

Artificial Intelligence

&

Machine Learning

(Sir.Rameez Raja)

Intelligence

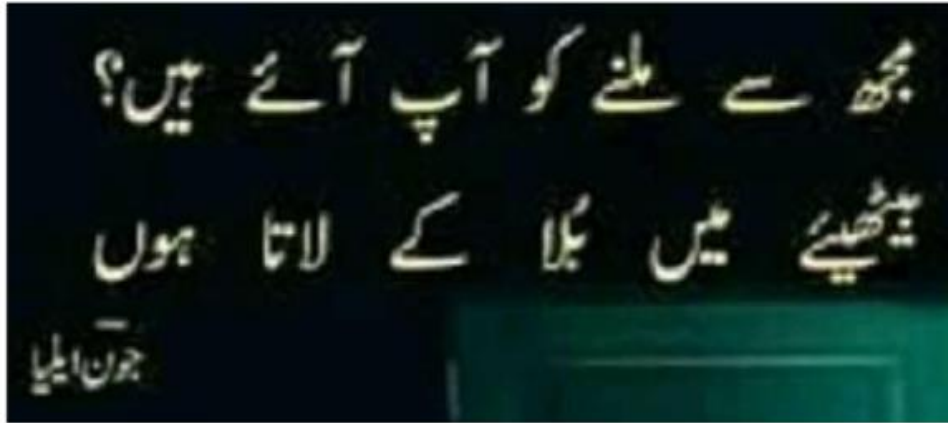
Moravec's paradox: The most difficult things to teach a computer are the ones that a two-year old has already learned – talking, listening, seeing, smelling, walking, grasping, memory and recall, thinking.



Intelligence

What is it?

Adult humans have uniquely human attributes – metaphor, poetry, satire, sarcasm.



Intelligence

What is it?

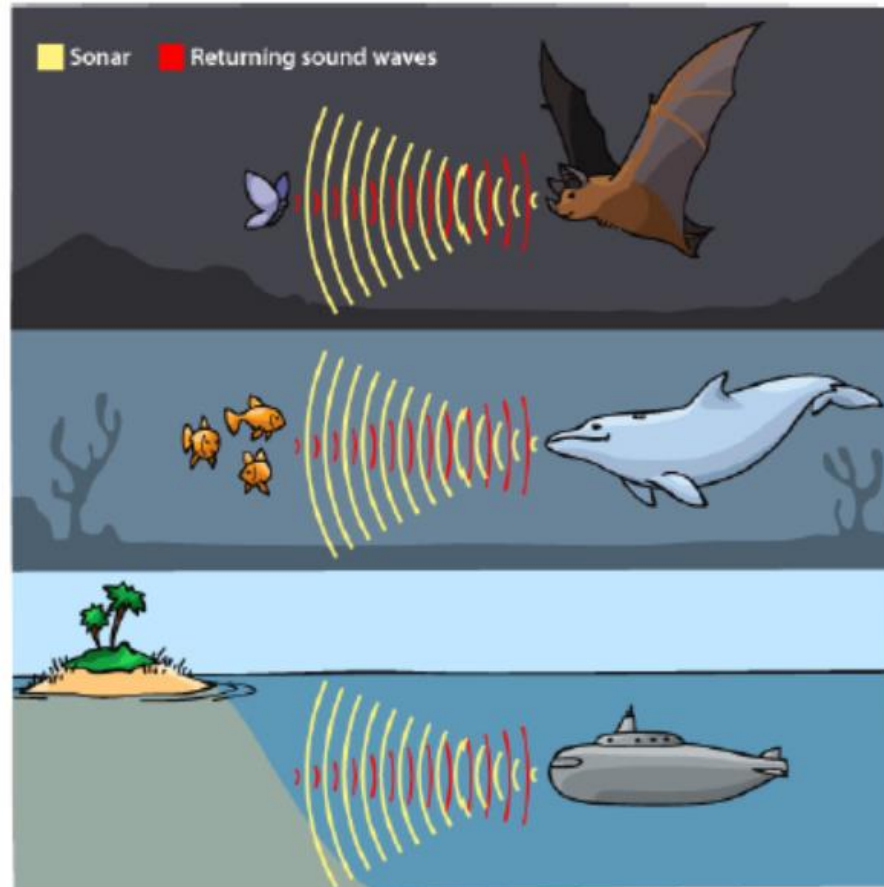
Birds can fly through very small holes at full-speed *while fighting each other*.



