UNIT-4

Agenda

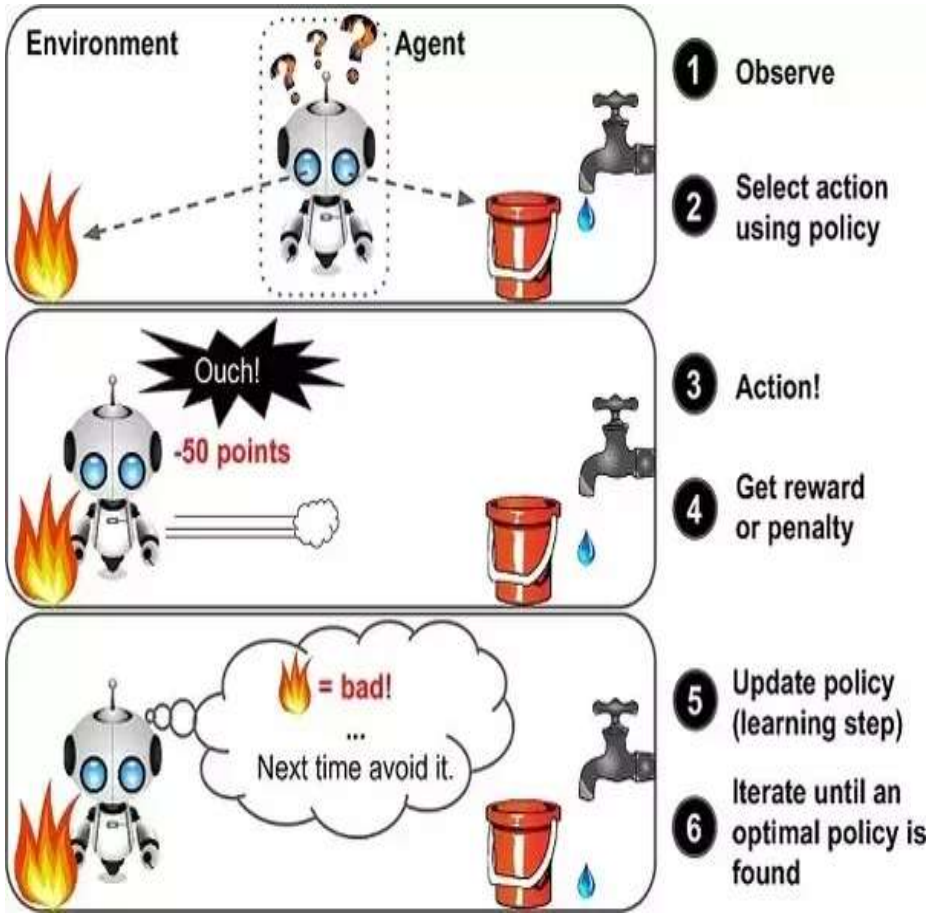
Introduction to

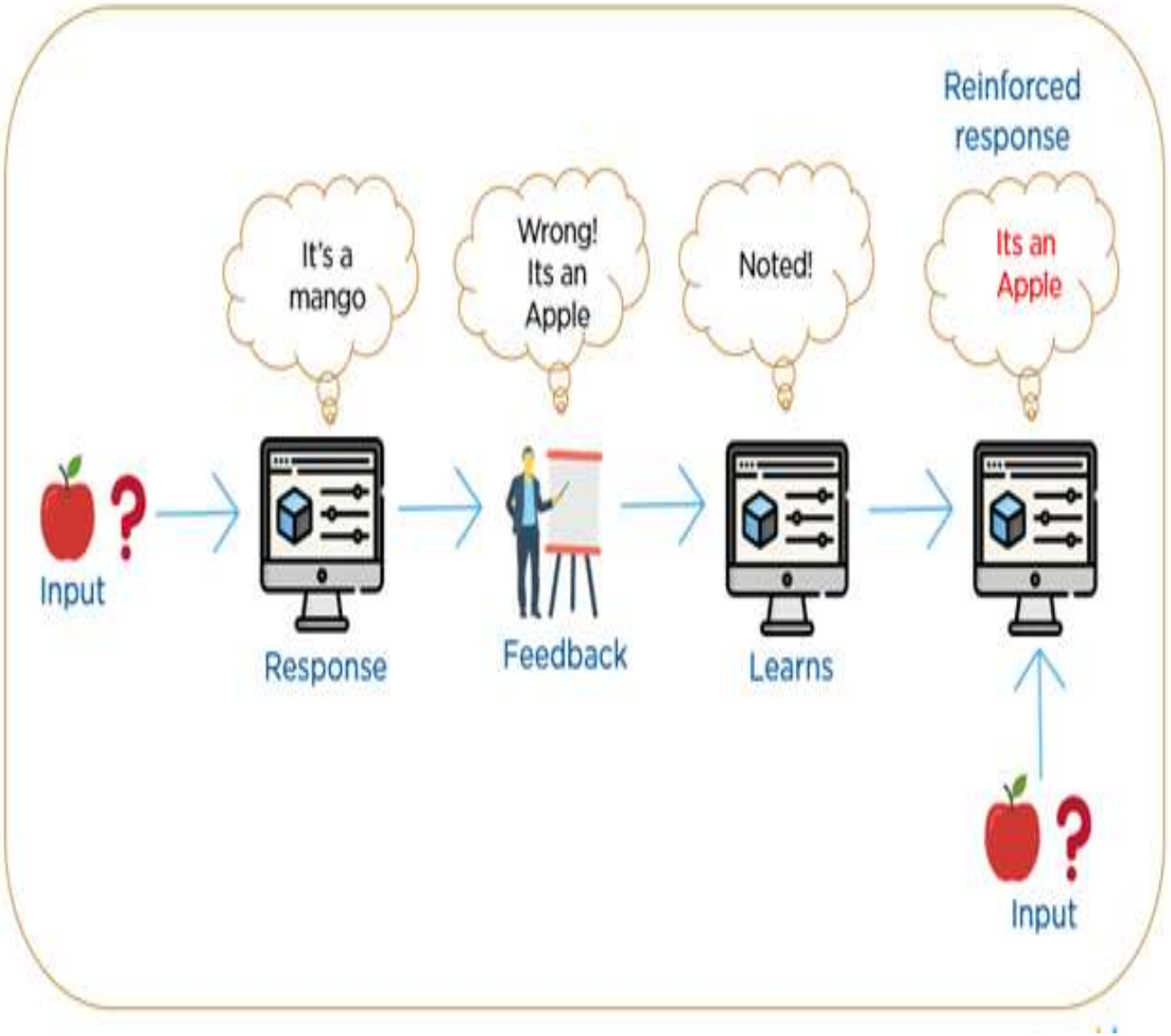
- Reinforcement Learning
- Neural Networks
- Deep Learning

Reinforcement Learning

- A reinforcement learning algorithm, or agent, learns by interacting with its environment.
- The agent receives rewards by performing correctly and penalties for performing incorrectly. The agent learns without intervention from a human by maximizing its reward and minimizing its penalty.
- It is a type of dynamic programming that trains algorithms using a system of reward and punishment.

- Given example, we can see that the agent is given 2 options i.e. a path with water or a path with fire.
- A reinforcement algorithm works on reward a system i.e. if the agent uses the fire path then the rewards are subtracted and agent tries to learn that it should avoid the fire path.
- If it had chosen the water path or the safe path then some points would have been added to the reward points, the agent then would try to learn what path is safe and what path isn't.





Reinforcement Learning

Introduction to Reinforcement Learning

- An approach to Artificial Intelligence
- Learning from interaction
- Goal-oriented learning
- Learning while interacting with an external environment
- Learning what to do—how to map situations to actions—so as to maximize a numerical reward signal

- Definition of RL:

  Reinforcement learning (RL) is a type of ML which is all about taking suitable action to maximize reward in a particular situation. It is employed by various software and machines to find the best possible behavior or path it should take in a specific situation.

