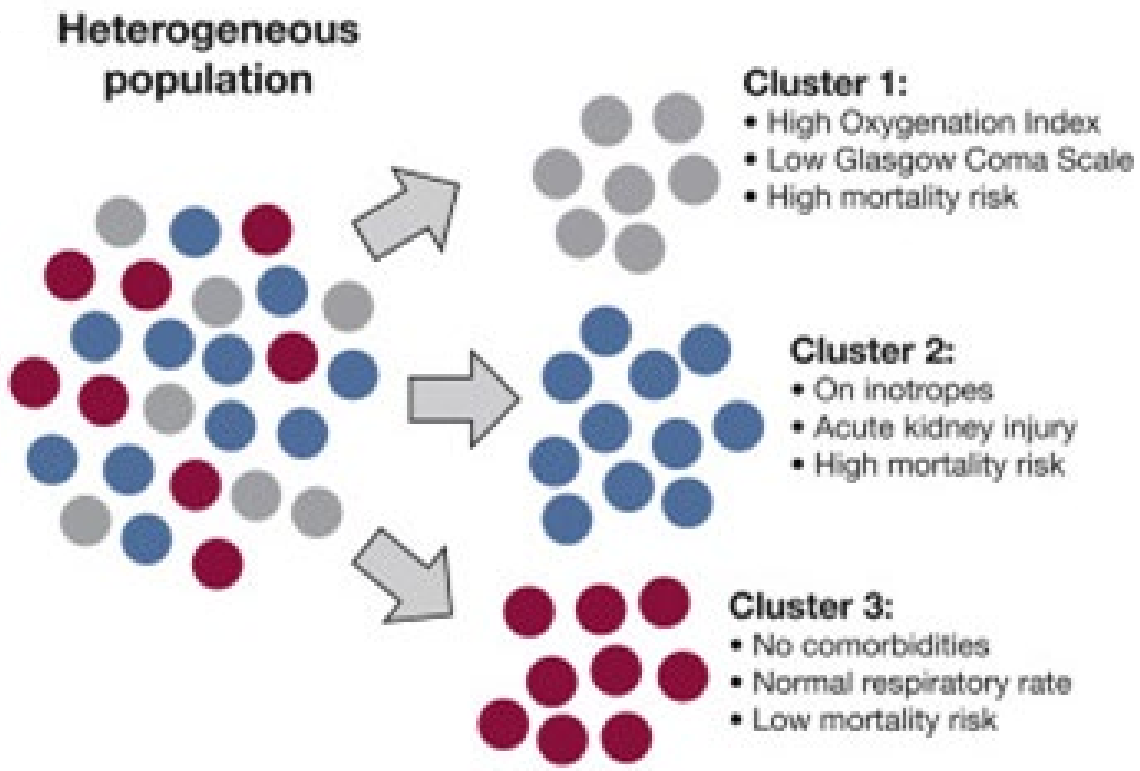
- Unsupervised learning
- Supervised learning
- Reinforcement learning

Unsupervised learning

- Unsupervised: Unsupervised learning algorithms are used to uncover naturally occurring patterns or groupings in the data, without targeting a specific outcome.

- The most compelling use case of unsupervised learning in health care is in precision medicine, in which the goal is to uncover subsets of patients who share similar clinical or molecular characteristics and are, in theory, more likely to respond to targeted therapies directed at their shared underlying pathobiology.

