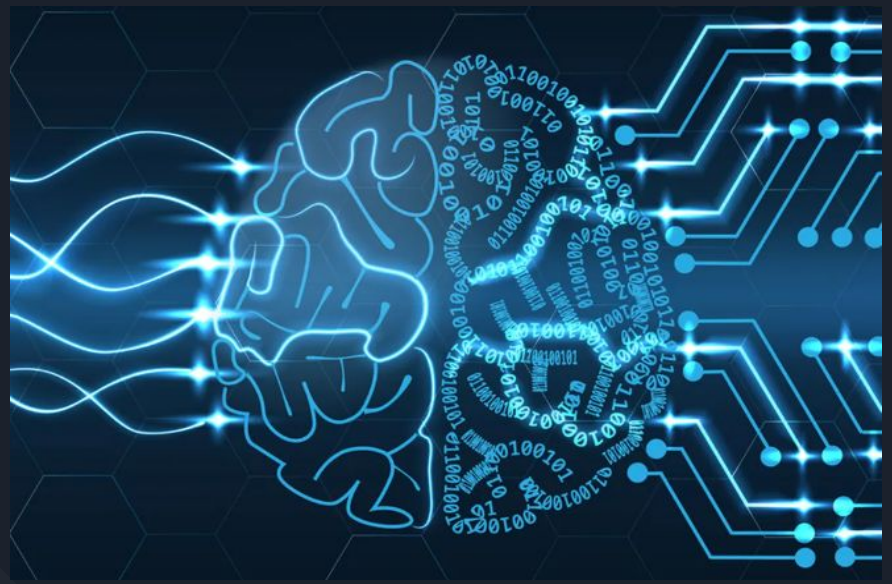
INTRO TO DEEP LEARNING

Analytics Club IITM

COMPUTER VISION AND INTELLIGENCE GROUP

ANALYTICS + CVI presents

INDIAN INSTITUTE OF TECHNOLOGY MADRAS · लिद्धिर्भवति कर्मजा ·



SUMMER SCHOOL

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- PRESENTED BY RUTHWIK CHIVUKULA

Table of Contents

Artificial Intelligence vs Machine Learning vs Deep Learning

Let us first try to understand the difference between the most popular Buzzwords in today's tech world- AI, ML and Deep Learning.

Artificial Intelligence is a branch of computer science that deals with the wide range of capabilities of algorithms and techniques to simulate human intelligence.

For example, AI can be simply a combination of several if-else statements. An if-else statement is a simple rule which explains how a human mind thinks.

```
if something_is_in_the_way is True:
    stop_moving()
else:
    continue_moving()
```

- Now in order to develop such a model which can imitate the human brain, we can have several approaches or methods to do it. One such method is Machine Learning.

- Machine Learning is all about the algorithms that deal with computers mimicking humans and how these algorithms get better and better as they are exposed to more datasets.

- The training part of machine learning model involves optimizing a certain parameter which is generally the error between prediction and actual value.

- Few traditional machine learning methods - decision trees, SVM, Naive Bayes Classifier, Logistic regression.

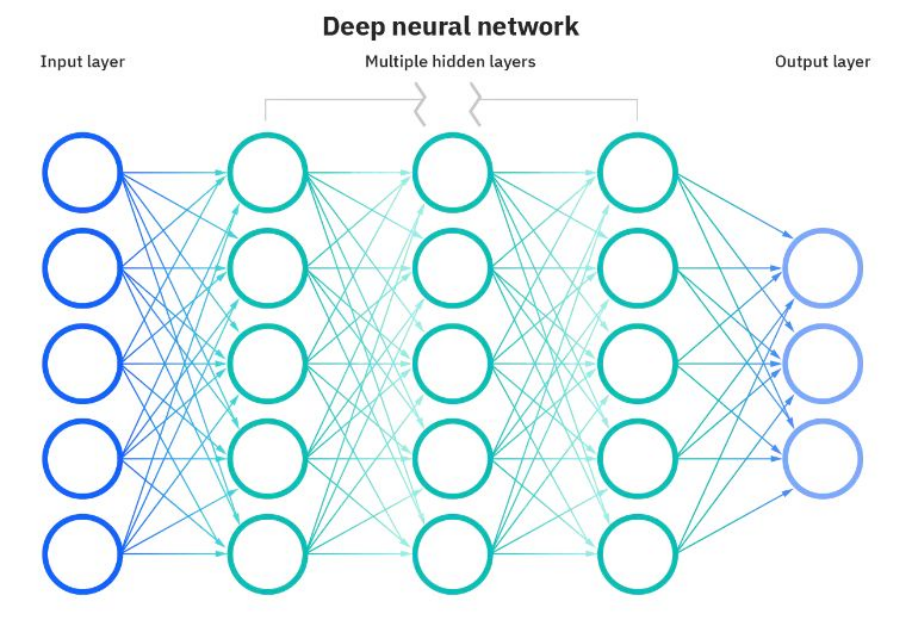
- Machine learning is a pretty old field and incorporates algorithms which has been is existence since the 60s.

