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SCC361: Artificial Intelligence

Week 1: Introduction to Artificial Intelligence and Machine Learning

Dr Alistair Baron
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Slides from Dr. Bryan M. Williams

Introduction to the Module

- Introduction to the Module
- Lectures, Materials and Expectations
- Overview of Artificial Intelligence
- Overview of Machine Learning

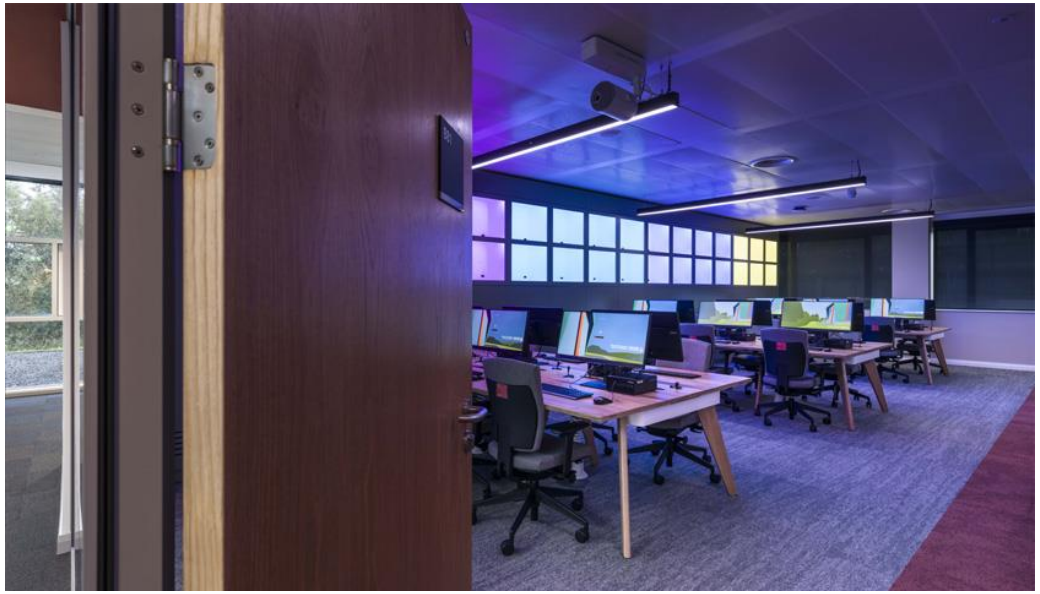
Expected Learning Outcomes

We will be able to:

- understand AI concepts, applications and trends
- understand machine learning terms
- train machine learning models for specific tasks
- learn to implement simple AI-based systems
- learn how to evaluate the performance of AI systems

Teaching Structure

- 10 weeks
- You have:
  - 2 x 1 hour lectures per week
  - 1 x 2 hour lab sessions per week
- Lectures and Labs are assigned on your timetable.
- Likely to be at capacity, please only come to your assigned sessions.
- If you need to change, please contact the teaching office.



Teaching Staff

Lecturers

Dr Alistair Baron

Weeks 1, 2, 8

Office Hours:
Mon. & Wed. PM

a.baron@lancaster.ac.uk

Dr Bryan M. Williams

Weeks 3-6, 8

Module Convenor

Dr Hossein Rahmani

Weeks 7, 9, 10

Guest Lectures in Week 8, presenting latest research in the area.

Lecture Plan

Weeks 1-2 (AB):

- Introduction to Artificial Intelligence and Machine Learning
- Features in Machine Learning and Feature Extraction

Weeks 3-6 (BW):

- Clustering and Classification
- Decision Trees
- Statistical approaches: Naïve Bayes
- Genetic Algorithms

Weeks 7-10 (HR):

- Artificial Neural Networks: MLP
- Current research in AI (AB & BW)
- Introduction to Deep Neural Networks
- Introduction to Convolutional Neural Networks
- Segmentation and Generative AI

Assessment

Two Courseworks: 40%

- CW1 (20 marks):
  - Submission: On Moodle
  - Available: **4pm Friday 18th October, 2024 (Week 2)**
  - Deadline: **4pm Friday 8th November, 2024 (Week 5)**
- CW2 (20 marks):
  - Available: **4pm Friday 15th November, 2024 (Week 6)**
  - Deadline: **4pm Friday 13th December, 2024 (Week 10)**

Exam: 60%

- Summer 2025

Lectures, Materials and Expectations

- Introduction to the Module
- Lectures, Materials and Expectations
- Overview of Artificial Intelligence
- Overview of Machine Learning

Learning Support

- All materials will be available on Moodle, including
  - Lecture slides and recordings
  - Lab details, assignments and solutions
- Lab sessions
  - Discuss assignments and questions with lecturer and TAs
  - Try to maximise usage of labs
- Arrange extra support if you are struggling and let us know on time
  - Office hours
  - Send a message on Teams or Email
- Check other available (online) resources

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Recommended Reading

- Artificial Intelligence: *Foundations of Computational Agents* 2ed. Poole & Mackworth 2017
- *Artificial Intelligence A Modern Approach*, Russell & Norvig, 2016 (chapters 1,2,5,6)
- *Deep Learning*, Goodfellow et al. , 2016
- *Deep Learning with PyTorch*, Stevens et al, 2020.
- *Machine Learning*, T. M. Mitchell, 1997
- Deisenroth MP, Faisal AA, Ong CS. *Mathematics for machine learning*. Cambridge University Press.
- Artificial Intelligence on Wikipedia
- Many online resources

Accessibility

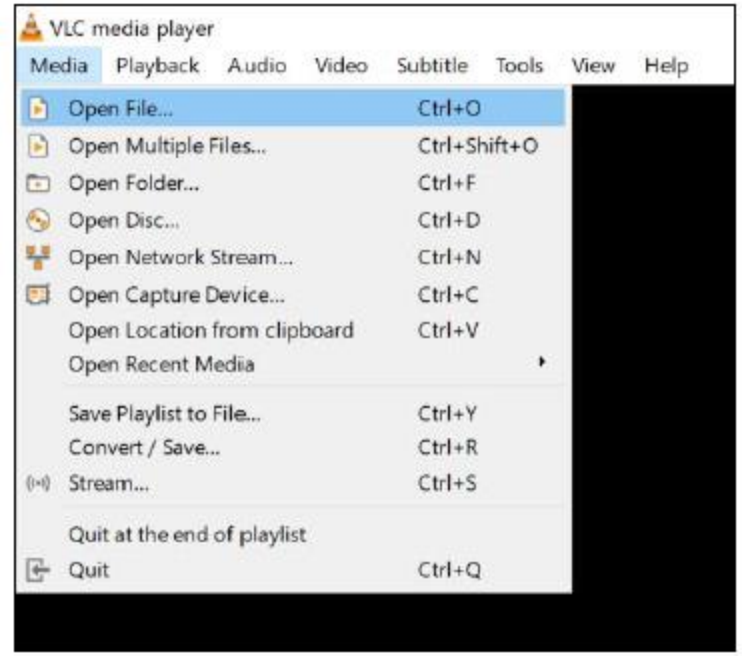
- All our content is expected to meet the UK accessibility requirements
- We have done our best to ensure that this is the case with these course materials
- However, if any course material or part of its content is inaccessible in any way to any individual or group, kindly let us know.

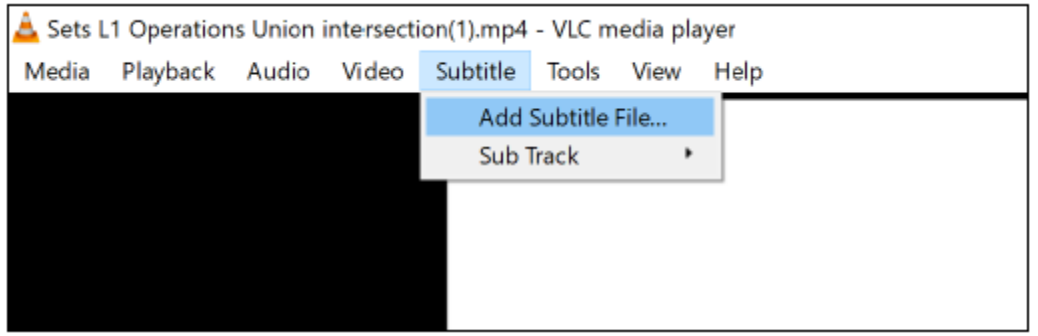
Using Materials Offline

The lectures can be watched on the Moodle space.

If you are struggling to watch the videos on Moodle:

- Download the video and caption file (*.vtt) from Moodle
- Download the free, open source VLC Media player: https://www.videolan.org/vlc/index.en-GB.html
- Open video file in VLC and add caption file





Note:

All learning materials: slides, videos and caption files are @Lancaster University copyright and are **not to be shared or distributed**.

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Plagiarism

Passing off someone else's work as your own, including:

- Colluding with a classmate or someone else to do your work
  - Submitting code written by someone else
  - Paying for someone else to do your work
  - Adapting code by someone else with only a minor modification
- Coursework is submitted on Moodle and will be checked automatically for plagiarism.
- Academic malpractice and plagiarism applies online and offline
- Direct sharing of code, sharing solutions and/or partial solutions with other students, either privately or in an open chat, is **not acceptable**

What do we expect from you?

Attendance:

- Lectures, labs etc., be punctual

Active learning:

- Read around (explore) the subject
- Use recommended books and available online resources
- Ask questions, try things yourself, keep notes
- Have a study plan, get a study partner

Integrity:

- Honesty, no plagiarism, no result manipulation

Attendance Check-in

Be sure to check in to all timetabled sessions using Attendance Check-in

To check in:

- Check the **Attendance Hub** in iLancaster
- Click **Check In**
- Wait for the “You are checked in” confirmation page
- Here is a demo

Please do not leave a timetabled session without your attendance being registered

https://estream.lancaster.ac.uk/GetMP4.ashx?ppID=2&file=2878_4z%7EaVw8tWQF.mp4&source=8&cs=nDCBA71pCqFI4fuOomVNZLAVRQnJfeGTqiu8ejPavzqy4TWfxwpIPtQmQmamblzXo_Pelw6Yf_Pv6K9AtEqmbA

Overview of Artificial Intelligence

- Introduction to the Module
- Lectures, Materials and Expectations
- **Overview of Artificial Intelligence**
- Overview of Machine Learning

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Overview of AI

1. Applications of AI
2. Definition of AI
3. Goals of AI
4. AI and Society

Applications of AI

AI in Real Life

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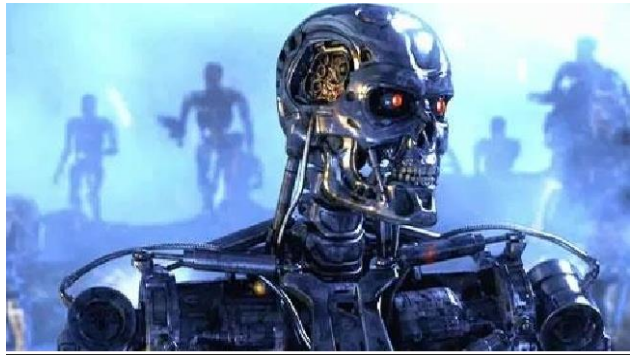
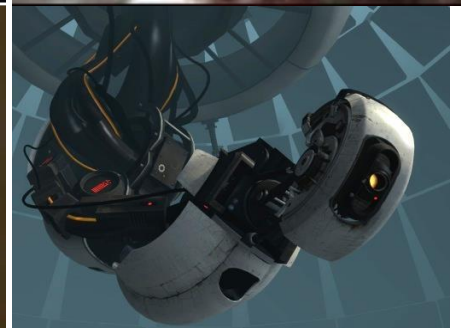
AI in Science Fiction Movies