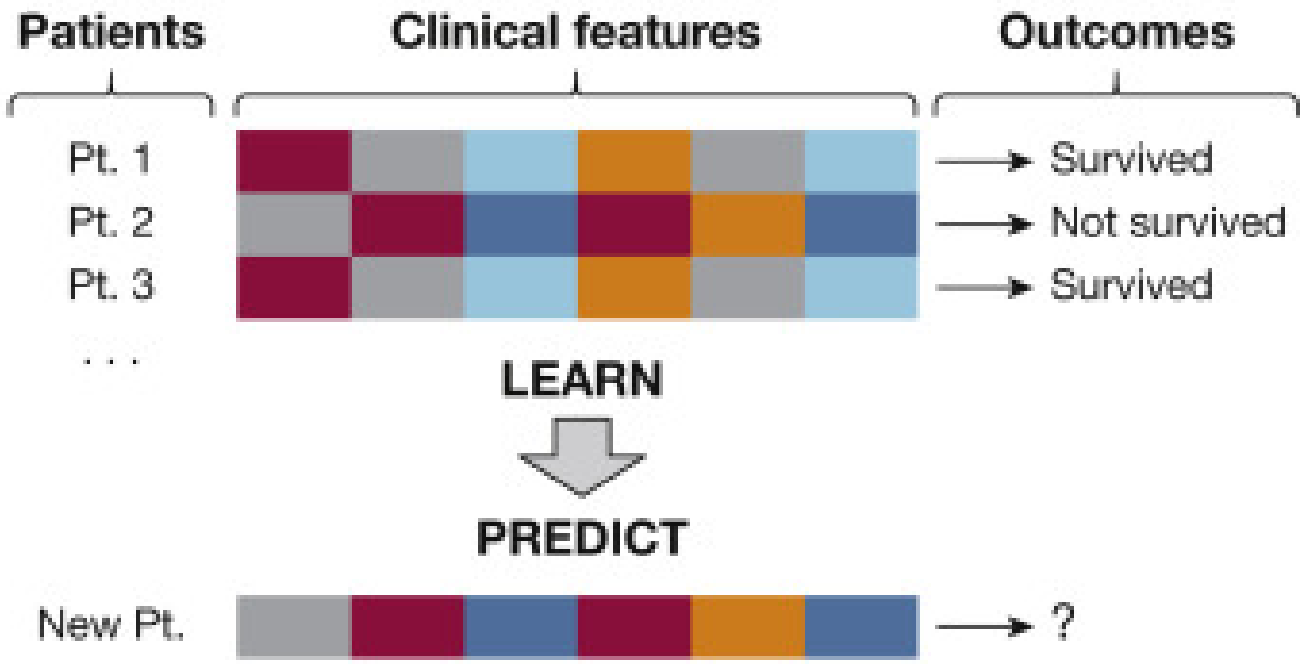
Unsupervised



Unsupervised example

An unsupervised learning algorithm may be used to uncover subgroups of patients with sepsis who have distinct molecular and clinical characteristics and will respond differently to specific drugs, such as corticosteroids

Supervised


Patients
Clinical features
Outcomes
Pt. 1
Pt. 2
Pt. 3
. . .
Survived
Not survived
Survived
LEARN
PREDICT
New Pt.
?

Supervised Learning Algorithms

Supervised: Used to uncover the relationship between variables of interest and one or more target outcomes.

For supervised problems, the target outcome(s) must be known.

For example, if researchers want to know whether a set of clinical features (eg, vital signs, laboratory tests) can predict ICU mortality, they could apply a supervised learning algorithm to a dataset in which each patient record contains the set of clinical features of interest and a label specifying their outcome

Types of Supervised Learning

- REGRESSIO
- I

tput

Computer Vision

The processing of an image to enable identification of image input and to provide an appropriate output

Convolutional neural network (CNN)

- One type of deep learning

- Inspired by animal visual cortex!
  - Each neuron responds to stimulus in a small field (receptive field)
  - Many neurons‘ receptive field overlap to form the whole visual field

- Mostly used for
  - Image & video recognition, natural language processing

CNN: basic components

- Feature extraction
  - Detect features in input
    - Eg. Triangle shape of cheesecake, berries on top
  - Convolution layers
  - Pooling layers
  - Fully connected layers

- Classification
  - Probability on image prediction
    - 80% cheesecake

Why CNNs?

- Learn features on their own
  - In many classical ML algorithms, features are engineered by us – which are not always appropriate
  - Different layers allow more precise feature extraction

Application of Machine Learning to medical imaging

- Medical images are one of the fastest growing data sources in healthcare
- Imaging data continues to become more complex
- Machine learning can…
  - Find relevant patterns within the data
  - Reduce the mass amounts of data into important clinical contexts
  - Bypass deficits of traditional methods using its automated approach