Intelligence

What is it?

In complete darkness, bats can locate, identify and catch their *flying* prey by sending, receiving and analysing sound waves.



The Brain

The ability of biological brains to sense, perceive, analyse and recognise patterns can only be described as stunning.

- ▶ They also have the ability to learn from new examples with or without being taught.
- ▶ Mankind's understanding of biological brains and how they operate exactly is embarrassingly limited.

The Brain

- ▶ We are clueless regarding the most fundamental questions.
 - ▶ What is intelligence?
 - ▶ Are you intelligent if you can't make a mistake?
 - ▶ Where in our brains does intelligence lie?
 - ▶ What is our brain?
 - ▶ Are our brains *just* computational devices or do they *do something more*?
 - ▶ What is consciousness?

The Brain

The average human brain has *about* **86 billion neurons** (or nerve cells) and **many more neuroglia** (or glial cells) which serve to support and protect the neurons [and *perhaps* even assist in their functionality]. Each neuron *may* be connected to *up to* **10,000 other neurons**, passing signals to each other via as many as **1,000 trillion synaptic connections**, equivalent *by some estimates* to a **computer with a 1 trillion bit per second processor**. Estimates of the human brain's memory capacity *vary wildly* from **1 to 1,000 terabytes** (for comparison, the 19 million volumes in the US Library of Congress represents about 10 terabytes of data).

Source: <https://human-memory.net/brain-neurons-synapses/>

- ▶ Claims about the brain are vague.
 - ▶ We know *something* about the brain, but we do not know *most* of the crucial functioning.
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So what is this course about?

- ▶ Modelling what we do not understand seems foolish.
- ▶ However, there do exist numerous *practical* techniques that give machines the *illusion of being intelligent*.
- ▶ This is the domain of artificial intelligence, pattern recognition, machine learning and deep learning.

So what is this course about?

- ▶ Instead of attempting to mimic the complex workings of a biological brain, this course
 - ▶ aims at explaining mathematically well-founded techniques for analysing patterns and learning from them, and is therefore
 - ▶ a *mathematically involved* introduction into the field of pattern recognition and machine learning.
- ▶ It will prepare you for further study/research in machine learning, computer vision, natural language processing and others areas attempting to solve AI type problems.

Prerequisites

- ▶ The course is designed to be self-contained.
- ▶ *Required mathematical details will be covered in the lectures.*
- ▶ However, this is a *math-heavy course*. Students are encouraged¹ to brush up on their knowledge of
 - ▶ Probability (Bernoulli, Binomial, Gaussian, Discrete, Continuous)
 - ▶ Calculus (Differentiation, Partial derivatives, Chain rule)
 - ▶ Linear Algebra (Vectors, Matrices, Dot-product, Orthogonality, Eigenvectors, SVD)
- ▶ This is also a *code-heavy* course. Be ready to become good at coding.