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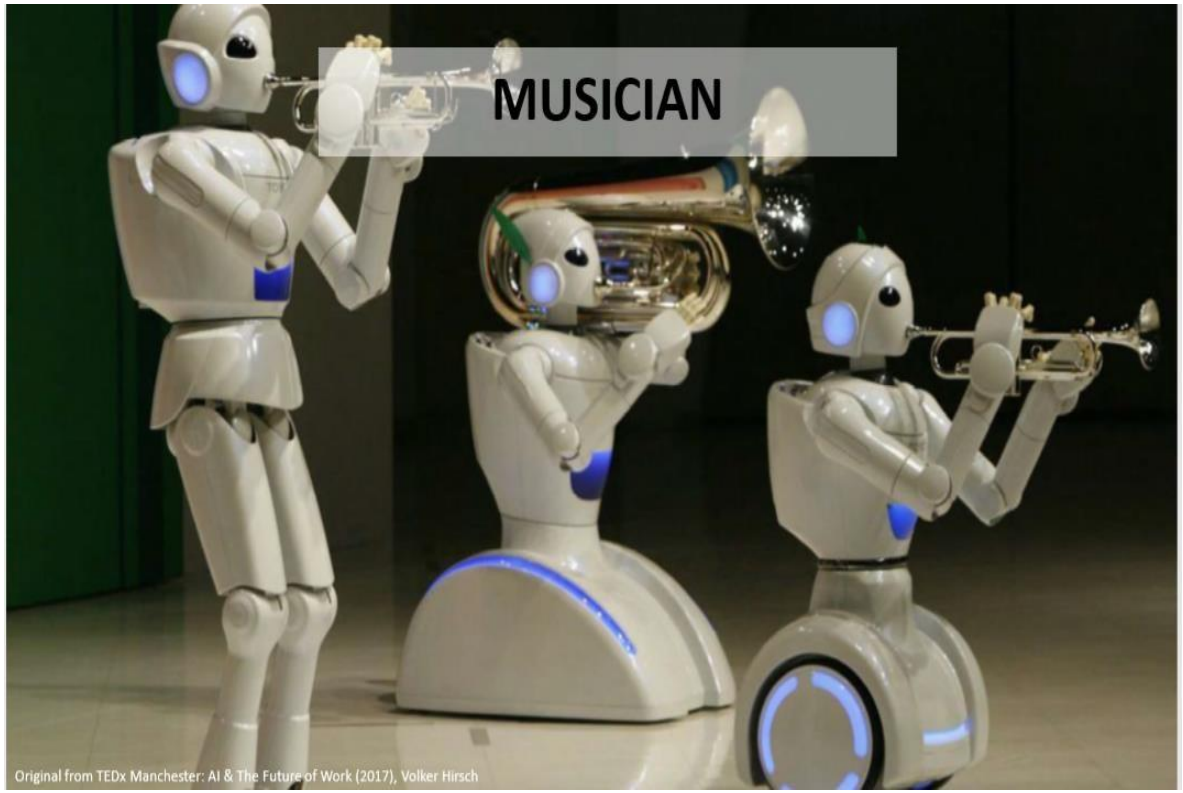
AI in Movies

AI in Music


MUSICIAN
Original from TEDx Manchester: AI & The Future of Work (2017), Volker Hirsch


NOW
AND
THEN

AI in Agriculture

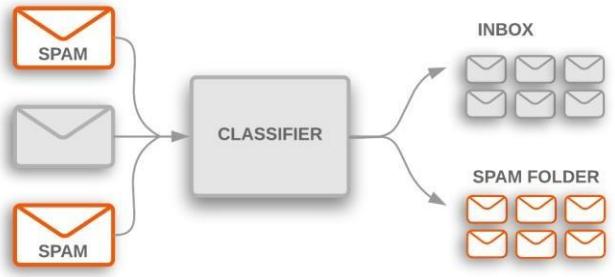
AI in Self-Driving Vehicles

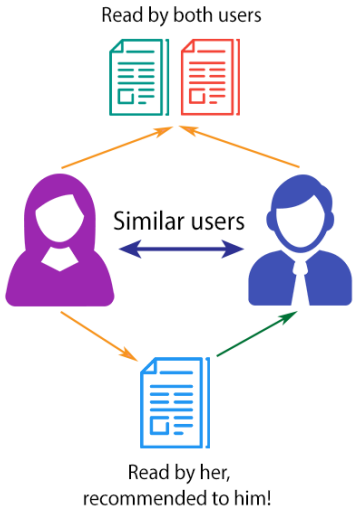
AI in Natural Language Processing

- Web search engines
- Text classification: sentiment, topic
- Spam filtering etc
- Machine translation
- Question answering
- Recommender Systems
- ChatGPT

Speech Technologies

- Siri, Alexa, Cortana, Google Assistant
- Automatic Speech Recognition
- Dialogue systems

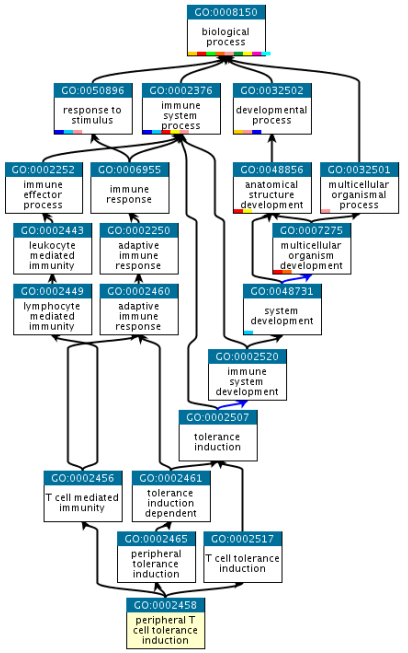




Natural Language Processing research

Spatial Humanities: GIS with NLP for analysing historical documents: https://www.lancaster.ac.uk/fass/projects/spatialhum.wordpress/

SAMS: Early diagnosis of dementia by monitoring interaction with a computer to monitor mental health: http://ucrel.lancs.ac.uk/sams/



Biomedical Text Mining: http://wp.lancs.ac.uk/btm/

Corporate Financial Information Environment: Automatic analysis of financial narratives: http://ucrel.lancs.ac.uk/cfie/

Analysing language style for insights into authors and their intentions.

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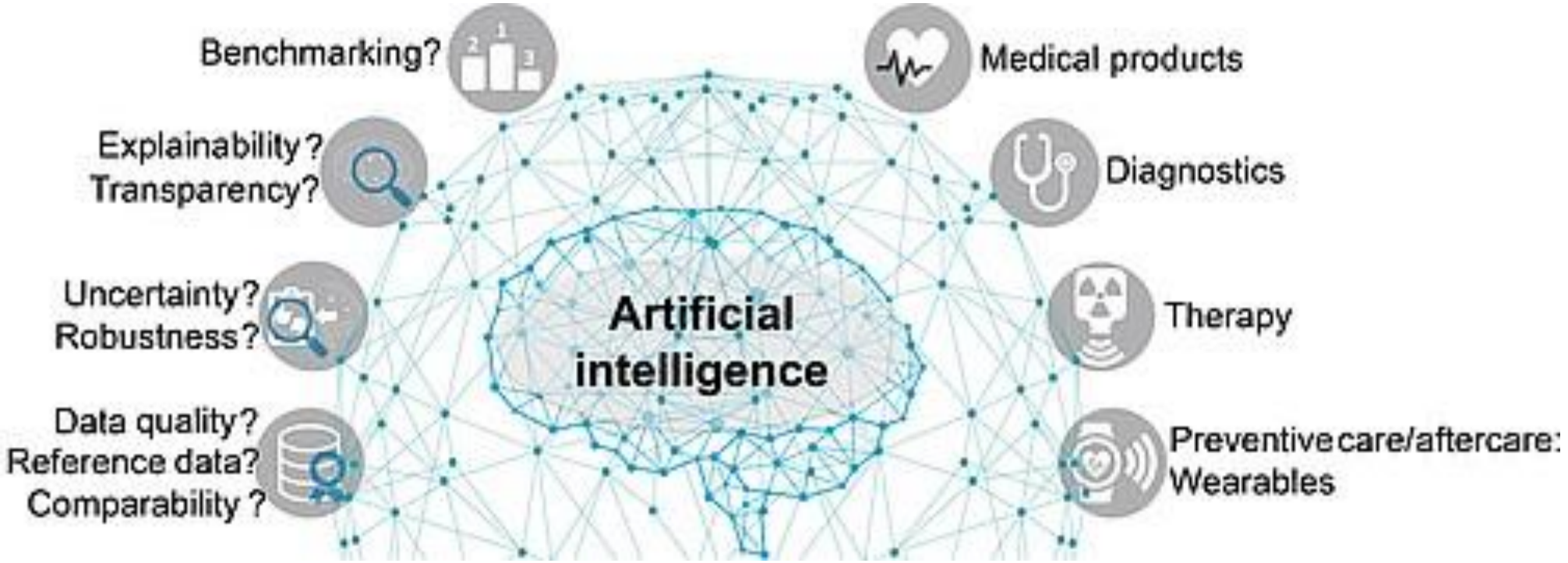
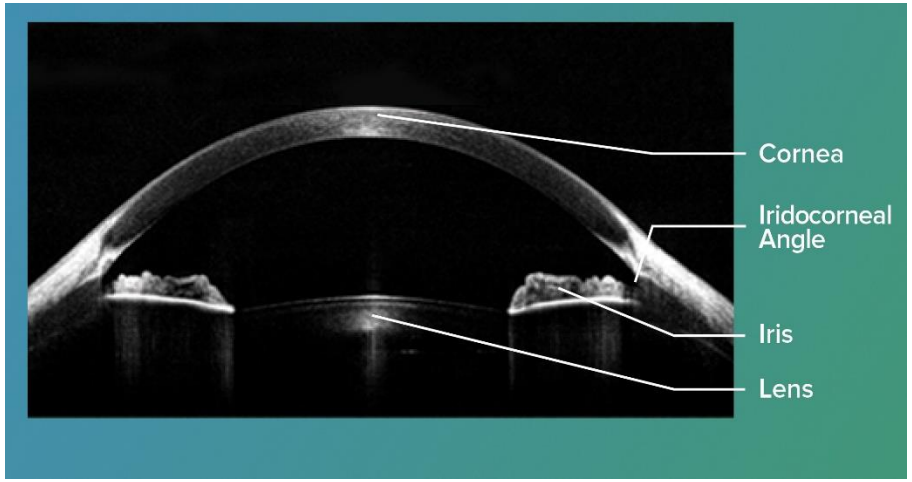
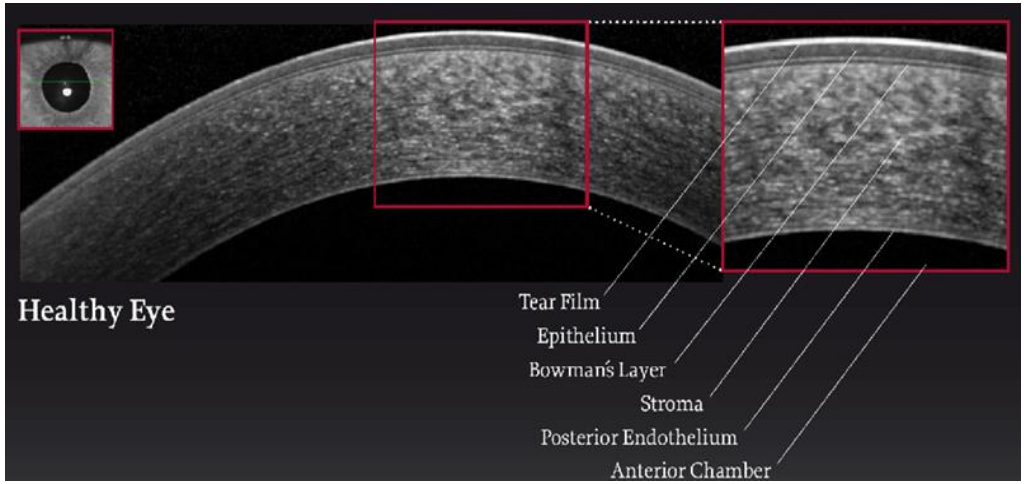
AI in Medicine