- Deep Learning, a subfield of Machine Learning is a very young field of AI which works on artificial neural networks.

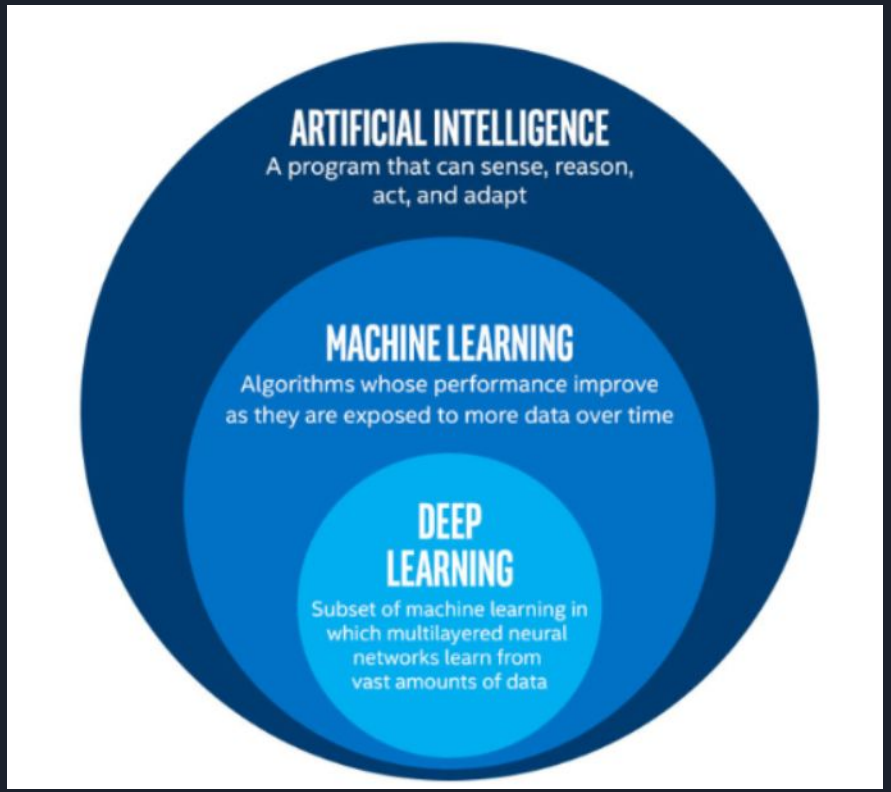
- Artificial neural networks involves use of multi-layered structure of algorithms which enables it to solve tasks that machine learning model could never have solved.

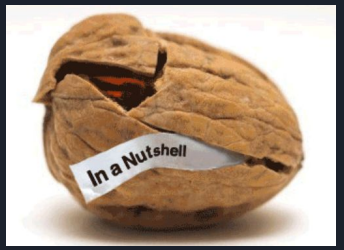
- Self-driving cars, voice assistants like Alexa and Siri, chat boxes all these are a product of deep learning.