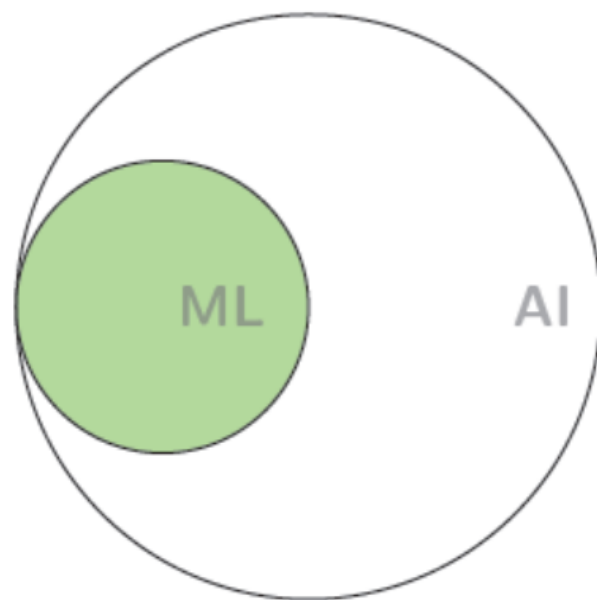
¹ordered

Programming Environment

We will be using

- ▶ Python
- ▶ PyTorch
- ▶ Google Colaboratory
- ▶ Jupyter notebooks

Machine Learning vs. Artificial Intelligence



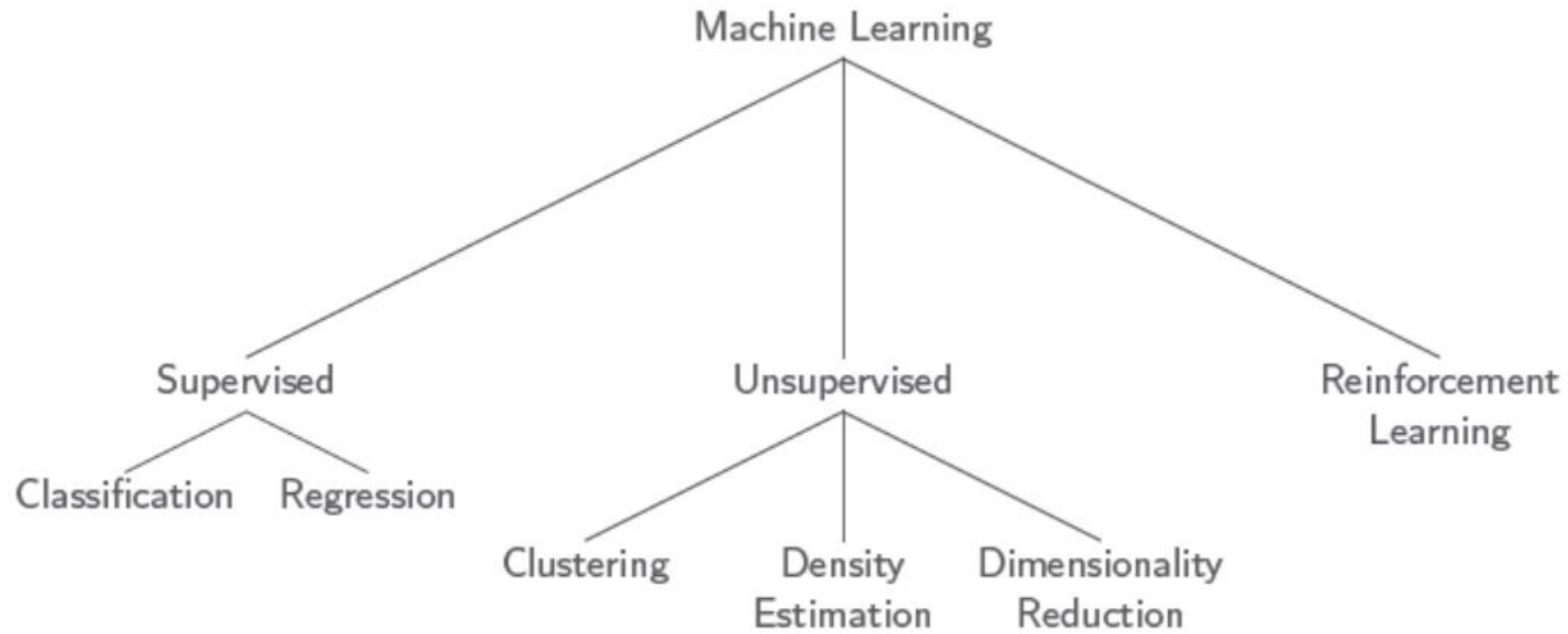
AI: software that solves problems by itself.

ML: algorithms and models that *learn* from processed data.

