Artificial Intelligence

Over the decades, there have been MANY formal definitions available for AI.

Artificial intelligence (AI) is the intelligence of machines or software, as opposed to the intelligence of living beings, primarily of humans. It is a field of study in computer science that develops and studies intelligent machines.

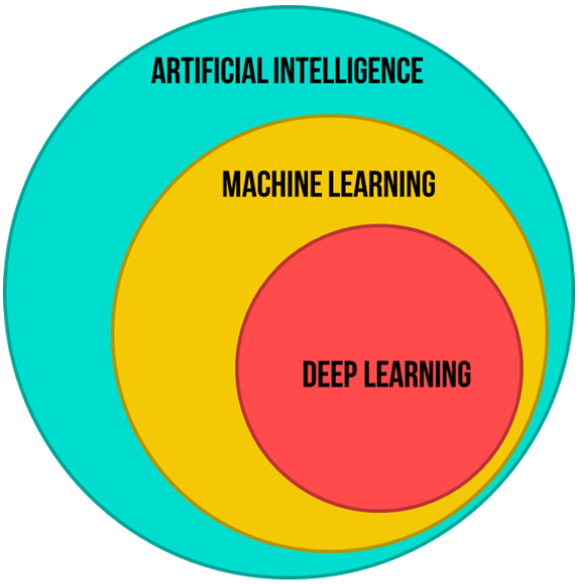
However, one of my favorite definitions is by François Chollet, creator of Keras, who defined it in simplistic terms. He described AI as “the effort to automate intellectual tasks normally performed by humans”.

Machine Learning

One of the pioneers of ML, Arthur Samuel, defined it as a “field of study that gives computers the ability to learn without being explicitly programmed”.

Deep Learning

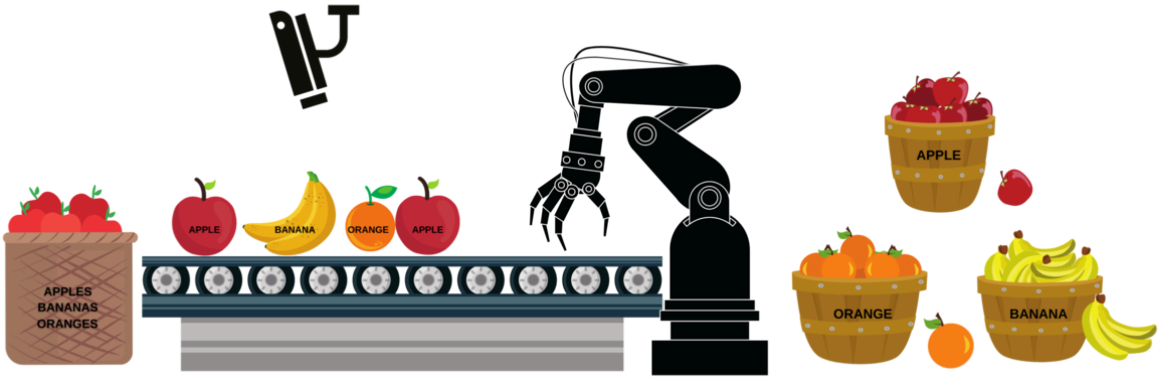
DL is ML taken to the next level. It is a subset of ML inspired by how human brains work. Typically, when people use the term deep learning, they refer to deep artificial neural networks. DL effectively teaches computers to do what humans naturally do: learning by example.



Let’s understand them with an example

Artificial Intelligence

An AI-based algorithm segregates the fruits using decision logic within a rule-based engine. For example, if an apple is on the conveyor belt, a scanner would scan the label, informing the AI algorithm that the fruit is indeed an apple. Then the apple would be routed to the apple fruit tray via sorting rollers/arms.