THIS IS HOW A NEURAL NETWORK LOOKS LIKE



EVERYTHING THAT WE DISCUSSED TILL NOW IN A NUTSHELL





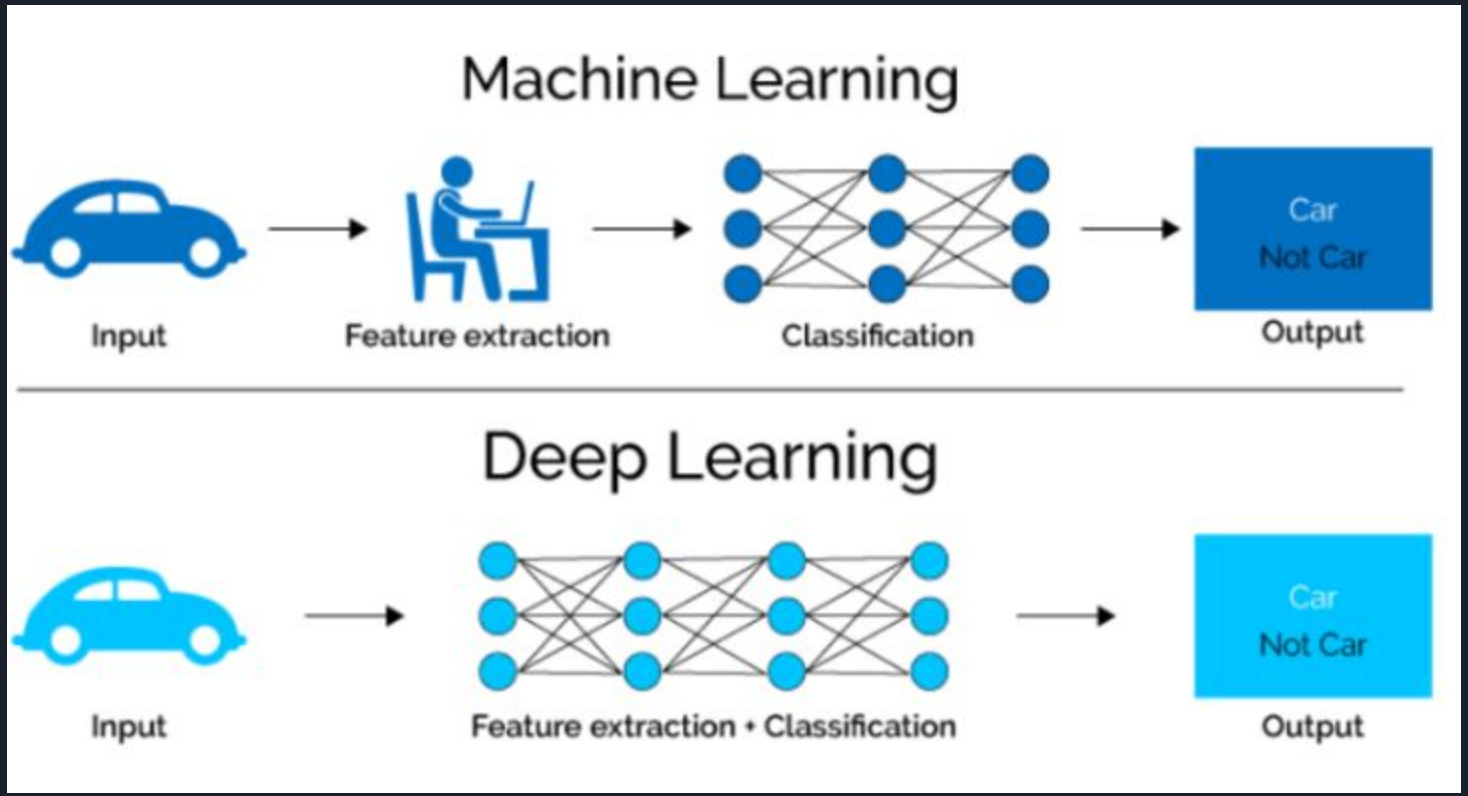
WHY DEEP LEARNING?

Deep learning vs Machine learning

- Deep learning is the new hot topic, which is evolving rapidly as it is more user friendly. Long before deep learning was used, traditional machine learning methods were popular, such as Decision Trees, SVM, Naïve Bayes Classifier and Logistic Regression.

- These algorithms are also called “flat algorithms”. Flat means here that these algorithms can not normally be applied directly to the raw data (such as .csv, images, text, etc.). We require a preprocessing step called Feature Extraction.