- RL is useful to establish or encourage a pattern of behavior

Key Features

- Learner not aware which actions to take
- Trial-and-Error search
- Possibility of delayed reward – Sacrifice short-term gains for greater long-term gains
- Considers the whole problem of a goal-directed agent interacting with an uncertain environment

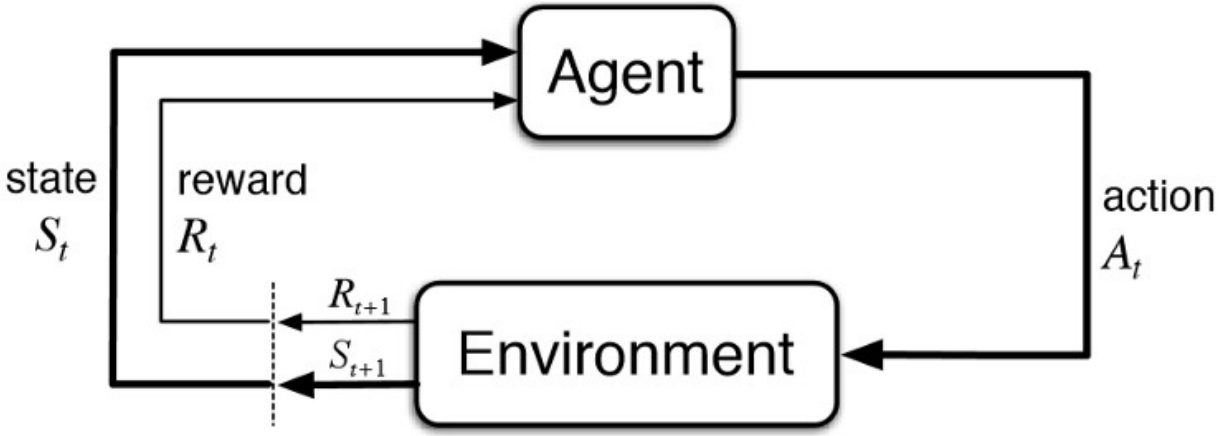
- A kid learning to walk (Figure) is an example of reinforcement learning.
  - The kid will get the reward as encouragement from parents and failure as the falling of the kid.
  - By learning from the failure and rewards, the kid will learn to walk.

Counter Strike Example

1. The RL Agent (Player1) collects state S^0 from the environment
2. Based on the state S^0, the RL agent takes an action A^0, initially the action is random
3. The environment is now in a new state S^1
4. RL agent now gets a reward R^1 from the environment
5. The RL loop goes on until the RL agent is dead or reaches the destination

Basic concepts of RL

- A Reinforcement learning setup is composed of 2 main components, an agent and an environment.



How do RL work?

- A basic reinforcement learning involves these steps:
  - Observation of the environment
  - Deciding how to act using some strategy
  - Acting accordingly
  - Receiving a reward or penalty
  - Learning from the experiences and refining our strategy
  - Iterate until an optimal strategy is found

- **Google's Deep Mind in AlphaGo**
  - AlphaGo is a computer program that plays the board game Go.
  - It was developed by DeepMind Technologies which was later acquired by Google.
  - AlphaGo versus Lee Sedol, also known as the Google DeepMind Challenge Match, was a five-game Go match between 18-time world champion Lee Sedol and AlphaGo, a computer Go program developed by Google DeepMind, played in Seoul, South Korea between the 9th and 15th of March 2016.
  - It is able to do this by using a novel form of **reinforcement learning**, in which AlphaGo Zero becomes its own teacher.