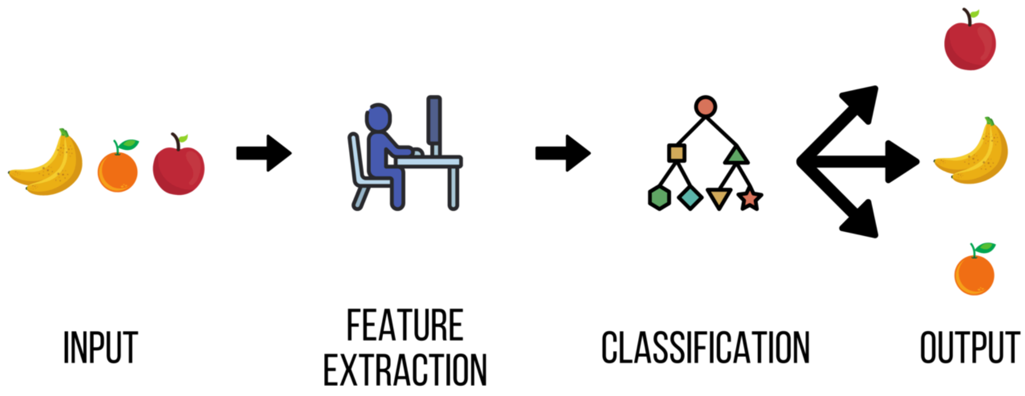
The success of the AI-based system hinges upon the fruit being correctly labeled by the fruit pickers and having a scanning system that can inform the algorithm of what the fruit is. Here, Mark utilizes an AI-based system to automate intellectual tasks generally performed by humans. As this system is based upon a rule-based engine that has been hard coded by humans, it is an example of AI without ML.

Problem??!!
With the increased throughput, the business has expanded, and the fruit supply is now coming from multiple sources where most of the fruits are not labeled. This has now provoked the need for a system to be more advanced.

Machine Learning

An ML-based algorithm is now proposed to solve the problem of fruit sorting by enhancing the AI-based approach when labels are not present.

To create a ML model, a definition of what each fruit looks like is required: this is termed feature extraction. To do this, features and attributes that characterise each fruit are used to create a blueprint. Features such as sizes, colours, shapes, etc., are extracted and used to train the algorithm to classify the fruits accordingly.



For example, once the ML algorithm has seen what a banana looks like many times, i.e., has been trained, when a new fruit is presented, it can then compare the attributes against the learned features to classify the fruit.

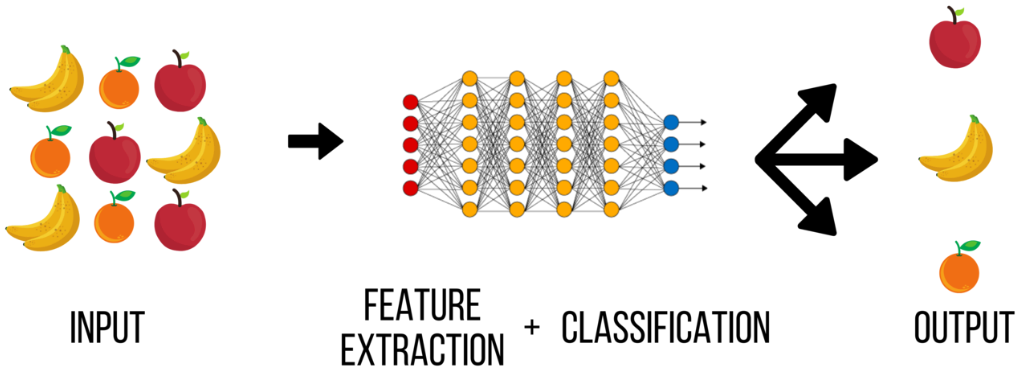
The algorithm provides a degree of confidence, which can then be used to determine whether the fruit is classified as a banana or not and routed on the conveyor belt accordingly. The system can now automatically classify fruits based on what it has learned.