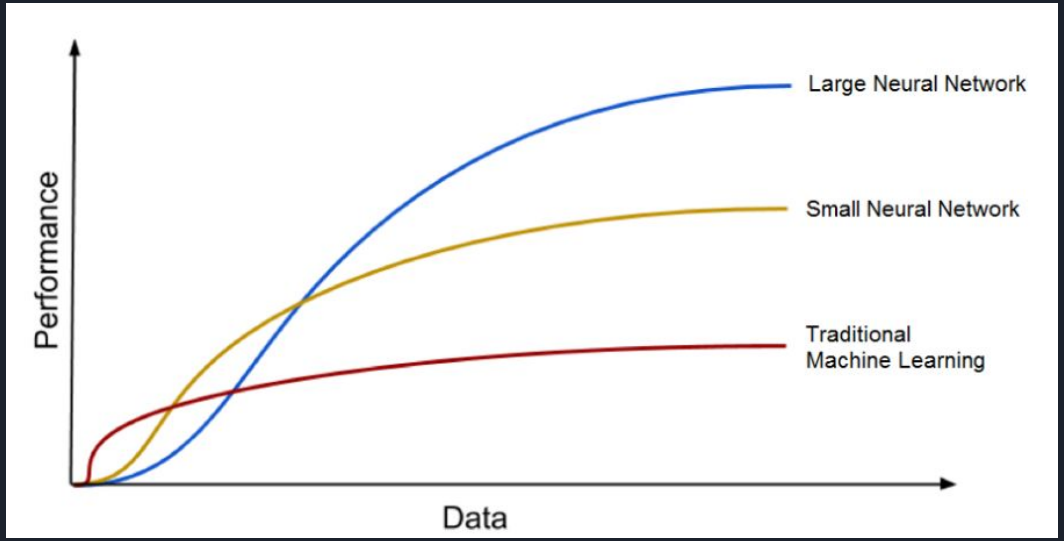
- But this is not the case with deep learning where the artificial neural networks can learn implicit representation of the raw data on their own.This means that the models of deep learning thus require little to no manual effort to perform and optimize the feature extraction process.


Machine Learning
Input
Feature extraction
Classification
Car
Not Car
Output
Deep Learning
Input
Feature extraction + Classification
Car
Not Car
Output

The era of big data

“ The analogy to deep learning is that the rocket engine is the deep learning models and the fuel is the huge amounts of data we can feed to these algorithms. “

Deep Learning models tend to increase their accuracy with the increasing amount of training data, where’s traditional machine learning models such as SVM and Naive Bayes classifier stop improving after a saturation point.