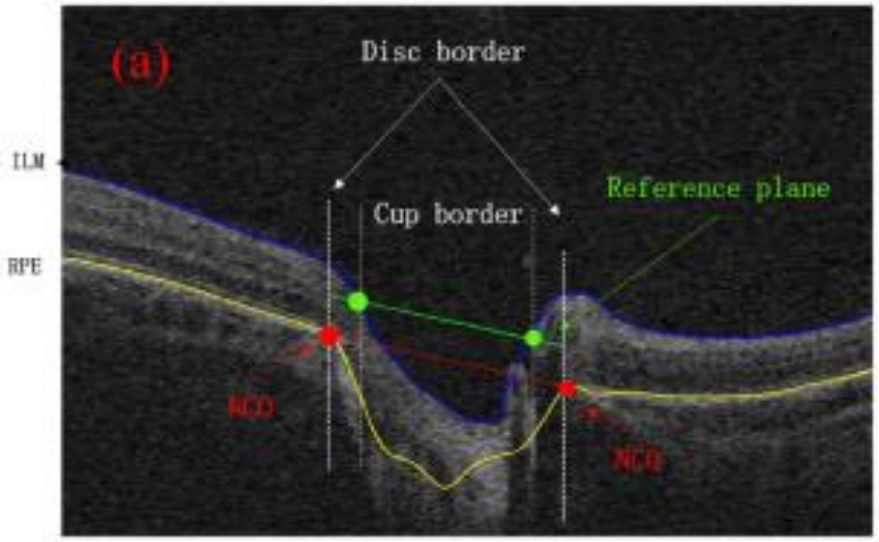
AI in Medicine – Considerations

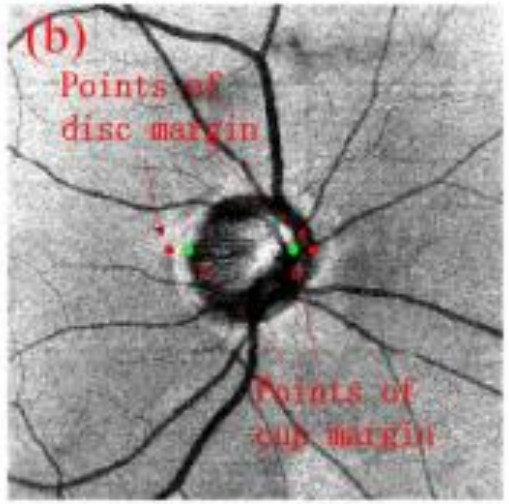


AI in Medicine – Eye scanning

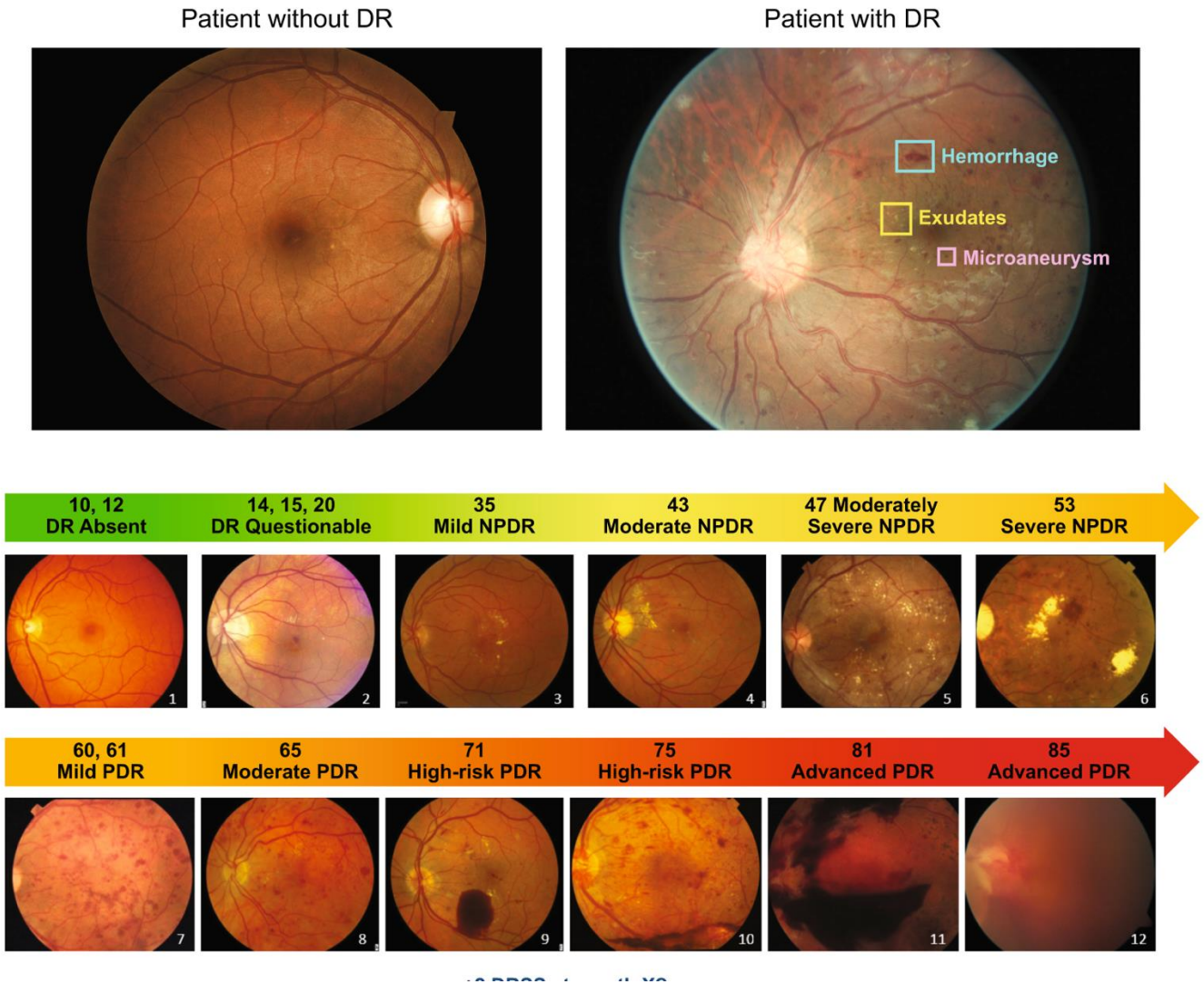




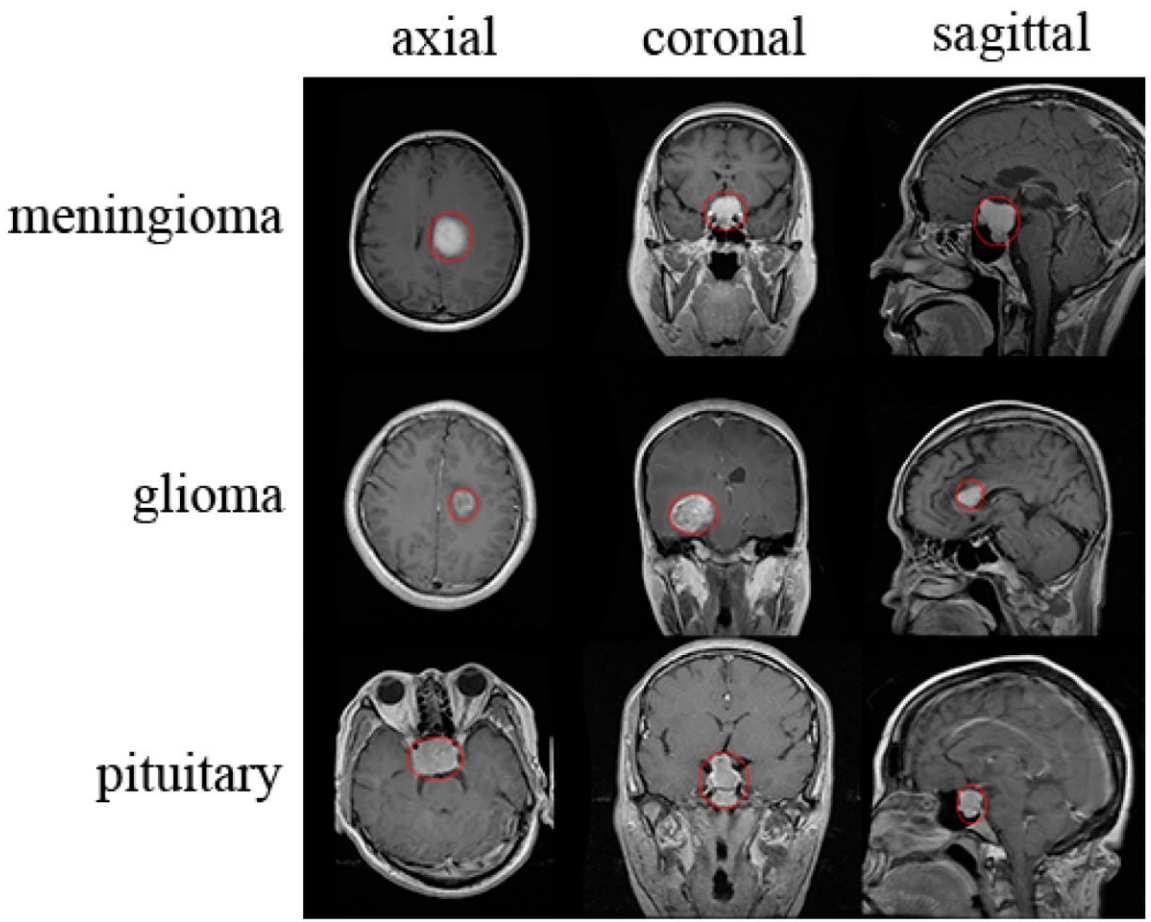


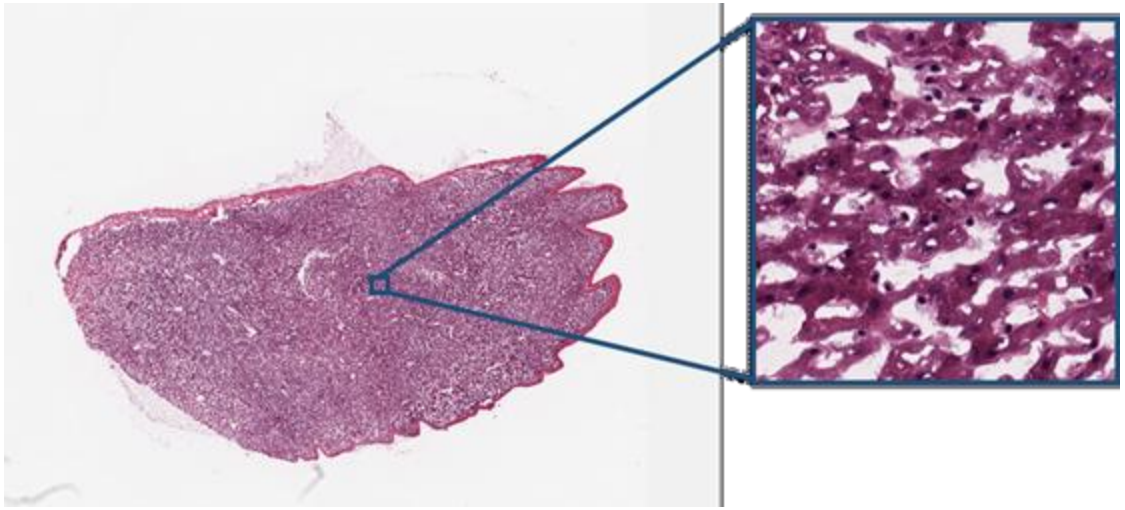


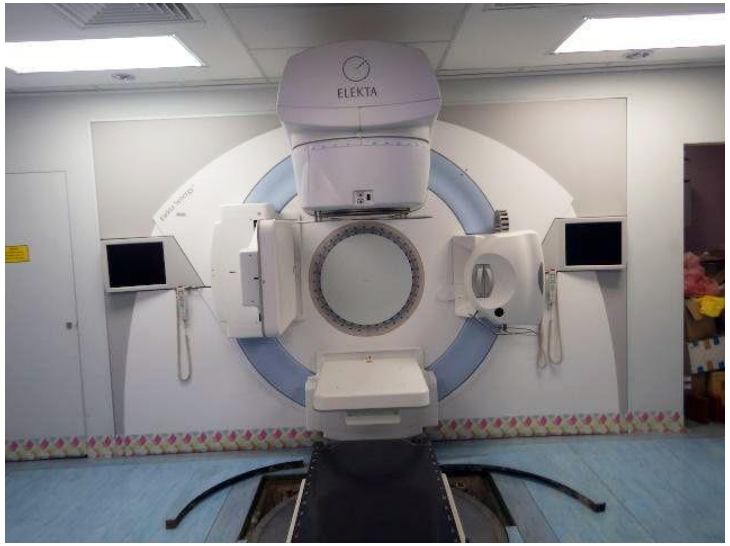
AI in Medicine – Disease monitoring



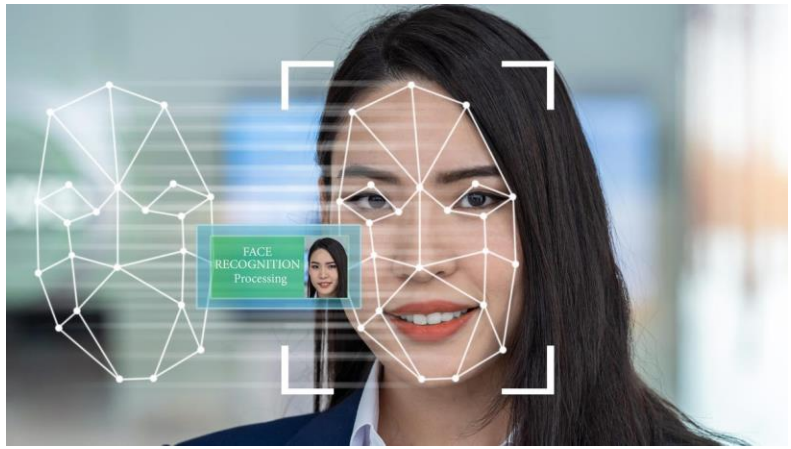
AI in Medicine – Brain scanning

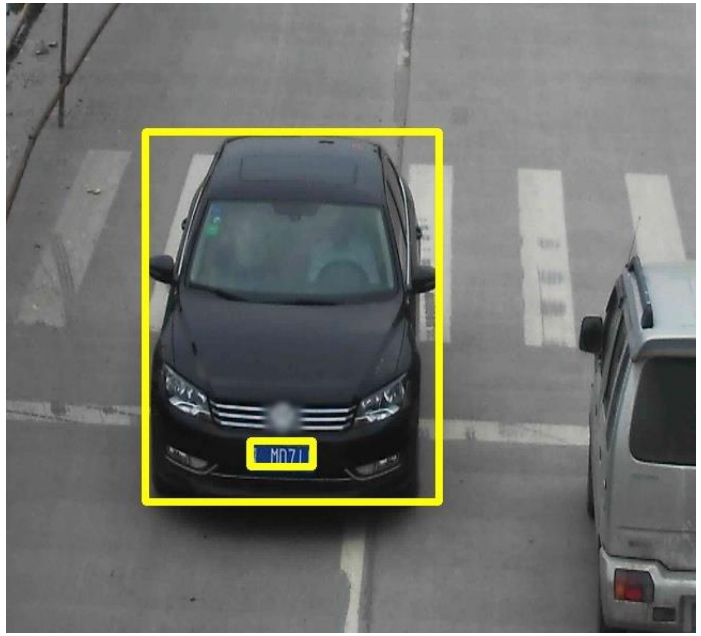


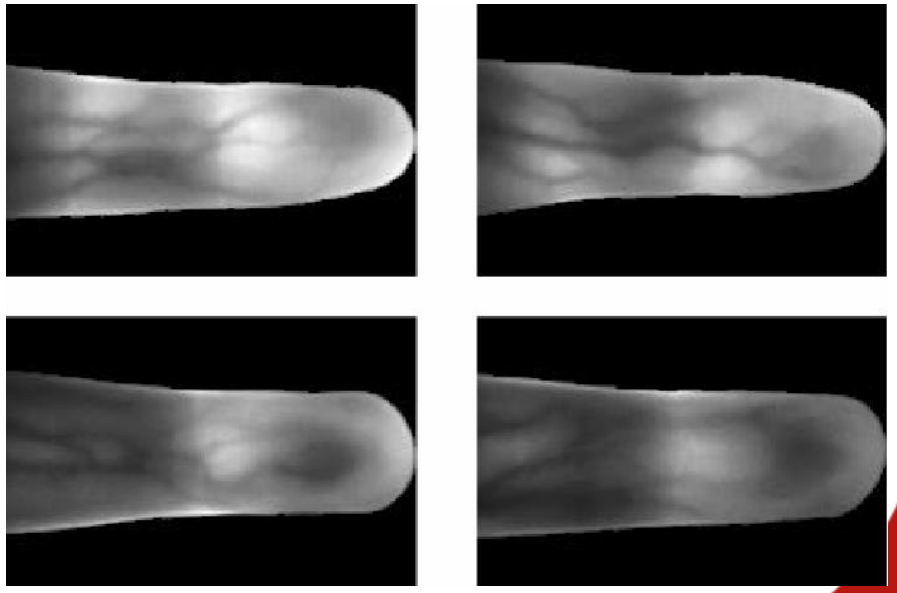




AI in Security



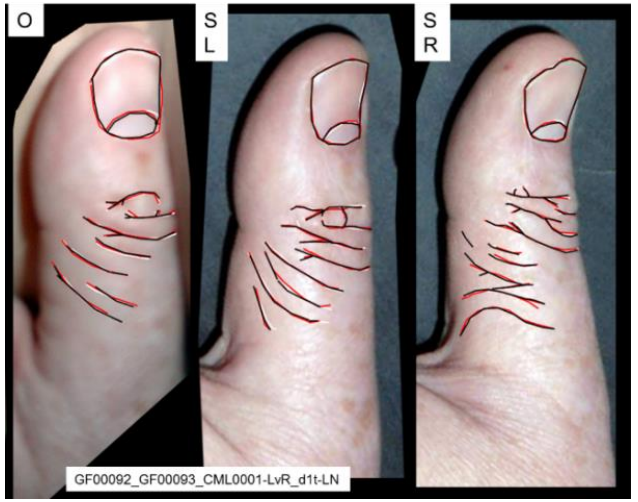


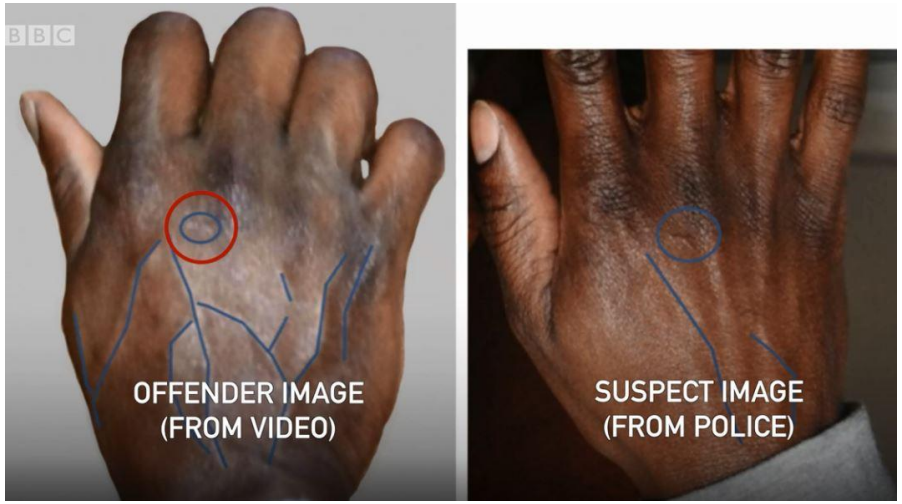


AI in Forensic Investigation

AI in Forensic Identification

AI in Forensic Identification – H-Unique





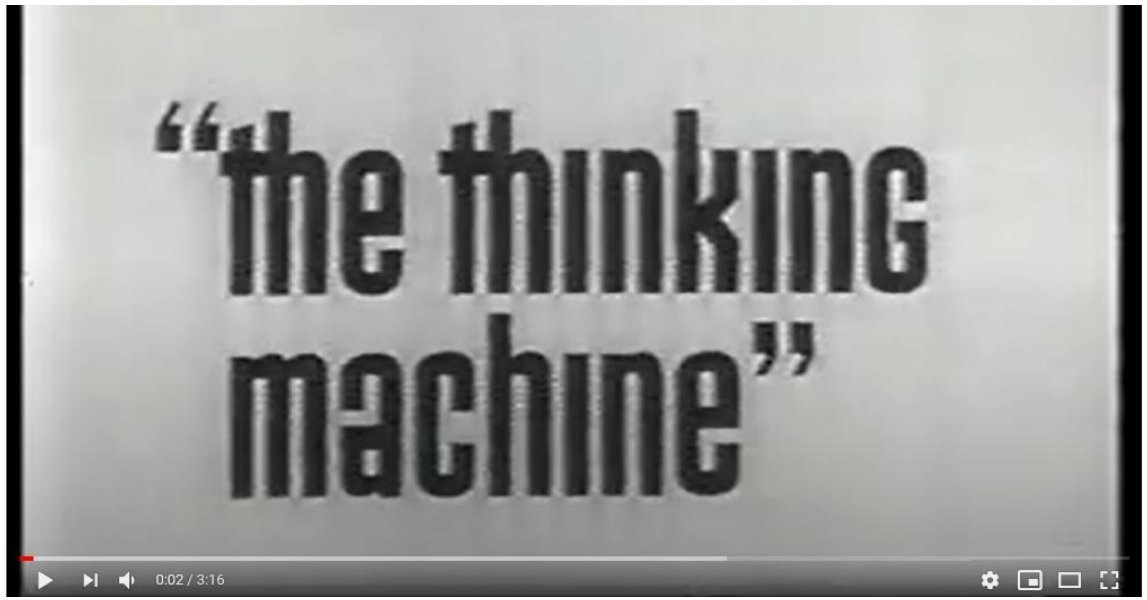
H-Unique

https://h-unique.lancaster.ac.uk/

How can we define AI?

The Thinking Machine

- Can machines really think?
- Interviews by some of the AI pioneers in the 1960s:
  - Jerome Wiesner,
  - Oliver Selfridge,
  - Claude Shannon
- Will a robot marry my daughter?
- Can AI translate poetry?



https://www.youtube.com/watch?v=aygSMgK3BEM

Human Intelligence

Learning

Reasoning

Perceiving

Understanding of Language

Feeling

What is Artificial Intelligence? – Approach 1

Approach 1

- "The exciting new effort to make computers think ...machines with minds, in the full and literal sense." (Haugeland, 1985)
- "[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning..." (Bellman, 1978)

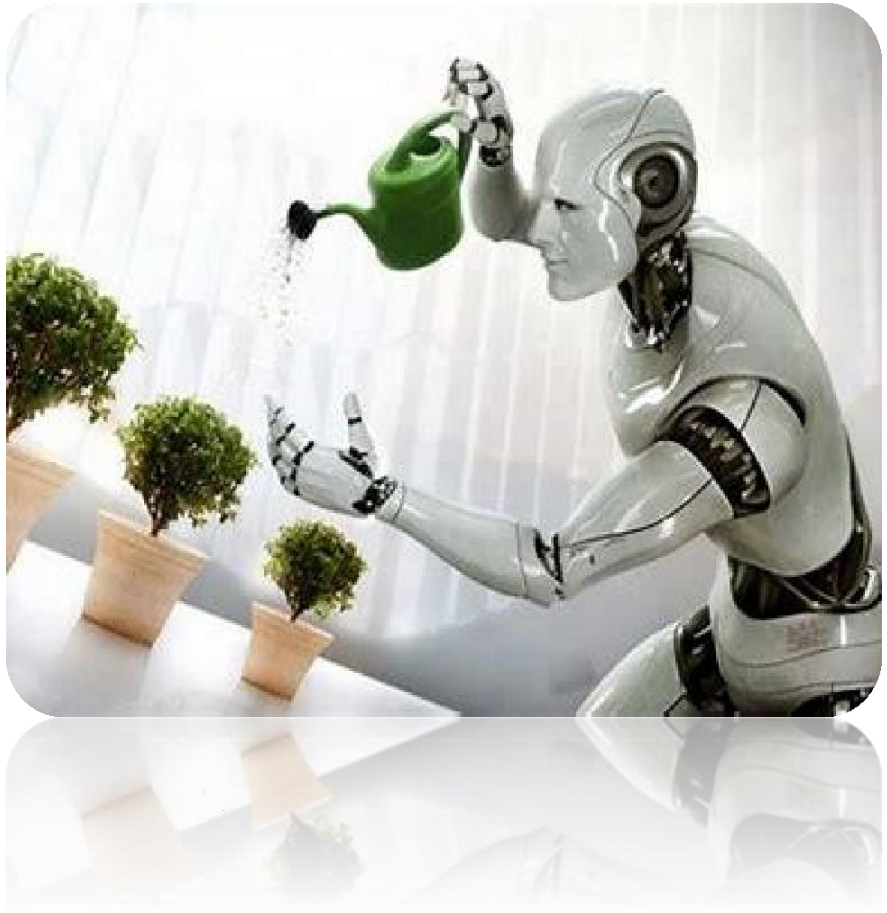
Thinking Humanly

Artificial Intelligence: A Modern Approach, 2016, Russell & Norvig

What is Artificial Intelligence? – Approach 2

Approach 2

- "The art of creating machines that perform functions that require intelligence when performed by people." (Kurzweil, 1990)
- "The study of how to make computers do things at which, at the moment, people are better." (Rich and Knight, 1991)



Acting Humanly

Artificial Intelligence: A Modern Approach, 2016, Russell & Norvig

What is Artificial Intelligence? – Approach 3

Approach 3

- "The study of mental faculties through the use of computational models." (Charniak and McDermott, 1985)
- "The study of the computations that make it possible to perceive, reason, and act." (Winston, 1992)

Thinking Rationally

Artificial Intelligence: A Modern Approach, 2016, Russell & Norvig

What is Artificial Intelligence? – Approach 4

Approach 4

- "Computational Intelligence is the study of the design of intelligent agents." (Poole et al., 1998)
- "AI ... is concerned with intelligent behavior in artifacts." (Nilsson, 1998)