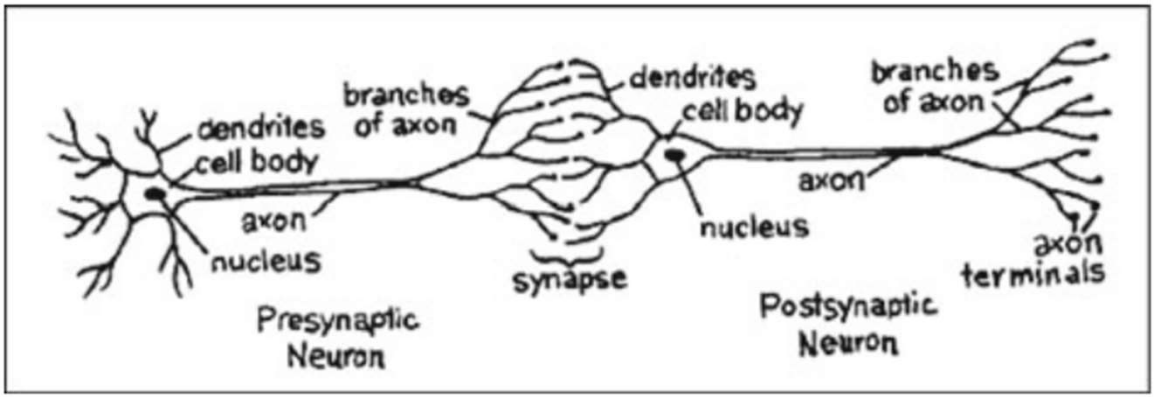
Challenges with RL

- The main challenge in reinforcement learning lies in preparing the simulation environment, which is highly dependent on the task to be performed.
- When the model has to go superhuman in Chess and Go game etc., preparing the simulation environment is relatively simple.
- When it comes to building a model capable of driving an autonomous car, building a realistic simulator is crucial before letting the car ride on the street.
  - The model has to figure out how to brake or avoid a collision in a safe environment
  - Transferring the model out of the training environment and into the real world is where things get tricky.