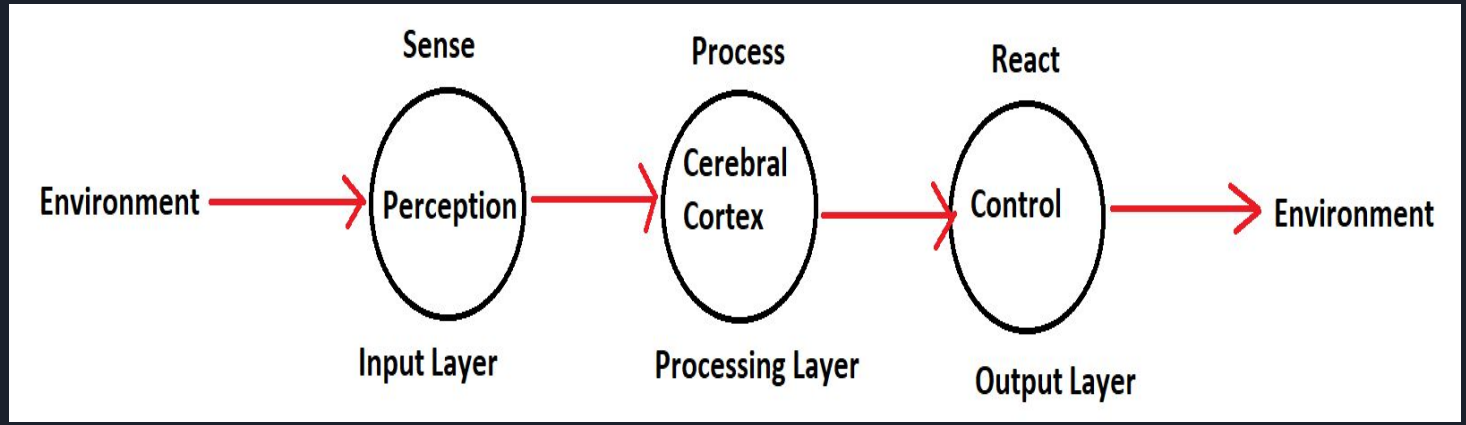


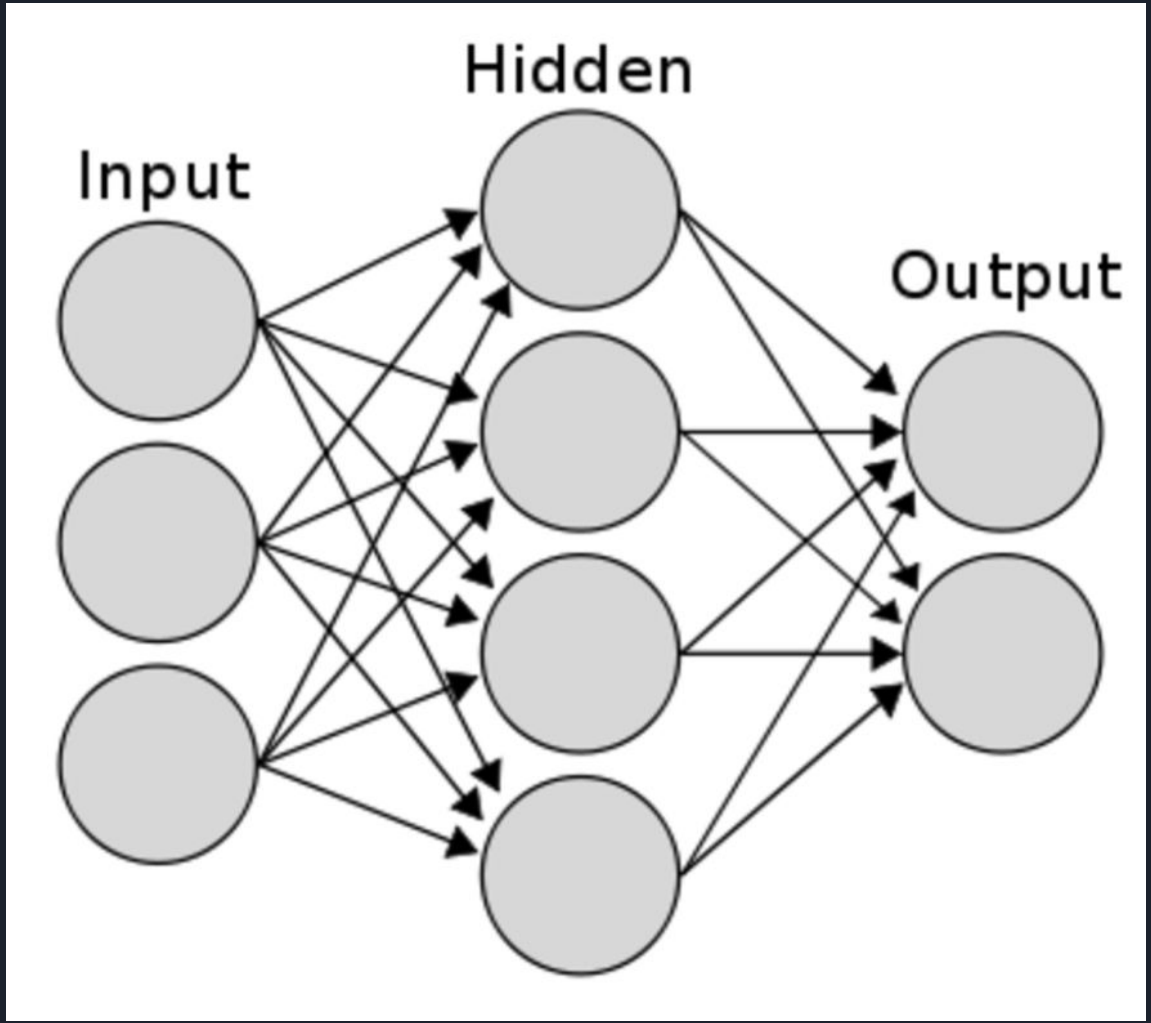
Neural Networks

- Neural networks also known as Artificial neural networks (ANNs) are at the heart of deep learning algorithms. Their name and structure is inspired by the human brain, mimicking the way that biological neurons send signals to one another.

- The term deep in Deep learning refers to the depth of the hidden layers in these artificial neural networks which clearly indicates how important ANNs are.