Problem??!!
The business has been doing so well at improving the throughput of the sorting plant. It has cut costs and put local competitors out of business, taking over their fruit quota. It now needs to sort even more fruit, but this time fruit it has never seen before and with an added requirement of higher classification accuracy. This has provoked discussions around DL.

Deep Learning

A DL-based algorithm is now proposed to solve the problem of sorting any fruit by totally removing the need to define what each fruit looks like.

The main advantage of the DL model is that it does not necessarily need to be provided with features to classify the fruits correctly.



By providing the DL model with lots of images of the fruits, it will build up a pattern of what each fruit looks like. The images will be processed through different layers of neural network within the DL model. Then each network layer will define specific features of the images, like the shape of the fruits, size of the fruits, colour of the fruits, etc. A DL based model, however, comes at a considerable upfront cost of requiring significant computational power and vast amounts of data.

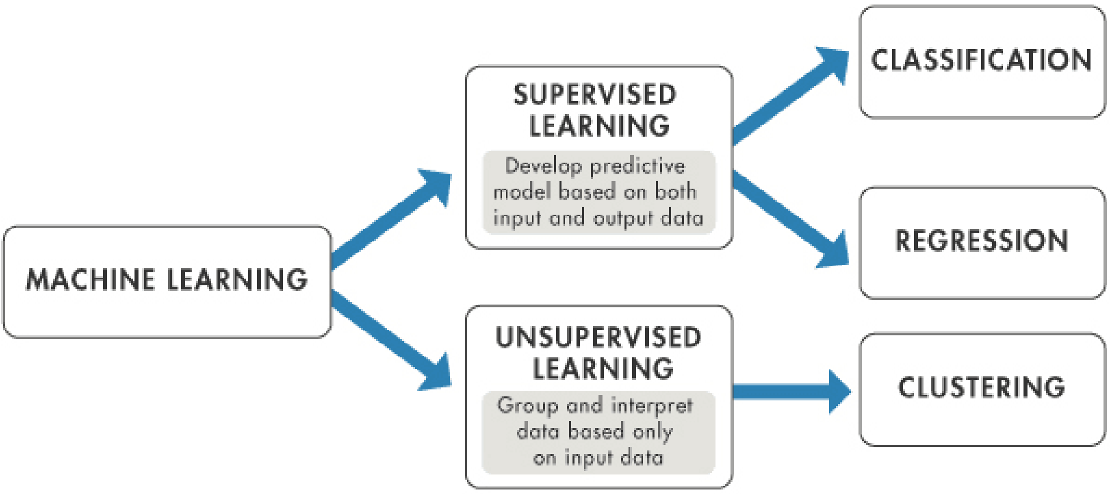
This is similar to how our brains work to classify objects. Our brains process data through many layers of neurons and then finds the appropriate identifiers to classify objects. In this example, the DL model will group the fruits into their respective fruit trays based on their statistical similarities.

Classification of Machine Learning

3 Types of Machine Learning You Should Know -

1. **Supervised Learning**
   The most common approach in ML. The model is <u>trained on a labeled dataset</u>. Or, the data is accompanied by a label that the model is trying to predict.
   The model learns a mapping between the input (features) and the output (label) during the training process. Once trained, the model can predict the output for new, unseen data. In practical terms, this could look like an image recognition process, wherein a dataset of images where each picture is labeled as "cat," "dog," etc., a supervised model can recognize and categorize new images accurately.