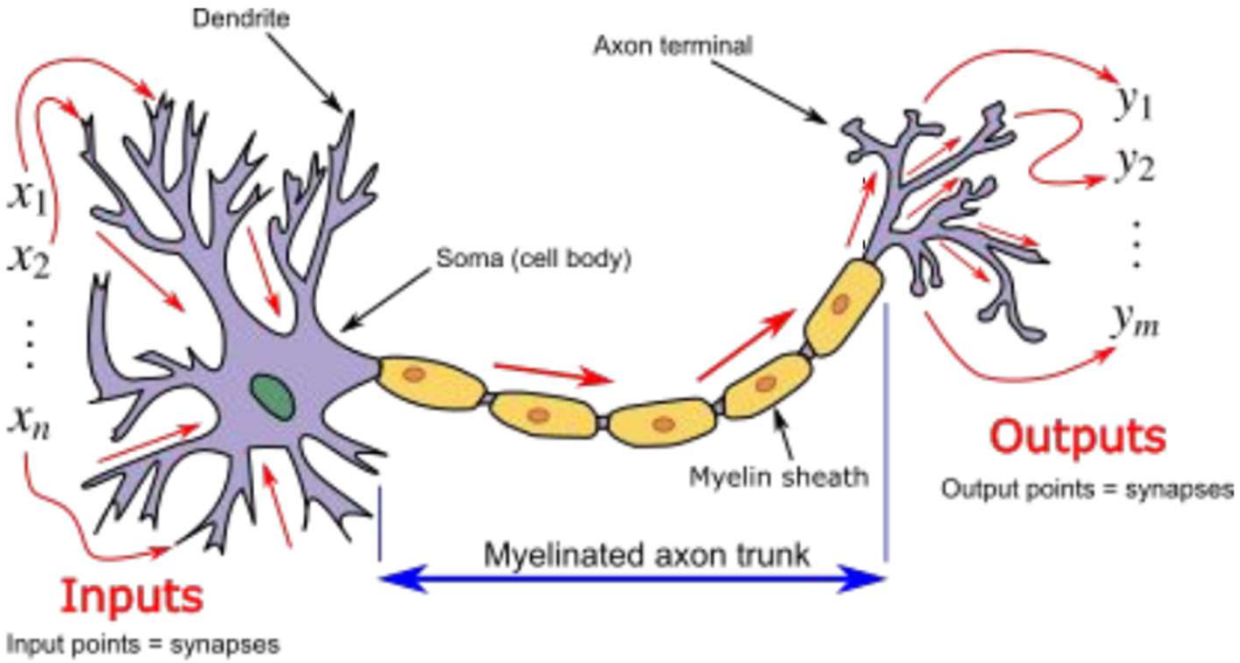
Neural Networks

- Neural Networks (NNs) are a class of artificial intelligence algorithms that are modeled after the structure and functioning of the human brain
- **Artificial neural network (**ANN) is a network of **artificial neurons** which are conceptually derived from biological neurons.
    - Each artificial neuron has inputs and produces a single output which can be sent to multiple other neurons.
- **ANNs** usually simply called **neural networks** (**NNs**) or, more simply yet, **neural nets**, are computing systems inspired by the biological neural networks that constitute human brain
- They are designed to learn from data and can be used for a variety of tasks, such as classification, regression, and prediction.
- A neural network is composed of a large number of interconnected processing units, known as neurons, which work together to process information.
- Each neuron receives input from other neurons, processes that input, and then produces output that is sent to other neurons.

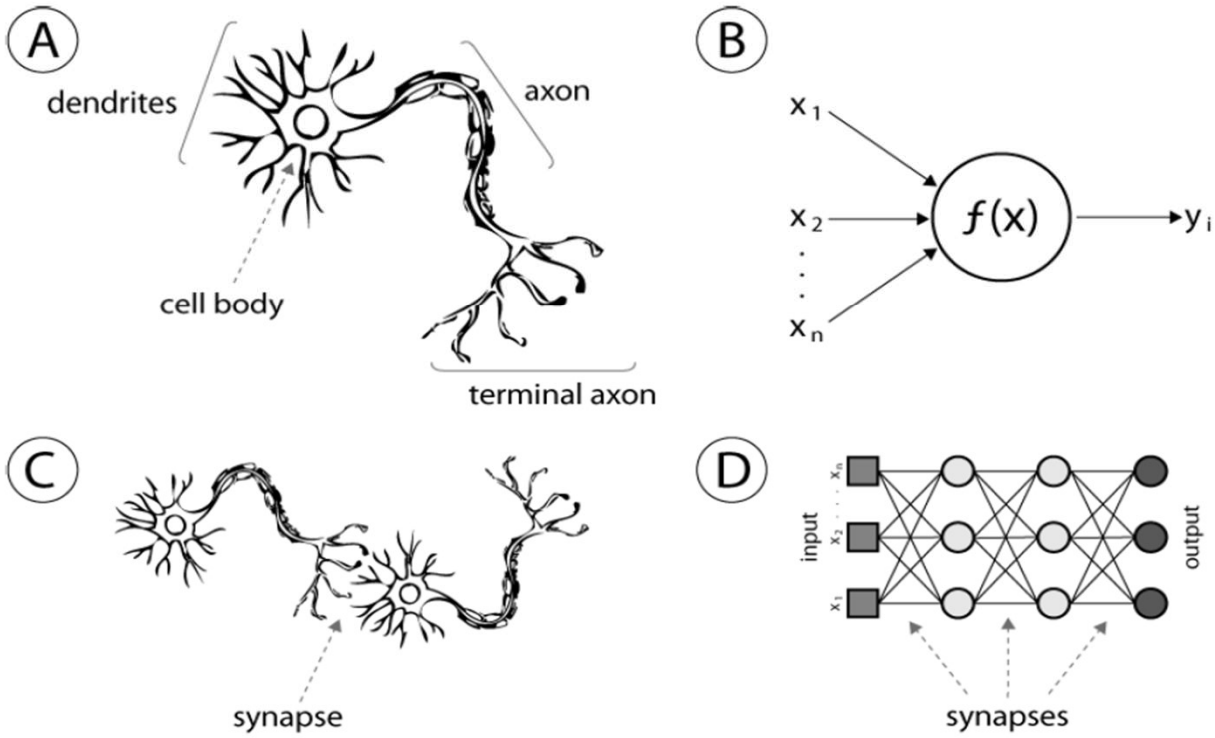
Neuron (in Brain)



Biological neural network



Neurons and the brain



The Basic Architecture of Neural Networks

Single Layer Network:

In the single layer network, a set of inputs is directly mapped to an output by using a generalized variation of a linear function. This simple instantiation of a neural network is also referred to as the **perceptron**.