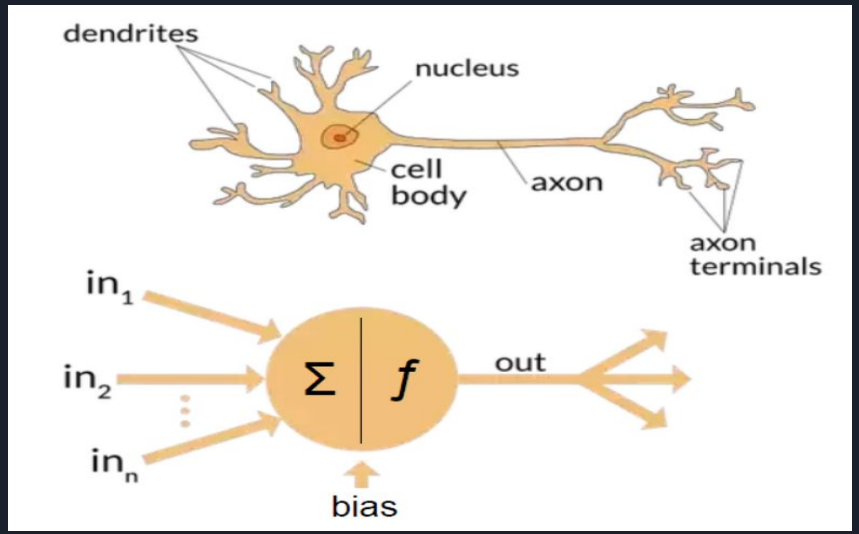
Layered architecture of a simple brain




Hidden
Input
Output

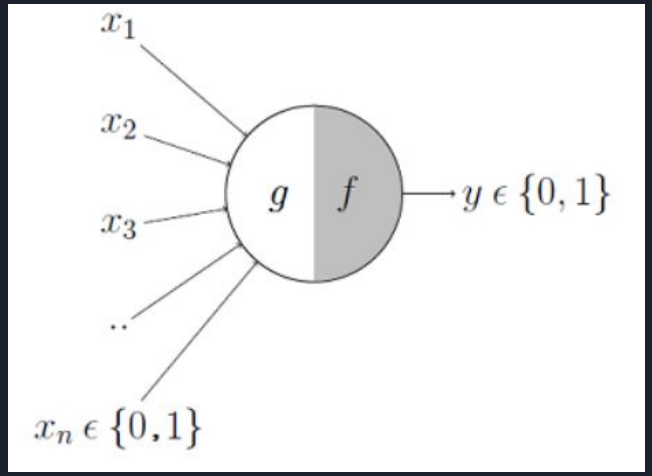
- Here we can notice some similarities between neural networks and biological neurons. Though there are differences in the ways they function, there are also some noticeable resemblances.

- ‘F’ in the diagram denotes the activation function which has been inspired from biological neurons.Research shows that dendrites themselves apply a nonlinear function on the input before it is passed to the nucleus. We will be discussing about activation function in greater detail in a while.



McCulloch-Pitts Neuron- Mankind's first neural network

- The first computational model of a neuron was proposed by Warren McCulloch (neuroscientist) and Walter Pitts (logician) in 1943.
- It may be divided into 2 parts. The first part, g takes an input (ahem dendrite ahem), performs an aggregation and based on the aggregated value the second part, f makes a decision.
- theta here is called thresholding parameter. If g is greater than the thresholding parameter then f return 1 else it returns 0. This is called the Thresholding Logic.



$$g(x_1, x_2, x_3, ..., x_n) = g(\mathbf{x}) = \sum_{i=1}^{n} x_i$$

$$y = f(g(\mathbf{x})) = 1 \quad if \quad g(\mathbf{x}) \geq \theta$$
$$= 0 \quad if \quad g(\mathbf{x}) < \theta$$

Let us try to understand this better with the help of an example.

Assume there is an IPL match in the evening and you have to decide whether you want to watch it or not based on the McCulloh Pitts neuron.

Inputs are : (if Yes then input is 1 else input is 0)

- x_1 is tomorrow a Sunday ?
- x_2 is the match RCB vs CSK ? (Kohli vs Dhoni xD)
- x_3 can all friends watch the match together ?