Acting Rationally

Artificial Intelligence: A Modern Approach, 2016, Russell & Norvig

Approaches to defining AI

	Human	Rational
Thinking	**Systems that think like humans**	**Systems that think rationally**
Acting	**Systems that act like humans**	**Systems that act rationally**

Artificial Intelligence: A Modern Approach, 2016, Russell & Norvig

Approaches to defining AI: Human Thinking

	Human	Rational
Thinking	**Systems that think like humans** • Cognitive modelling approach • Introspection, psychological experiments, brain imaging • Cognitive Science	Systems that think rationally
Acting	Systems that act like humans	Systems that act rationally

Artificial Intelligence: A Modern Approach, 2016, Russell & Norvig

Approaches to defining AI: Rational Thinking

	Human	Rational
Thinking	**Systems that think like humans** • Cognitive modelling approach • Introspection, psychological experiments, brain imaging • Cognitive Science	**Systems that think rationally** • Laws of thought approach • "Logicist" tradition • Mostly rule-based • Logic
Acting	**Systems that act like humans**	**Systems that act rationally**

Artificial Intelligence: A Modern Approach, 2016, Russell & Norvig

Approaches to defining AI: Acting Human

	Human	Rational
Thinking	**Systems that think like humans** • Cognitive modelling approach • Introspection, psychological experiments, brain imaging • Cognitive Science	**Systems that think rationally** • Laws of thought approach • "Logicist" tradition • Mostly rule-based • Logic
Acting	**Systems that act like humans** • The (total) Turing Test • Requires the 6 disciplines • NLP, KR, Reasoning, ML, Computer vision, Robotics	**Systems that act rationally**

Artificial Intelligence: A Modern Approach, 2016, Russell & Norvig

Approaches to defining AI: Acting Rationally

	Human	Rational
Thinking	**Systems that think like humans** • Cognitive modelling approach • Introspection, psychological experiments, brain imaging • Cognitive Science	**Systems that think rationally** • Laws of thought approach • "Logicist" tradition • Mostly rule-based • Logic
Acting	**Systems that act like humans** • The (total) Turing Test • Requires the 6 disciplines • NLP, KR, Reasoning, ML, Computer vision, Robotics	**Systems that act rationally** • The rational agent approach • Autonomous, perceptive, persistent, adapts to change • Creates and pursues goals

Artificial Intelligence: A Modern Approach, 2016, Russell & Norvig

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What is an Agent?