Introduction

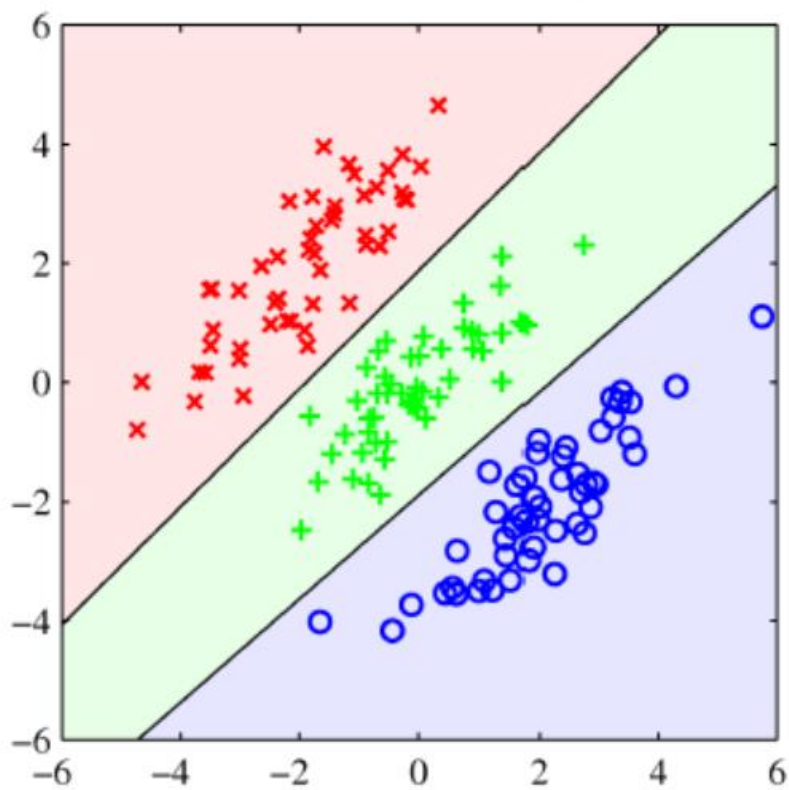
- ▶ Machine Learning is concerned with automatic discovery of regularities in data.
- ▶ Regularity implies order.
- ▶ Learning implies exploiting order to make predictions.

Machine Learning

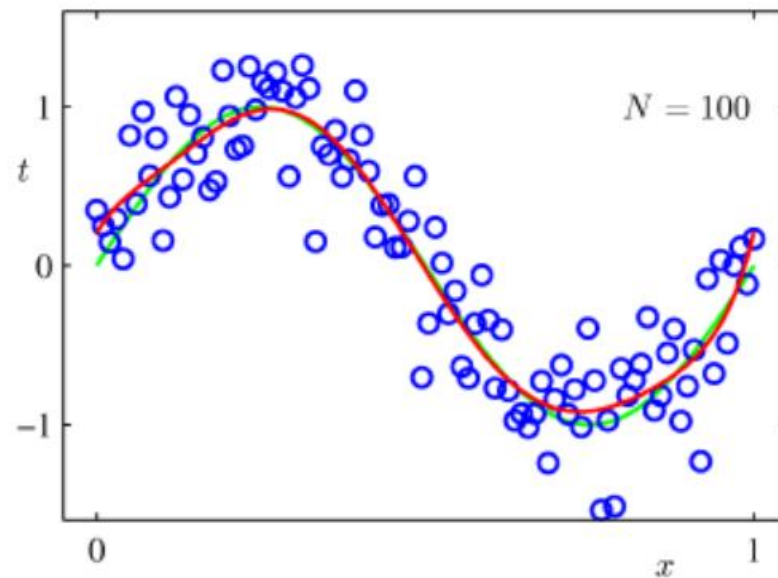


Supervised Learning

- ▶ **Classification:** Assign x to *discrete* categories.
 - ▶ Examples: Digit recognition, face recognition, etc..
- ▶ **Regression:** Find *continuous* values for x .
 - ▶ Examples: Price prediction, profit prediction.