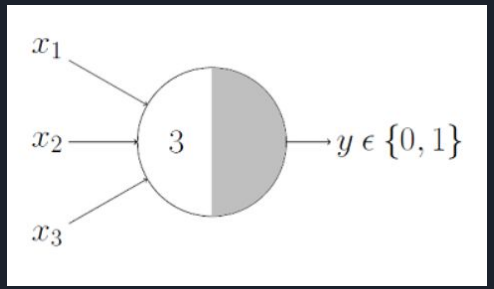
And let us set our thresholding parameter as 2.

So if x_1 + x_2 + x_3 >= 2 then output is 1 otherwise output is 0. If output is 1 then you will watch the match and if output is zero, you won't.

Boolean Functions Using M-P Neuron

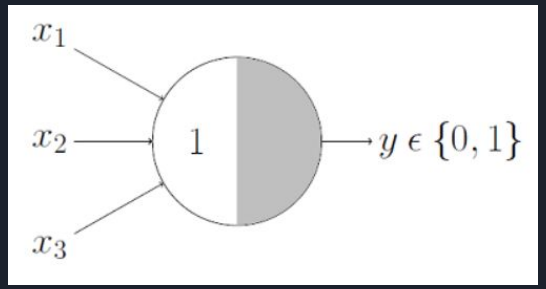
Since the inputs as well as the outputs are boolean values (either 0 or 1), M-P Neurons can represent Boolean Functions. This can be done by setting appropriate thresholding parameters.

AND function



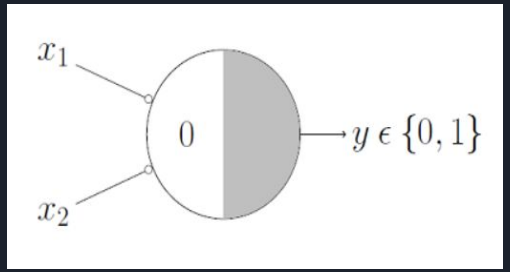
g(x) >=3

OR function



g(x) >=1

NOR function



g(x) = 0

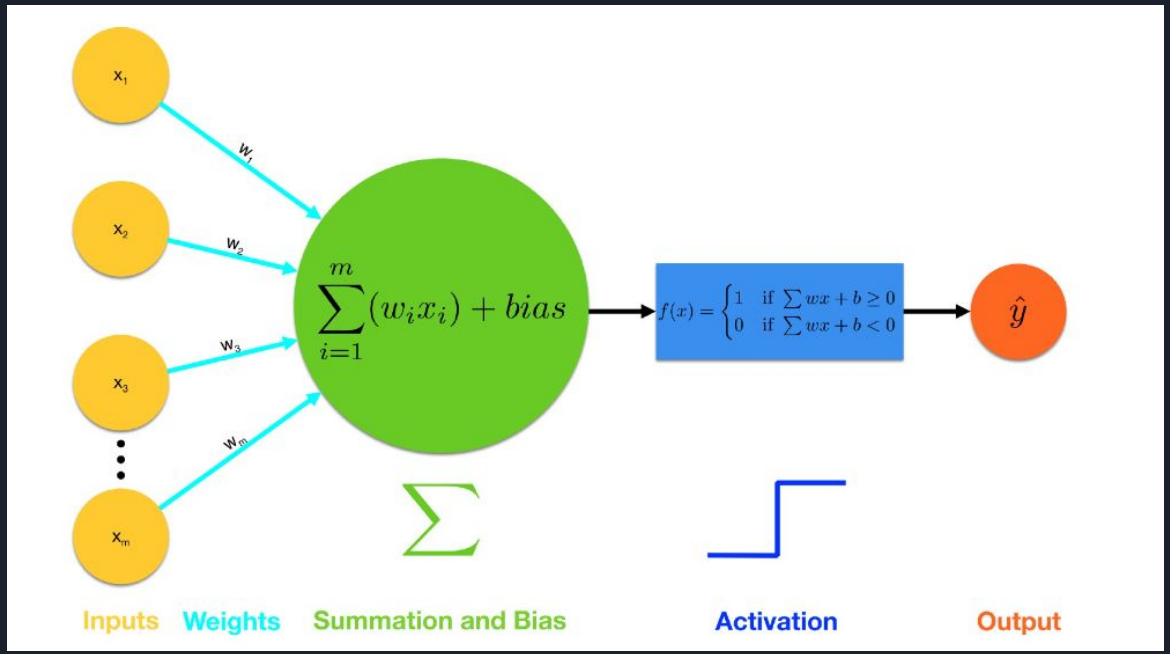
In a similar fashion, the other boolean functions can also be defined by choosing the right thresholding parameters.