An **agent** 'acts' (does something) within an **environment**

- e.g. worms, dogs, thermostats, airplanes, robots, humans, companies, and countries.

An agent acts **intelligently** if:

- action is appropriate for circumstances and goals
- flexible to changes in environment and goals
- learns from experience
- makes appropriate choices given perceptual and computational limitations

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Computational Agent

A **computational agent** is:

- An agent whose decisions and actions can be explained in terms of computation.
- Decision can be broken down into primitive operations that can be implemented in a physical device.
- Computations can take many forms
  - The human brain (“wetware”)
  - Computers (“hardware”)
- Non computational agents:
  - wind, rain, etc.

Rational Agent

- A **Rational agent** acts to ‘achieve the best outcome or, when there is uncertainty, the best expected outcome.’
- AI focuses on building the *general principles* of **rational agents** and *components* for constructing them.
- Two key advantages of the **rational-agent** approach over others:
  - More amenable to scientific development than approaches on human thoughts and behaviour
  - It is more general than the “laws of thought” approach
- Also deals with **limited rationality** – acting appropriately with limited computations

Artificial Intelligence: A Modern Approach, 2016, Russell & Norvig

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Intelligence

- AI is the field that studies the *synthesis* and *analysis* of **computational agents** that **act intelligently** - *Poole & Markworth*

- An agent acts **intelligently** if:
  - action is appropriate for circumstances and goals
  - flexible to changes in environment and goals
  - learns from experience
  - makes appropriate choices given perceptual and computational limitations

Intelligence -- rational

- AI is the field that studies the *synthesis* and *analysis* of **computational agents** that **act intelligently** - *Poole & Markworth*

- An agent acts **intelligently** if:
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  - flexible to changes in environment and goals
  - learns from experience
  - makes appropriate choices given perceptual and computational limitations

it is 'rational'

Artificial Intelligence: Foundations of Computational Agents, 2017, Poole & Markworth

Definition of AI

Artificial intelligence, or **AI** is the field that studies the *synthesis and analysis of* ***computational agents*** *that* ***act rationally***

Artificial Intelligence: A Modern Approach, 2016, Russell & Norvig
Artificial Intelligence: Foundations of Computational Agents, 2017, Poole & Markworth

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Goals of AI - Scientific

Two types of goals: **Scientific** and Engineering

- **Scientific goal** – understand the principles of intelligent behaviour:
  - Analysis of natural and artificial agents
  - Formulating and testing hypothesis
  - Designing, building and experimenting with computational agents
- Uses a general scientific approach
- Focuses on building **empirical systems**
- And **not** on the final **applications** that could be deployed to use

Goals of AI - Engineering

Two types of goals: Scientific and **Engineering**

- **Engineering goal** – concerned with constructing intelligent agents.
- Focuses on the **design** and **synthesis** of useful, intelligent artefact.
- Builds agents that act intelligently.
- Agents that are useful in many real-world applications.

Business Benefits of AI

- Workflow/Process automation
  - Use of bots for routine, repetitive tasks
- Enhance creative tasks
  - More time and tools to explore creative functions
- Increased accuracy
  - Human errors can be reduced
- Better predictions & improved decision making
  - Predictions of risks, performance targets, tailored product offerings, etc.

Social benefits of AI

- Healthcare
  - There is a huge effort in mobilizing AI for health.
- Smart cities, transportation, security
  - Maps, navigation systems, unmanned vehicles, route planning, security
- Forecasts and predictions
  - Weather, natural disasters, earthquakes, hurricanes, stock prices, economic
- Agriculture
  - Real-time data analytics help farmers to maximise their crop yields and profits
- Overall lifestyle

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Risks and Challenges of AI

- Safety and security
  - Driverless cars can be hacked
  - Failed Facebook AI chatbot experiment
  - Racist hijack of Microsoft AI Tweeter feed
- Trust and social manipulation
  - Facebook-Cambridge Analytica Scandal
- Explainable (or Interpretable) AI (XAI)
  - Deep neural models are naturally opaque
- Possible job losses
  - “AI will replace more than 75 million jobs by 2022” – World Economic Forum

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Ethical Concerns of AI

- Accountability
  - If AI violates ethical rules, who will be responsible?
- Accuracy, bias, privacy and inequality
- AI learns from data provided by humans which may encode human biases and prejudices
  - Facial recognition to ‘predict criminals’ sparks row over AI bias – BBC
  - IBM abandons “biased” facial recognition tech – BBC
- Technological social responsibility (TSR)
  - a conscious alignment between short- and medium-term business goals and longer-term societal ones – McKinsey Quarterly, August, 2019

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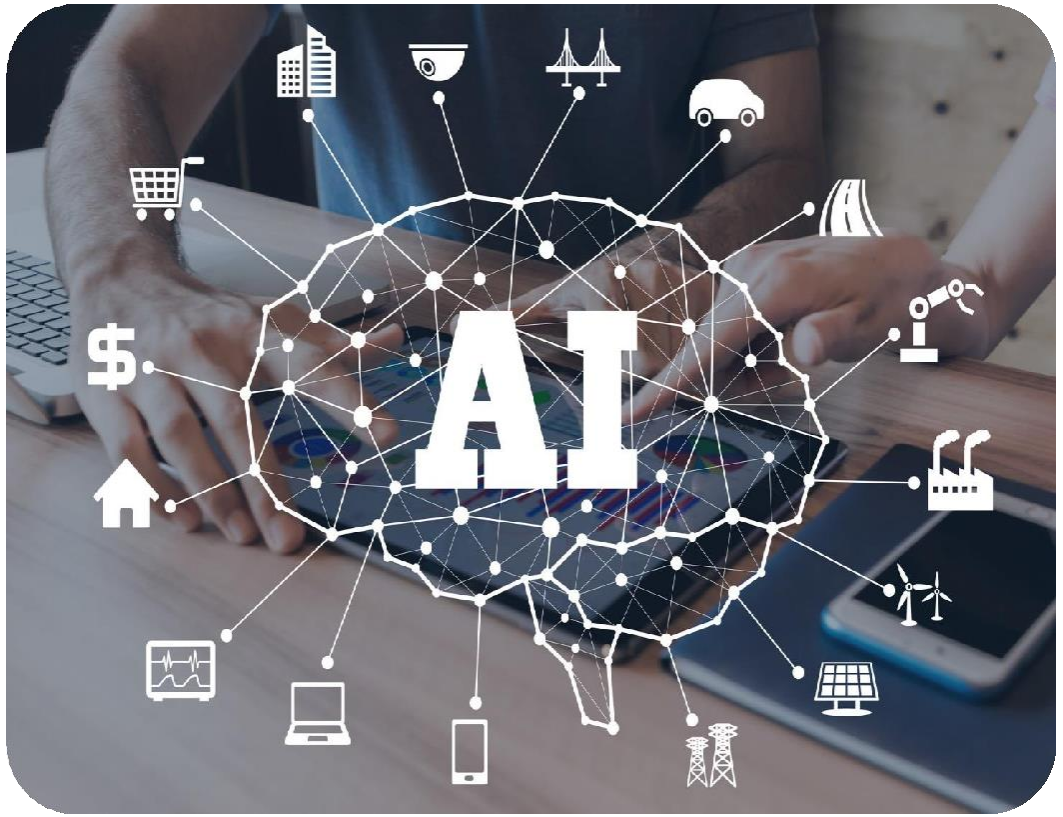
AI Summary

- Artificial Intelligence: An overview
  - Application, history, foundations of AI
- Definition of AI
  - Rational-agent approach
- Goals of AI
- AI and the Society
  - Benefits
  - Risk and Challenges
  - Ethical Issues



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Coming next

- Introduction to the Module
- Lectures, Materials and Expectations
- Overview of Artificial Intelligence
- Overview of Machine Learning

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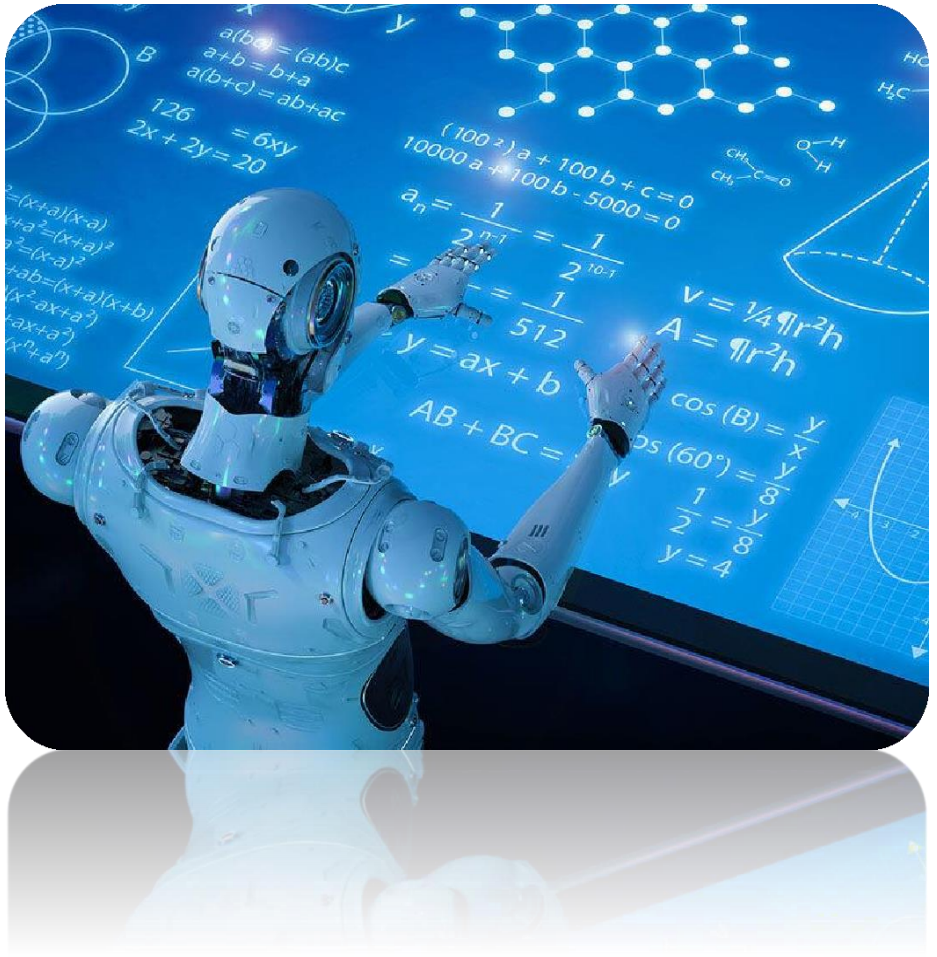
Introduction to Machine Learning

- Overview of Machine Learning
  - AI and ML, Definitions of ML, How to learn
- Types of Machine Learning
  - Supervised, unsupervised, semi-supervised
- Supervised Learning
  - Classification and regression
- Unsupervised Learning
  - Clustering and association

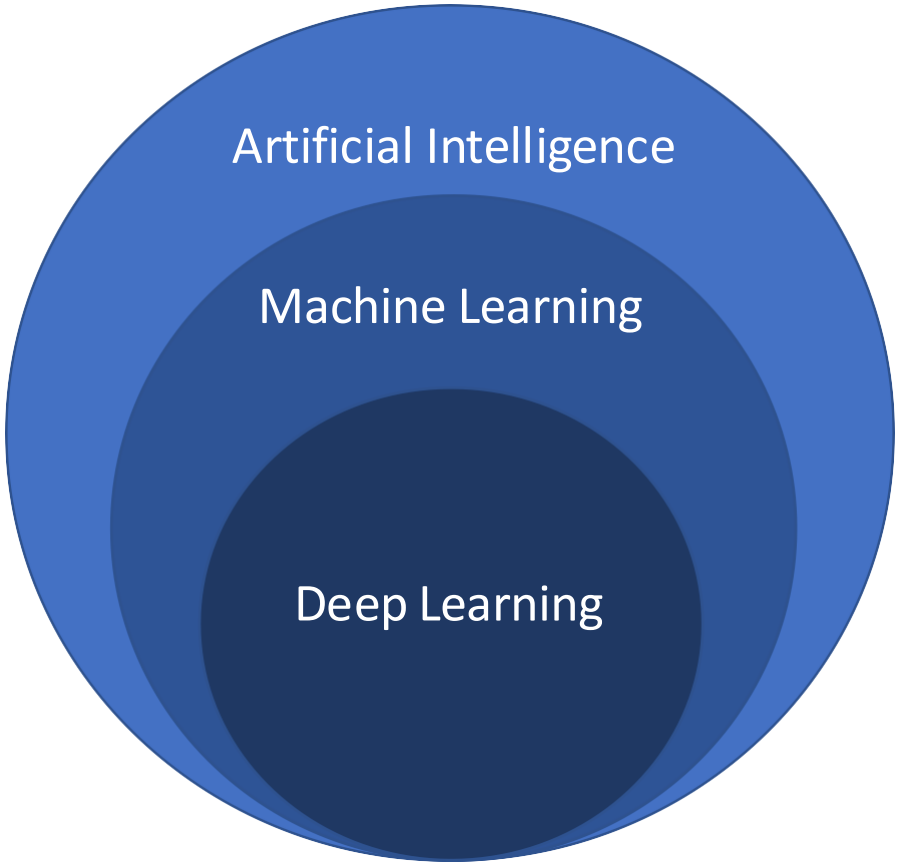


AI and Machine Learning

- In the past, AI systems were mostly **rule-based**
  - i.e. depended on hand-crafted rules.