Limitations

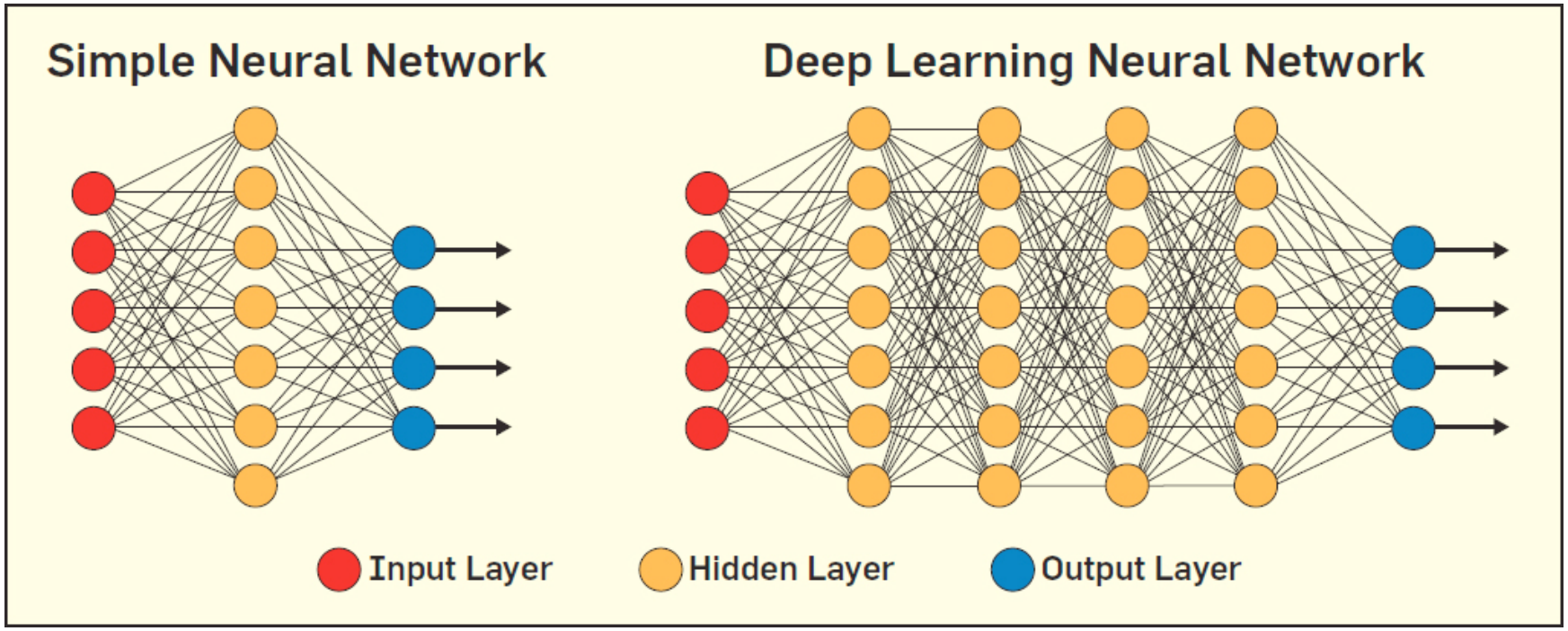
- Catastrophic forgetting: when the AI learns the new task, it overwrites the previous one.

- Cognition: the ability to build knowledge from interacting with the world through sensory and motor experiences, and creating abstract thought from there.

- Imagination: Imagination and innovation relies on models we've already built about our world, and extrapolating new scenarios from them.

Deep learning

- Part of ML
- Multiple layers of processing units



DL definition

- Subset of machine learning which is structured similar to human brain processing. Taking in account multiple datasets at the same time, which are evaluated and processed for second and third different evaluations.
- Every evaluation is carried out in a different layer.
- Layers of computation are called hidden layers (inputs and outputs are invisible). Each filter creates a different output.

For simplicity one can say that deep learning is a process in which an algorithm receives data (i.e. excel charts, images etc.) and then examines the data according to a predetermined pathway (artificial neural network) that was developed specifically to solve the desired problem.