Limitations Of M-P Neuron

- What about non-boolean (say, real) inputs?
- Do we always need to hand code the threshold?
- Are all inputs equal? What if we want to assign more importance to some inputs?

PERCEPTRONS

- In 1958, Frank Rosenblatt, an American psychologist, attempted to build “a machine which senses, recognizes, remembers, and responds like the human mind” and called the machine a Perceptron.
- Perceptrons resolved one of the major drawbacks which was faced by M-P Neurons that is are all inputs equally important ?



We can also write the perceptron function in the following terms:

$$f(x) \begin{cases} 1 & \text{if } w.x + b \geq 0 \\ 0 & \text{if } w.x + b < 0 \end{cases}$$

bias = - threshold

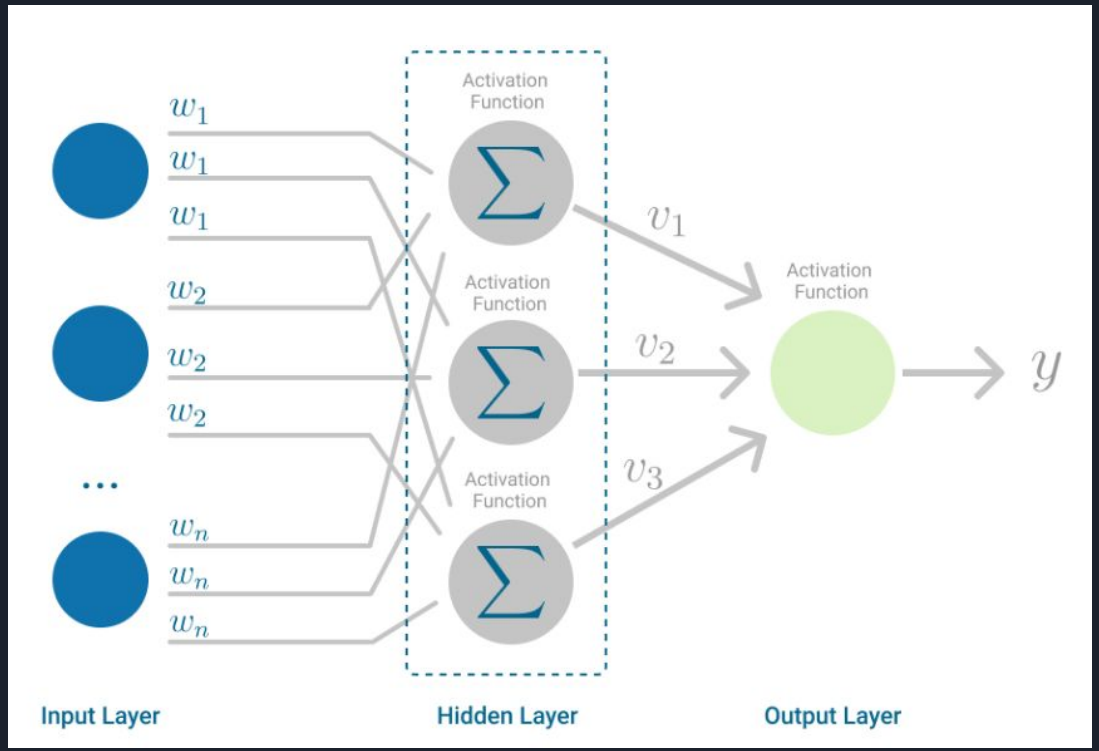
$w.x = \sum_j w_j x_j$

The perceptron follows these steps:

- Multiply all the inputs by their weights w, real numbers that express how important the corresponding inputs are to the output
- Bias term is added to this weighted sum. Weights deal with scaling the inputs and bias deal with shifting the input.
- Add them together referred as weighted sum: ∑ wj xj
- Apply the activation function (step function)

The major drawback here is the activation function which is a basic step function. We have much more sophisticated activation functions like sigmoid function and tanh function. These modifications have been done in the modern neural networks.

This is how a multi layer perceptron(MLP) looks like.



MODERN DAY NEURAL NETWORK