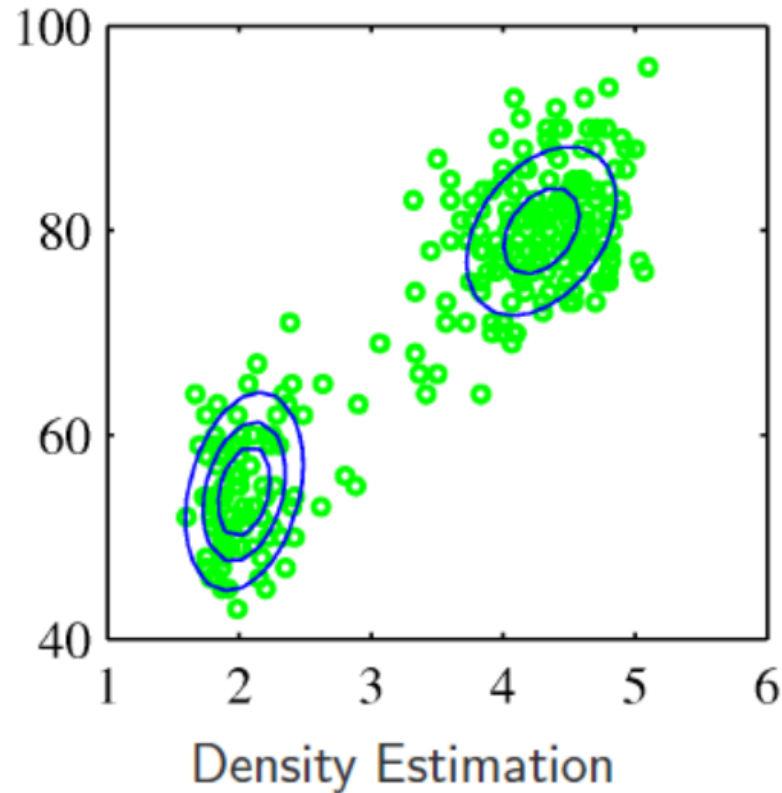
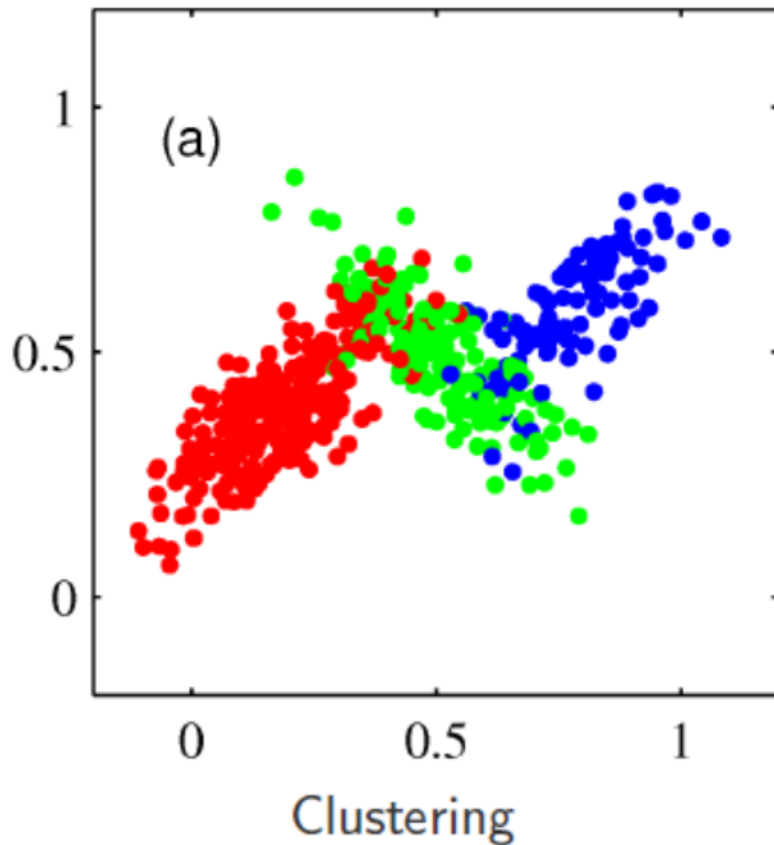
Classification



Regression

Unsupervised Learning

- ▶ **Clustering:** Discover groups of similar examples.
- ▶ **Density Estimation:** Determine probability distribution of data.
- ▶ **Dimensionality Reduction:** Map data to a lower dimensional space.



Reinforcement Learning

- ▶ Find actions that maximise a reward within an environment.



Figure: Based on the current state of the game (environment), each action of the player changes the state and yields a reward – points or death. The player learns to reinforce taking actions that lead to positive reward and not taking actions that lead to negative reward. Source: <https://www.freecodecamp.org/news/a-brief-introduction-to-reinforcement-learning-7799af5840db/>

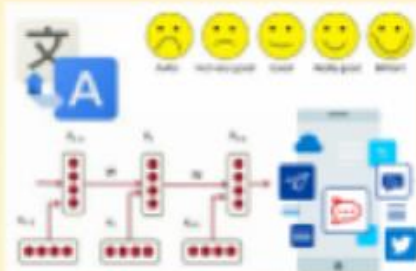
Applications of Machine Learning

Deep Learning-based Applications

Social Network Analysis



Natural Language Processing



Visual Data Processing



Speech and Audio Processing



Autonomous Driving

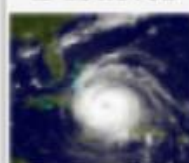


Computer Vision Multimedia Data Analysis

Biomedicine



Disaster



Speech Enhancement Speech Recognition

Information Retrieval



<https://doi.org/10.1145/3234150>