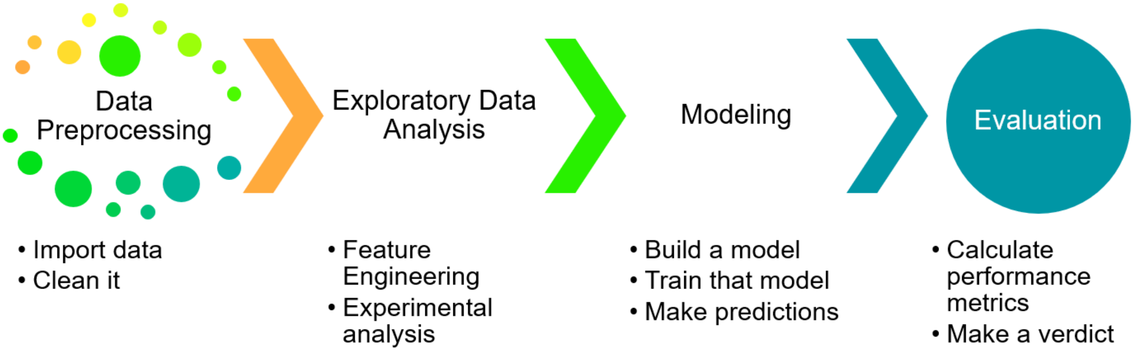
2. **Unsupervised learning**
   This model is <u>trained on an unlabeled dataset</u>. The model is left to find patterns and relationships in the data on its own. This type of learning is often used for clustering and dimensionality reduction. In the field of marketing, unsupervised learning is often used to segment a company's customer base. By examining purchasing patterns, demographic data, and other information, the algorithm can group customers into segments that exhibit similar behaviors without any pre-existing labels.

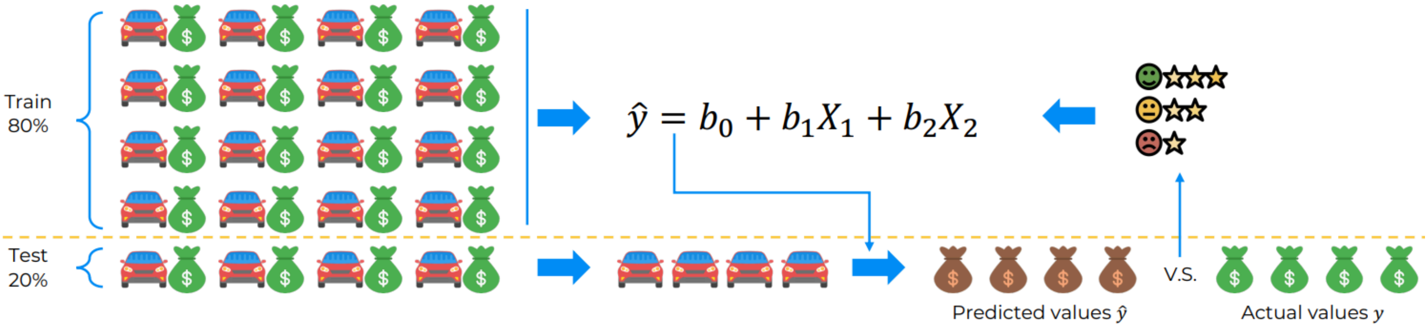


Comparison between Supervised and Unsupervised Learning

3. **Reinforcement learning**
   Here, the agent learns to make decisions by interacting with its environment. The agent is rewarded or penalized (with points) for the actions it takes, and its goal is to maximize the total reward. Unlike supervised and unsupervised learning, reinforcement learning is particularly suited to problems where the data is sequential, and the decisions made at each step can affect future outcomes. Common examples of reinforcement learning include game playing, **robotics**, resource management, and many more.

Machine Learning Process





Feature Scaling

Normalization	Standardization
$X' = \dfrac{X - X_{min}}{X_{max} - X_{min}}$	$X' = \dfrac{X - \mu}{\sigma}$
[0 ; 1]	[-3 ; +3]

Machine Learning Algorithms

Regression

1. Simple Linear Regression

$$\underbrace{\hat{y}}_{\text{Dependent variable}} = \underbrace{b_0}_{\text{y-intercept (constant)}} + \underbrace{b_1}_{\text{Slope coefficient}} \underbrace{X_1}_{\text{Independent variable}}$$