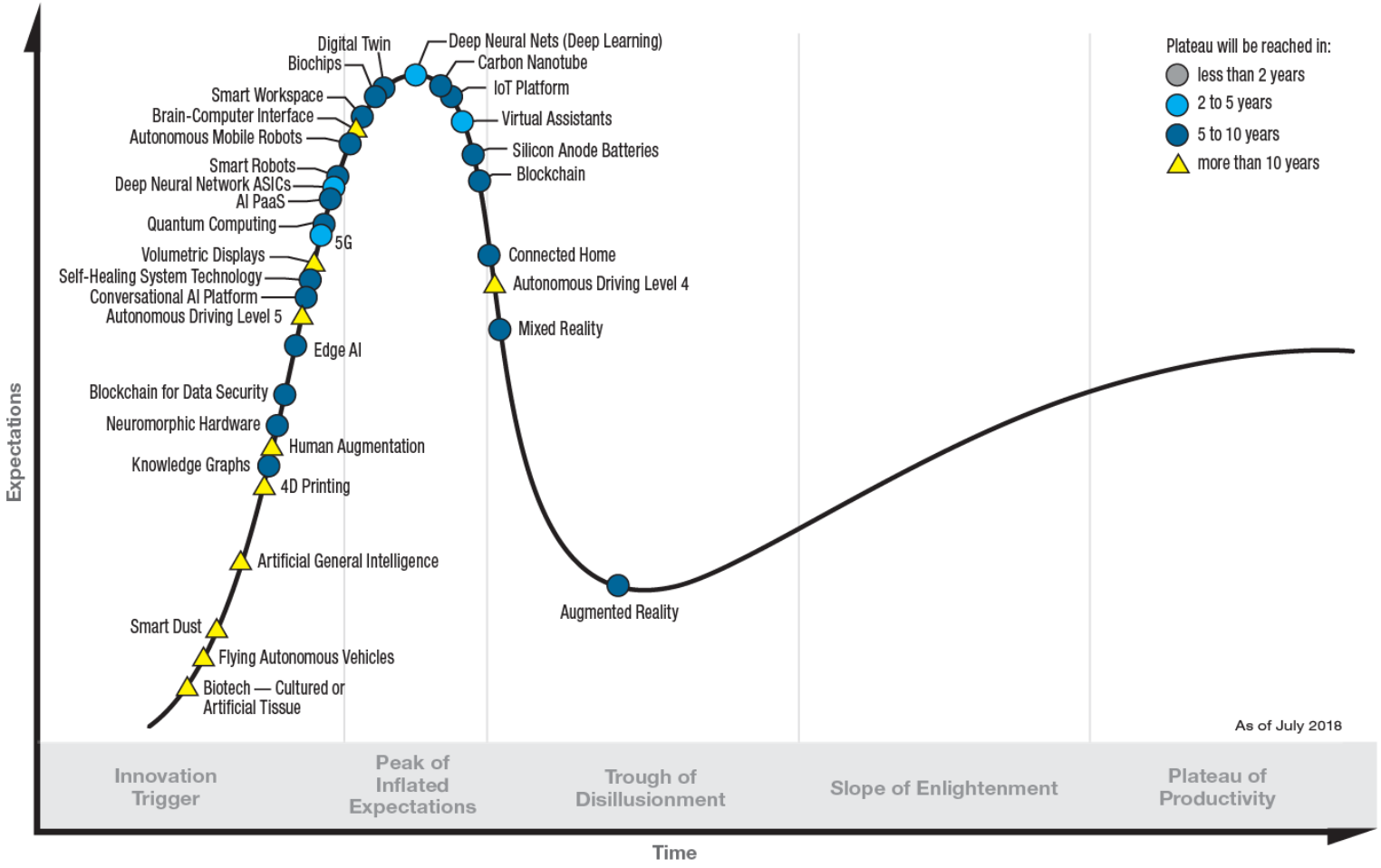
The ANN/ CNN is developed according to a training set of data provided to train the algorithm to answer a specific question.

The training data set must represent the problem it is being asked to solve, to ensure accurate results.

Deep Learning Limitations

- Lack of Interpretability
- Lack of Generalization
  - *When available data is limited*
- Vulnerability to Adversarial Attacks

Hype Cycle for Emerging Technologies, 2018



gartner.com/SmarterWithGartner

Source: Gartner (August 2018)

Gartner

Reinforcement learning

RL implementations, a model designer normally formulates the learning components (the objective, state, action and reward etc.), specifies the presentation and efficiency techniques, and then simply lets the RL algorithms run until a satisfactory solution is obtained

Reinforcement learning has achieved tremendous success in solving complex sequential decision making problems in various health care domains, such as treatment in HIV, cancer, diabetics, schizophrenia, and sepsis