- Machine learning drives AI
  - Learning algorithms create a logical mapping from data to output.

- Deep learning:
  - a subset of ML with additional layers to learn deeper representations data.

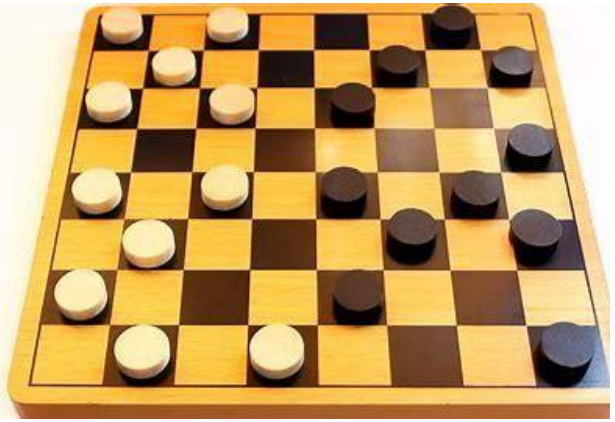


What is Machine Learning? – early definition

Early definition of machine learning:

> *"Field of study that gives computers the ability to learn without being explicitly programmed"*
>
> – Arthur Samuel (1959)

- ML pioneer that built first "self-learning" program that played checkers by learning from experience.



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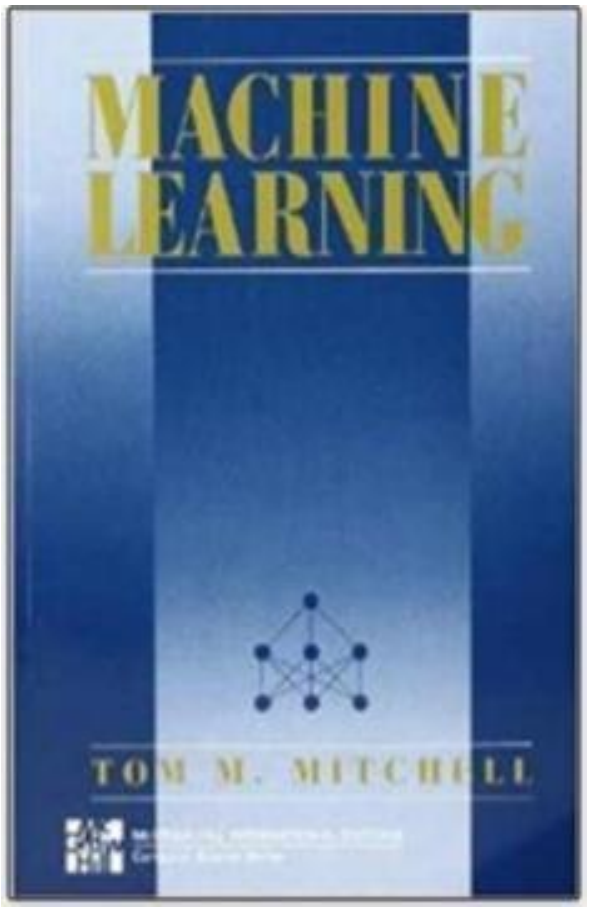
What is Machine Learning?

Another popular definition:

*"A computer is said to **learn** from experience **E** with respect to task **T** and some performance measure **P**, if its performance on **T**, as measured by **P**, improved with experience **E**"*

– Tom Mitchell (1997)



- Again, the key is learning from experience
- Not explicitly programmed

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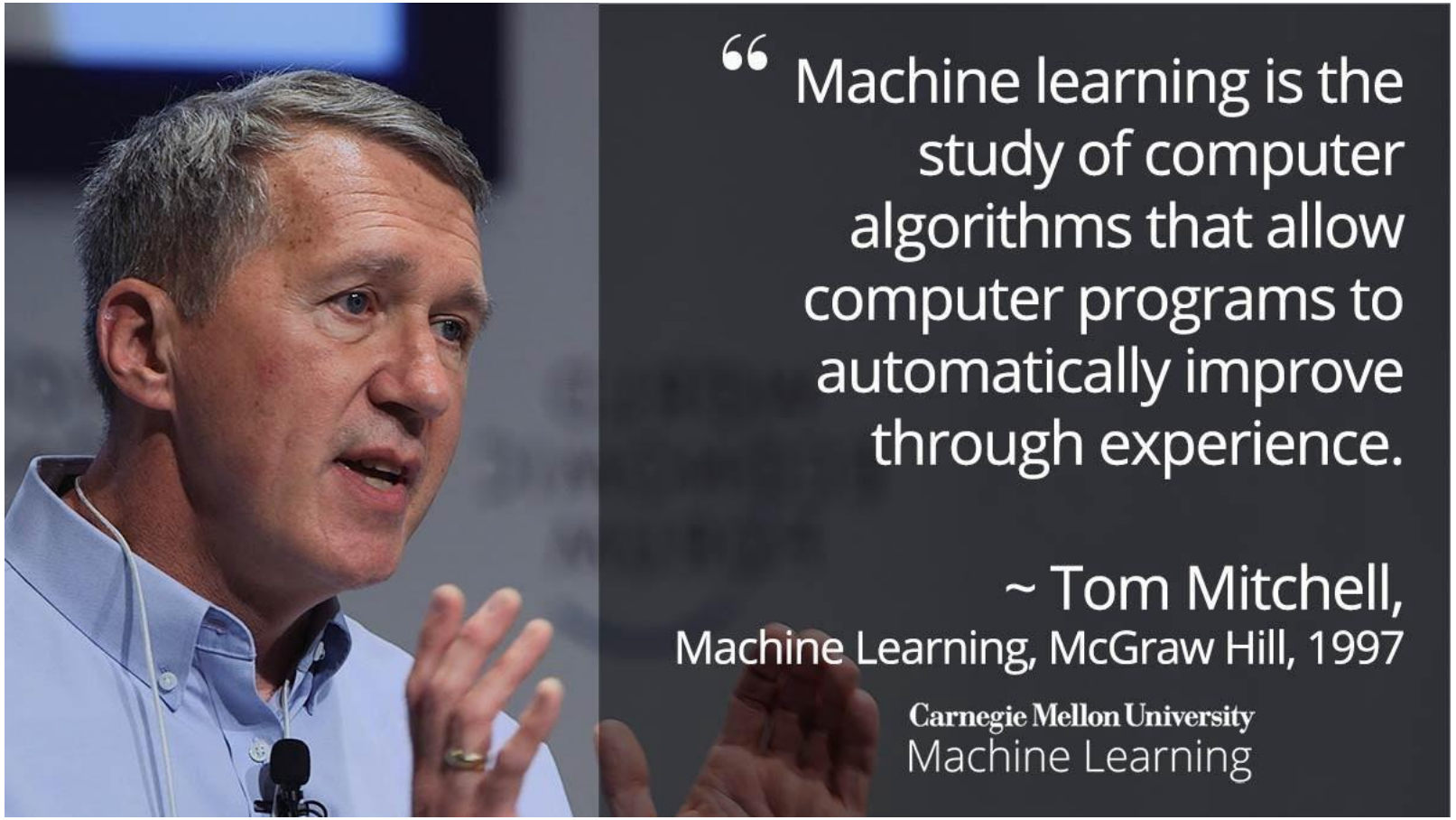
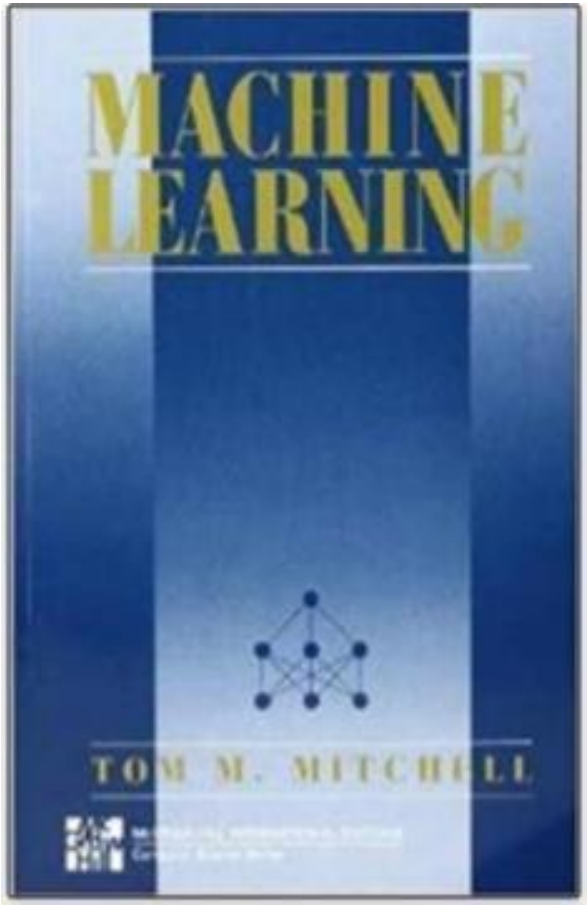
What is Machine Learning?





Spam or not SPAM

Given this definition:

*"A computer is said to **learn** from experience **E** with respect to task **T** and some performance measure **P**, if its performance on **T**, as measured by **P**, improved with experience **E**"*

My email program watches me mark some emails as spam, and improves on filtering spams. What is the T, E and P in the setting?

a. Watching me label emails as spam

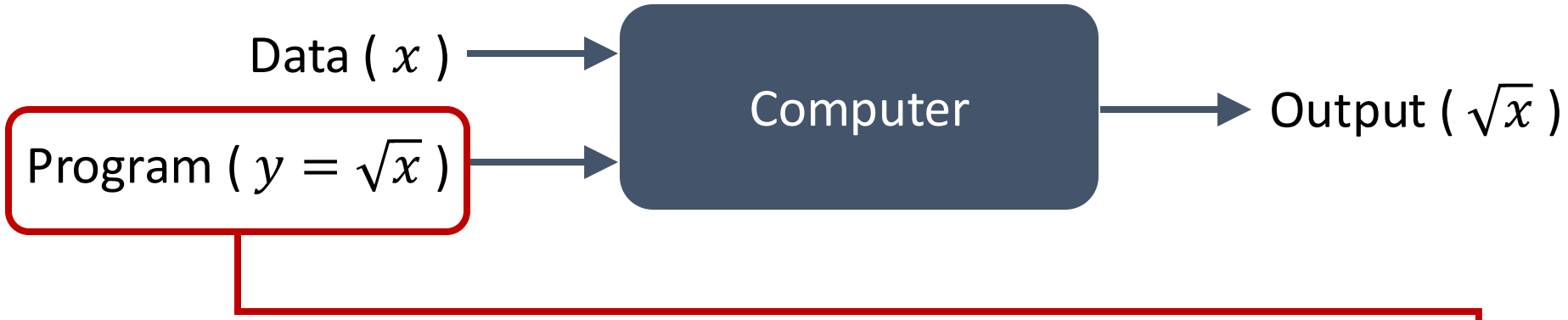
b. Classifying emails as spam or not spam

c. The fraction of emails correctly classified as spam or not

d. None of the above – this is not a machine learning problem

What is Machine Learning?