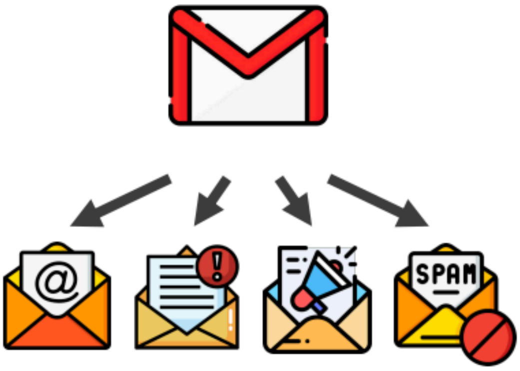
2. Multiple Linear Regression

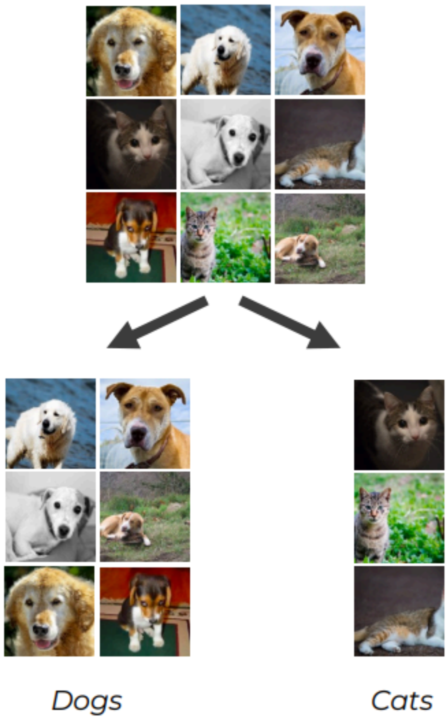
$$\underbrace{\hat{y}}_{\text{Dependent variable}} = \underbrace{b_0}_{\substack{\text{y-intercept} \\ \text{(constant)}}} + \underbrace{b_1}_{\text{Slope coefficient 1}} \underbrace{X_1}_{\text{Independent variable 1}} + \underbrace{b_2}_{\text{Slope coefficient 2}} \underbrace{X_2}_{\text{Independent variable 2}} + \cdots + \underbrace{b_n}_{\text{Slope coefficient n}} \underbrace{X_n}_{\text{Independent variable}}$$

3. Polynomial Regression

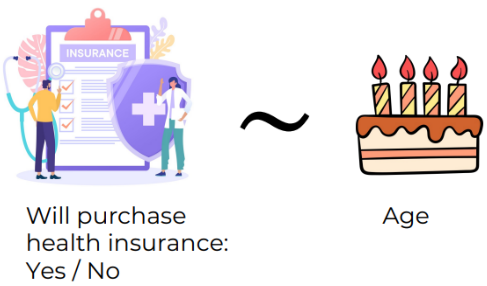
$$y = b_0 + b_1 x_1 + b_2 x_1^2 + \ldots + b_n x_1^n$$