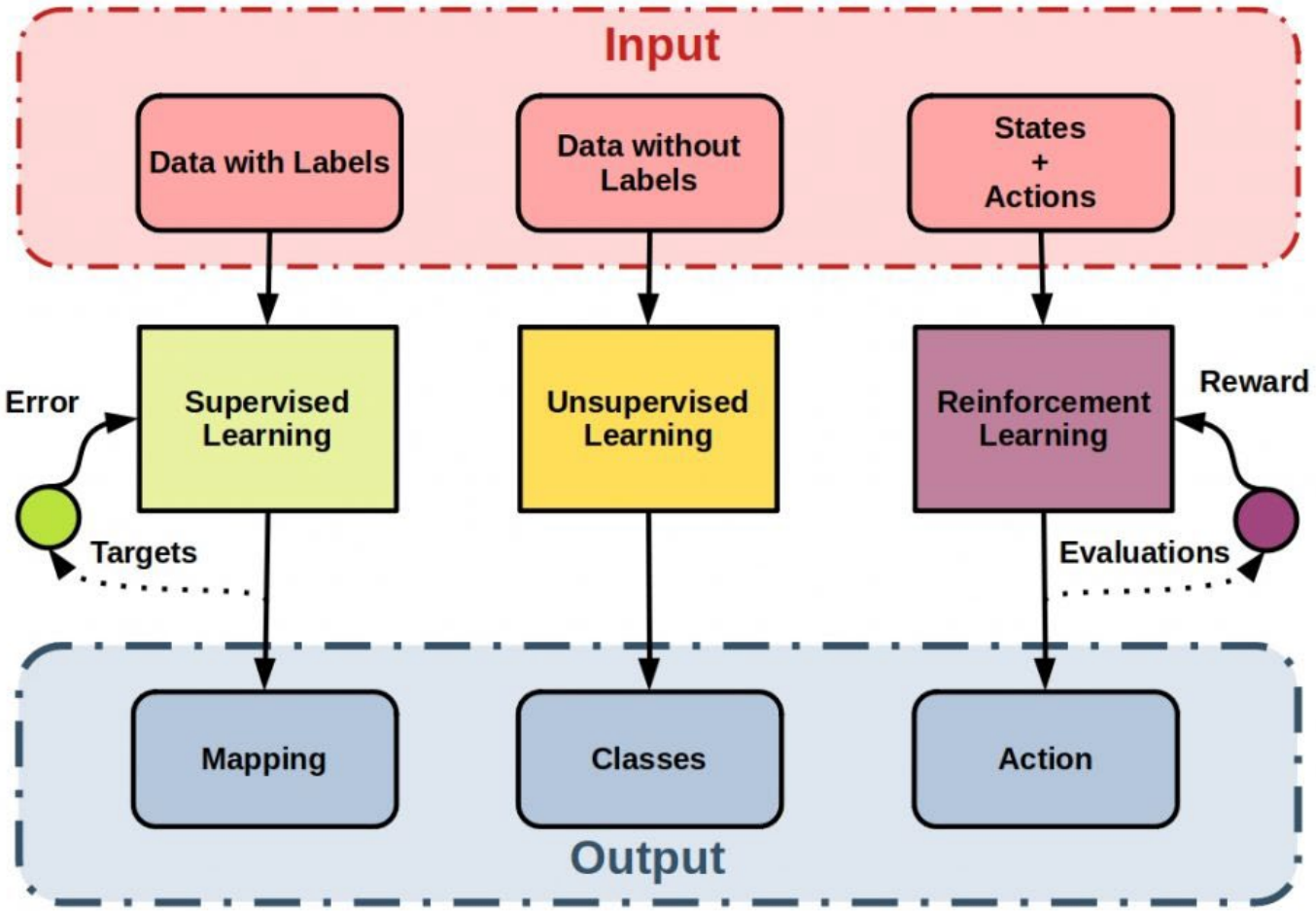
Precision Medicine in T2D

- Creating treatment options for hypertensive patients diagnosed with Type 2 Diabetes (T2D) using Reinforcement Learning
- Reinforcement Learning was able to optimize treatment dosing to reduce hypertension in T2D patients

Read about it here:

Oh SH, Lee SJ, Park J. Precision Medicine for Hypertension Patients with Type 2 Diabetes via Reinforcement Learning. J Pers Med. 2022 Jan 11;12(1):87. doi: 10.3390/jpm12010087. PMID: 35055402; PMCID: PMC8781402.

Summary


Input
Data with Labels
Data without Labels
States + Actions
Error
Supervised Learning
Unsupervised Learning
Reinforcement Learning
Reward
Targets
Evaluations
Mapping
Classes
Action
Output

End of Lecture 2

Next up Lecture 3: AI and Big Data