- Consider the function $y = f(x)$ (e.g. $f(x) = \sqrt{x}$)
- Traditional Programming (Software 1.0)



- Machine Learning (Software 2.0)

How things are learned

- Memorization
  - Accumulation of individual facts
  - Limited by
    - Time to observe facts
    - Memory to store facts

Declarative knowledge

How things are learned

- Memorization
  - Accumulation of individual facts
  - Limited by
    - Time to observe facts
    - Memory to store facts
- Generalization
  - Deduce new facts from old facts
  - Limited by accuracy of deduction process
    - Essentially a predictive activity
    - Assumes that the past predicts the future

Declarative knowledge

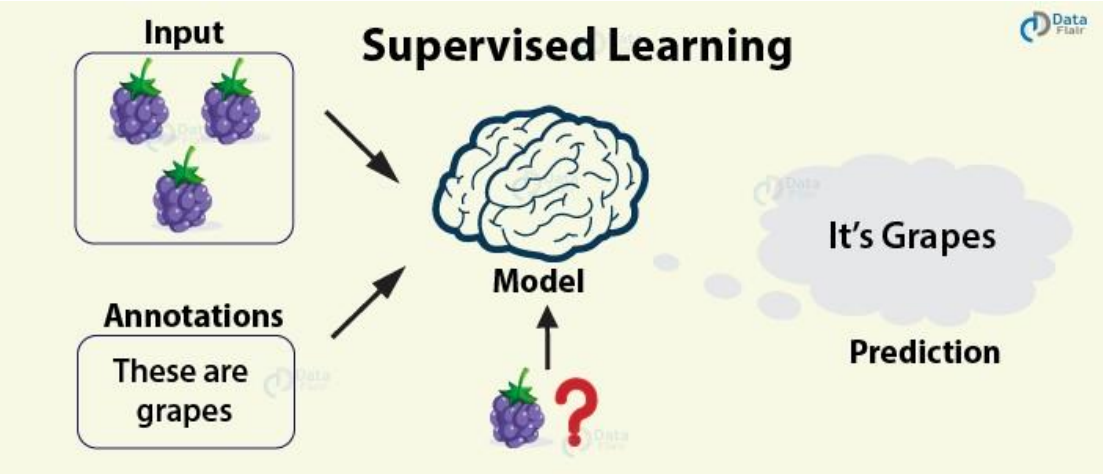
Better

Imperative knowledge

Types of Machine Learning

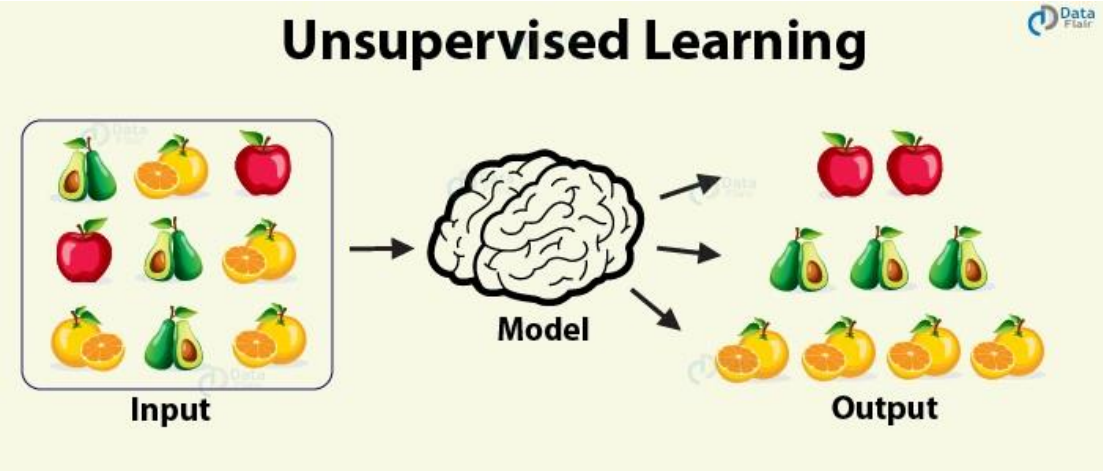
Supervised Learning

- Classification
- Regression



Unsupervised Learning

- Clustering
- Association



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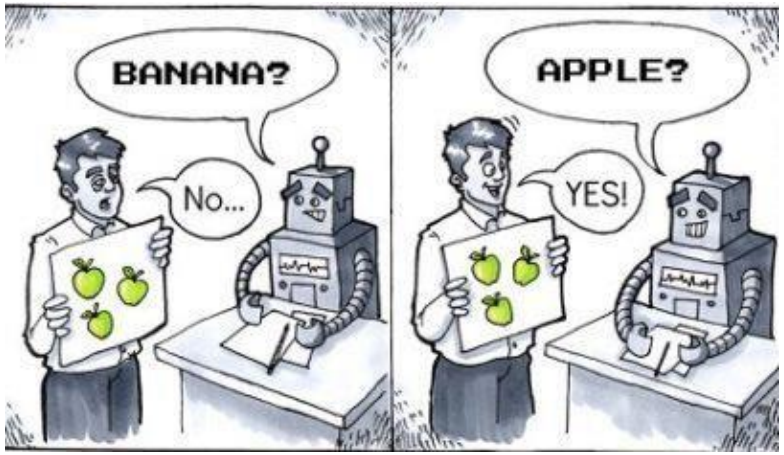
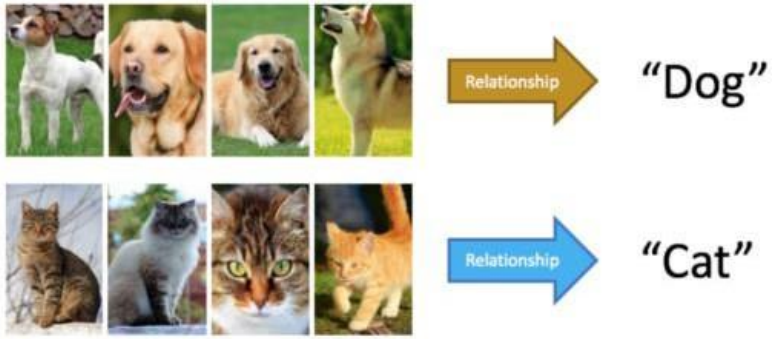
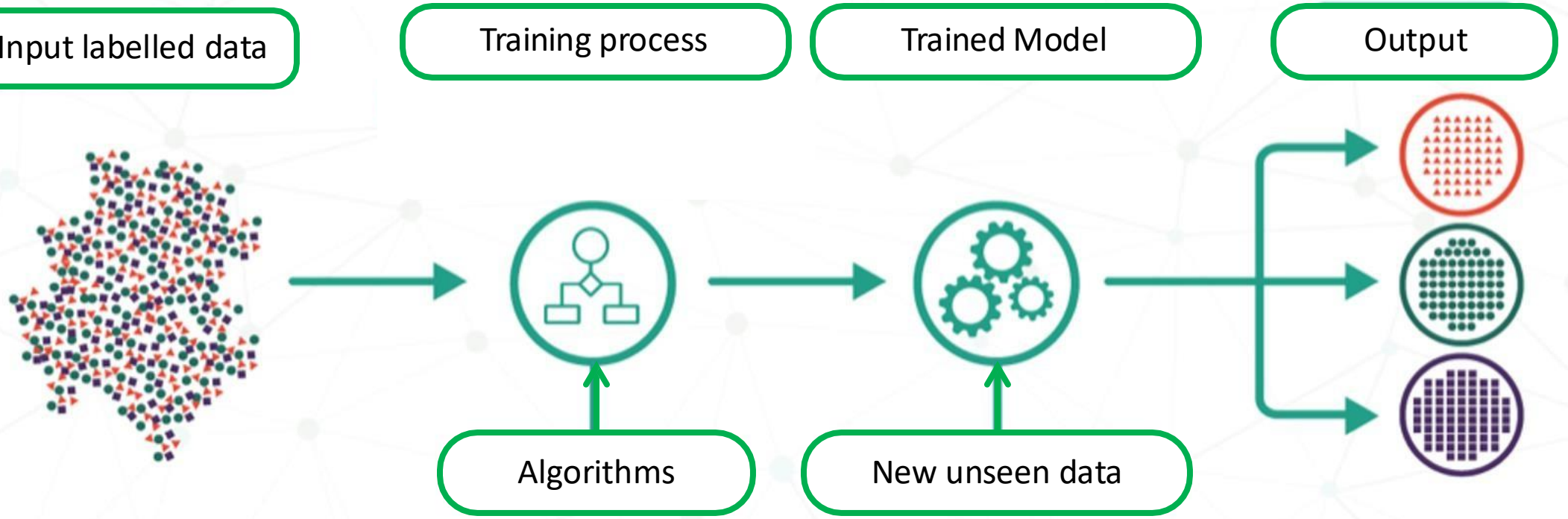
Supervised Learning

- The algorithm learns to map an **input** to a **particular output**.
- Instances of data are presented along with their **correctly labelled** output.
- Similar to a **teacher-student** scenario.
- The algorithm learns from **experience** to predict new unseen data.
- Two broad categories:
  - Regression
  - Classification



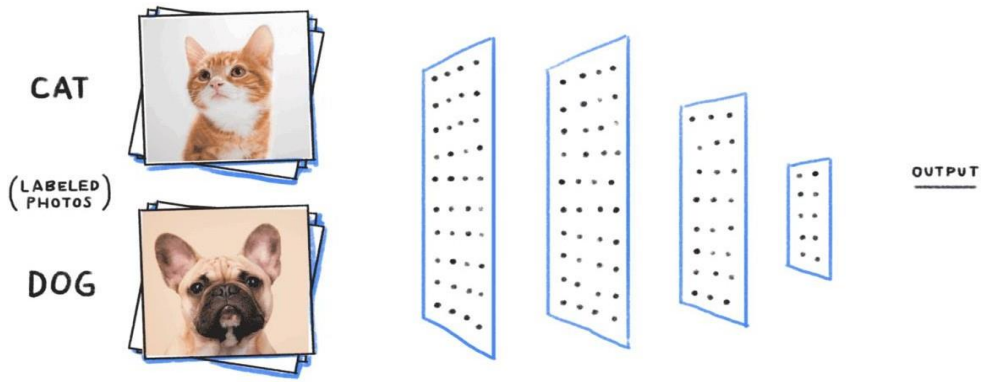


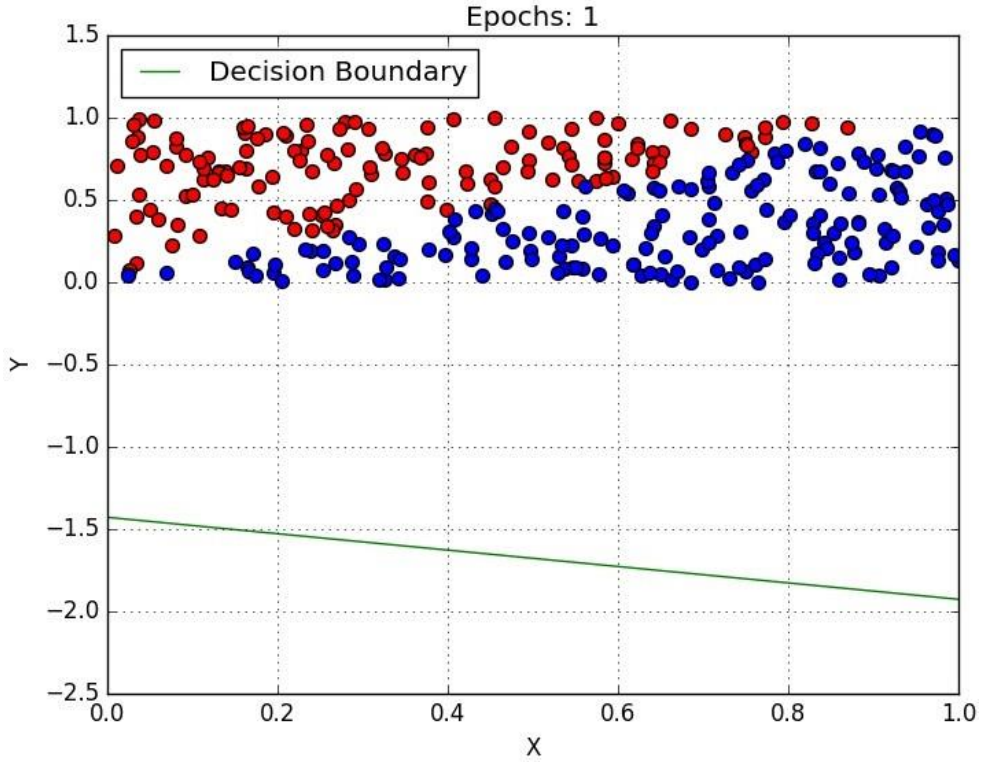
Supervised Learning



Classification

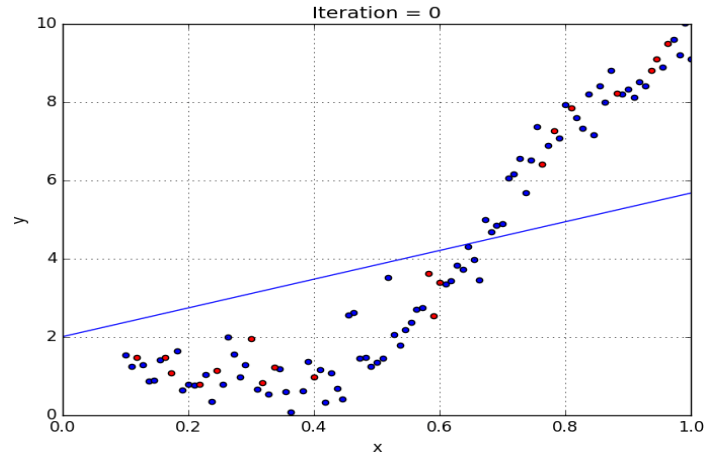
- Learns from labelled data (supervised)
- Predicts a **category** or a **class**
  - Cats|Dogs
  - Spam|Ham
  - Cancer|Not Cancer
- Attempts to separate the data into specific categories (or classes or labels)