Classification

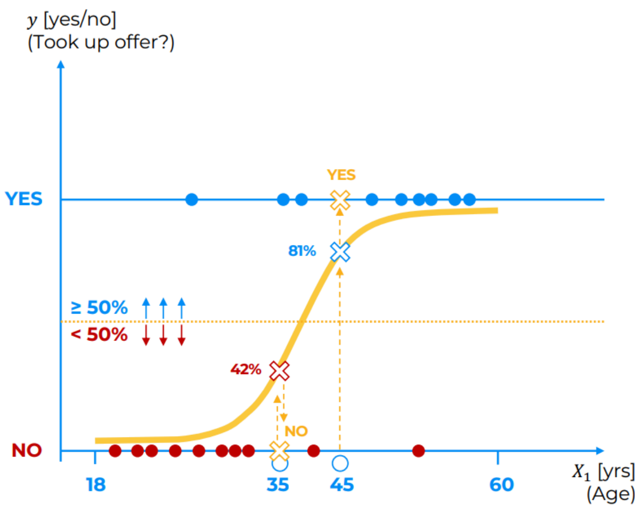




1. Logistic Regression

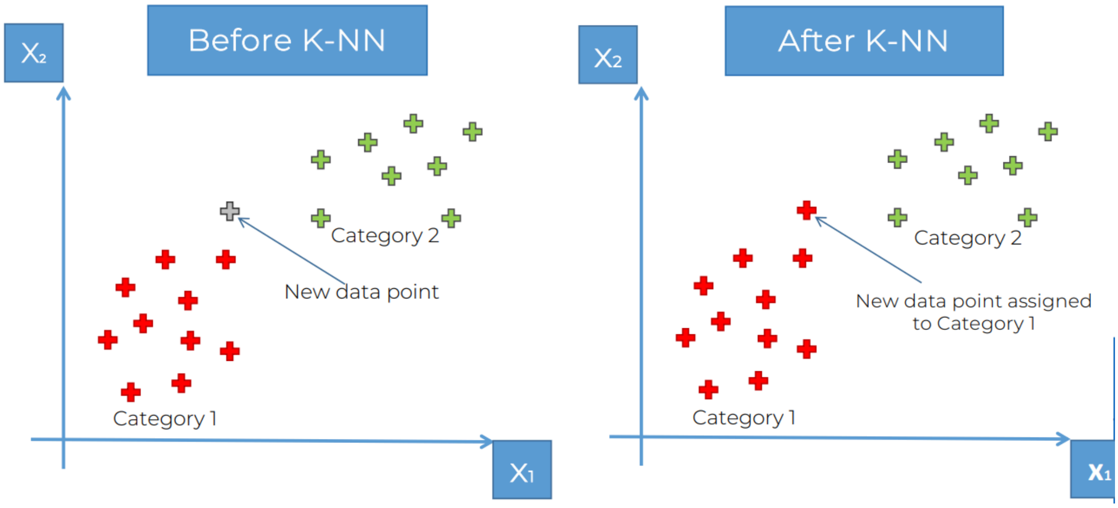


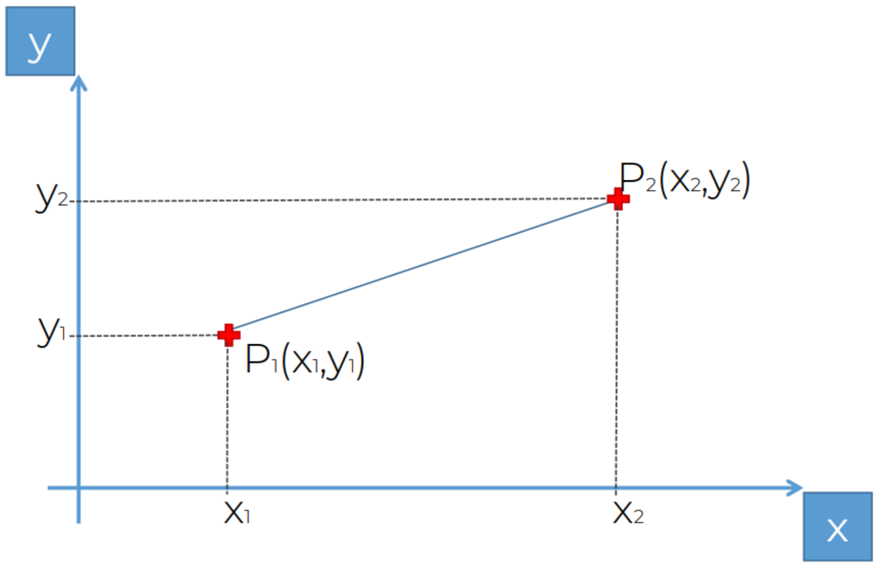
$$\ln \frac{p}{1-p} = b_0 + \ b_1 X_1$$



predict a categorical dependent variable from a number of independent variables.

2. K-NN





$$\text{Euclidean Distance between } P_1 \text{ and } P_2 = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$