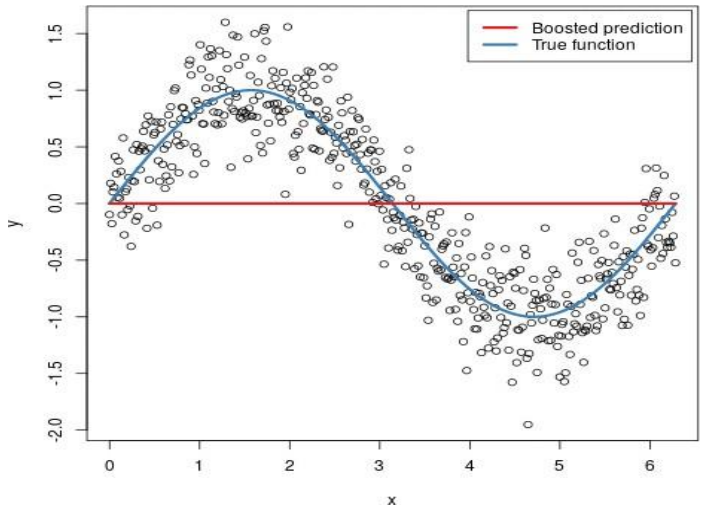




Regression

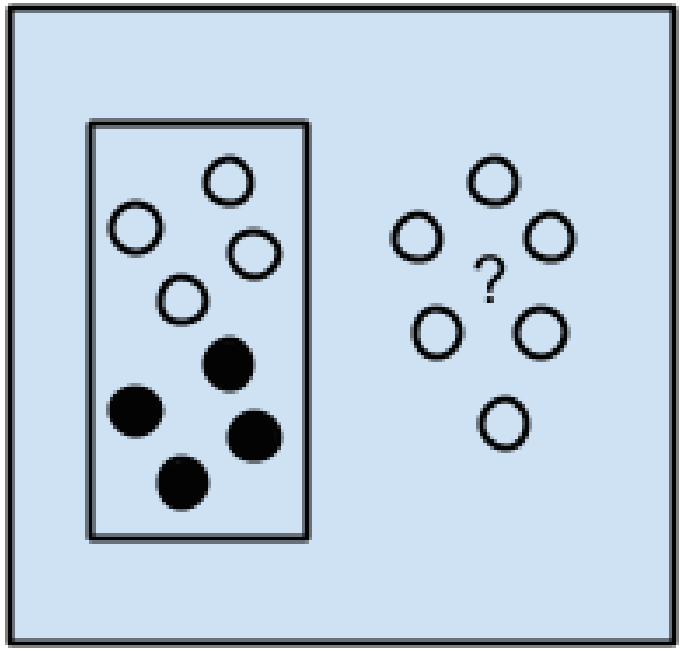
- Learns from labelled data (supervised)
- Predicts a **continuous-valued output**
  - height, price, duration etc.
- Consider a function $y = f(x)$
  - we want our model to predict y_i given x_i
  - x_i not seen during training
- Typically fits some linear or quadratic curve of the data plot
- Linear or logistic regression algorithms are often used





Supervised Learning Algorithms

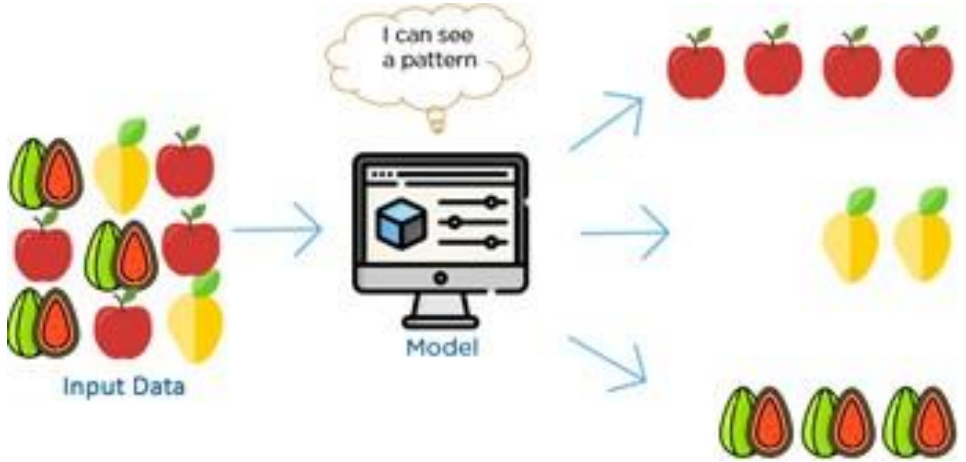
- Input data = training data
  - with labels e.g. spam/ham or stock price at t
- In training
  - the model makes a prediction and is corrected if the prediction is wrong
- Training process continues until a desired accuracy is achieved
- Problem types: Classification and Regression
- Algorithm examples:
  - Logistic Regression
  - Back Propagation Neural Network

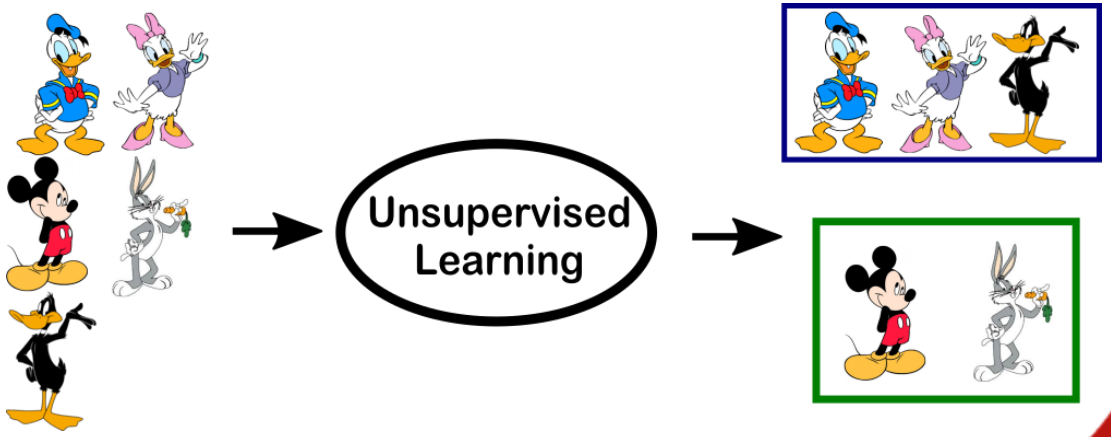


Supervised Learning Algorithms

Unsupervised Learning

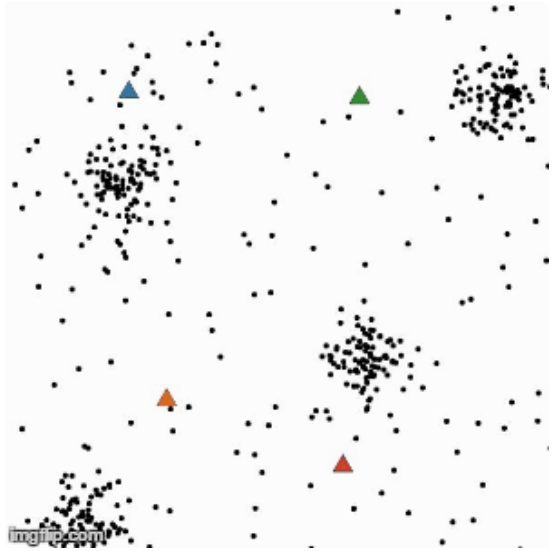
- Remember the function $y = f(x)$
- With unsupervised learning, only the input data, x, is available
- There are no corresponding labels (classes or categories) i.e. no output variable, y
- Aims at modelling the underlying structure of the data
- Two main categories:
  - Clustering
  - Association



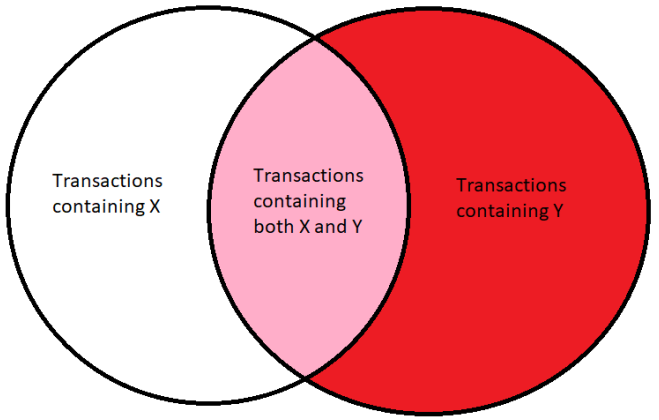


Clustering and Association

- In a clustering problem, we want to discover the inherent groupings in the data:
  - e.g. grouping customers by purchasing behaviour.

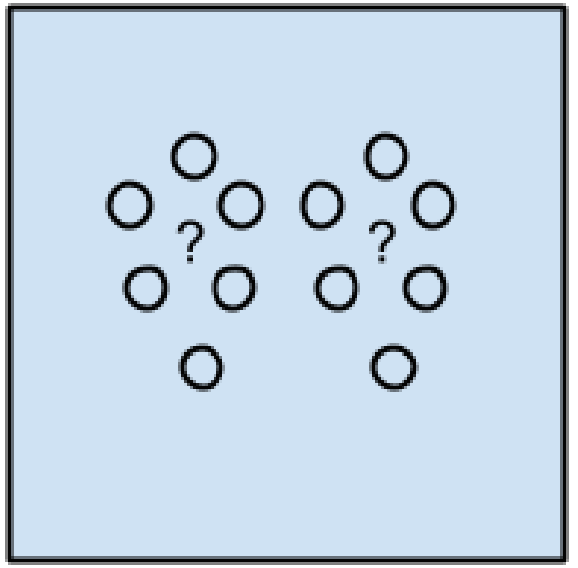


- In an association rule learning problem, we want to discover rules that describe large portions of your data
  - e.g. people that buy X also tend to buy Y



Unsupervised Learning Algorithms

- Input data is not labelled
  - Output not known
- In training
  - Deduces structures present in the input data
  - Extracting general rules, reducing redundancy or organise data by similarity
- Problem types: clustering, dimensionality reduction, and association rule learning
- Algorithms:
  - K-Means algorithm
  - Apriori algorithm.



Unsupervised Learning Algorithms

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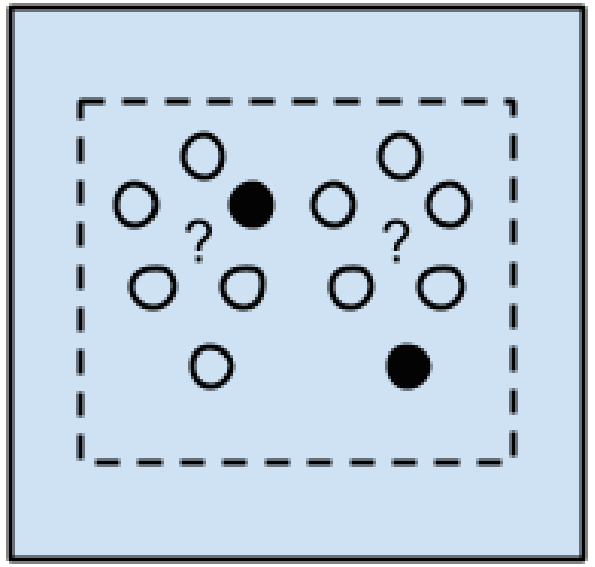
Semi-supervised Learning

- Semi-supervised learning approach refers to:
  - when we have a large amount of input data (X) but **only some** of the data is labelled (Y)
  - e.g. a photo archive where only some of the images are labelled (e.g. *dog, cat*), and the majority are unlabelled.
- Many real world problems adopt this method
  - It can be expensive or time-consuming to label data
  - A hybrid design often helps to bridge the gaps
- Algorithms:
  - A flexible combination of supervised and unsupervised algorithms



Semi-supervised Learning Algorithms

Machine Learning Summary

Today's Lecture

- Overview of Machine Learning
  - AI and ML, Definitions of ML, How to learn
- Types of Machine Learning
  - Supervised, unsupervised, semi-supervised
- Supervised Learning
  - Classification and regression
- Unsupervised Learning
  - Clustering and association