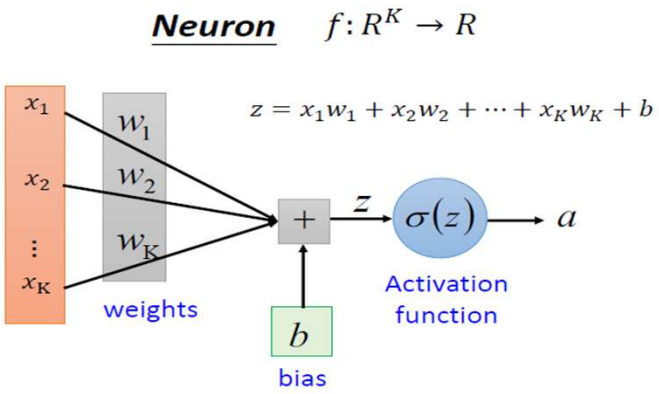
Multi Layer Network:

In multi-layer neural networks, the neurons are arranged in layered fashion, in which the input and output layers are separated by a group of hidden layers. This layer-wise architecture of the neural network is also referred to as a **feed-forward network.**

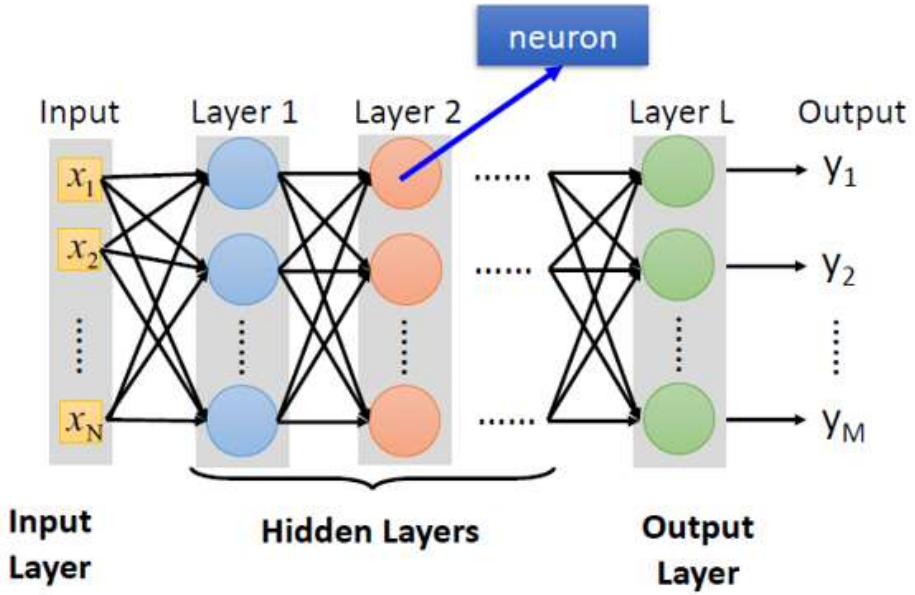
Single Layer Network:Perceptron

- The simplest neural network is referred to as the perceptron.
- This neural network contains a single input layer and an output node.

Example of Perceptron



Multilayer neural network



Neural Networks

- The strength of the connections between neurons, known as weights
- Training
  - the weights are adjusted during the learning process allowing the neural network to learn from data and improve its performance over time.
  - involves feeding the neural network with a large dataset and adjusting the weights to minimize the error between the predicted output and the actual output.

Types of Neural Networks

- feedforward neural networks
  - Feedforward neural networks (FFNN) are a type of artificial neural network where the information flows in only one direction from input to output.
  - FFNNs consist of layers of interconnected neurons, where each neuron in a layer is connected to every neuron in the previous layer.
- recurrent neural networks
  - Recurrent Neural Networks (RNNs) are a type of neural network architecture that can process sequential data, such as time series or natural language.
  - Unlike FFNNs, which process input data in a fixed and linear order, RNNs have loops in their architecture that allow them to maintain an internal memory or hidden state" that can capture information from previous inputs.

Neural Networks Applications

- Neural networks have been used in a wide range of applications
  - image and speech recognition
  - natural language processing
  - game playing.
  - They have also been used to solve complex problems in fields such as
    - finance
    - Healthcare and
    - manufacturing

Deep Learning

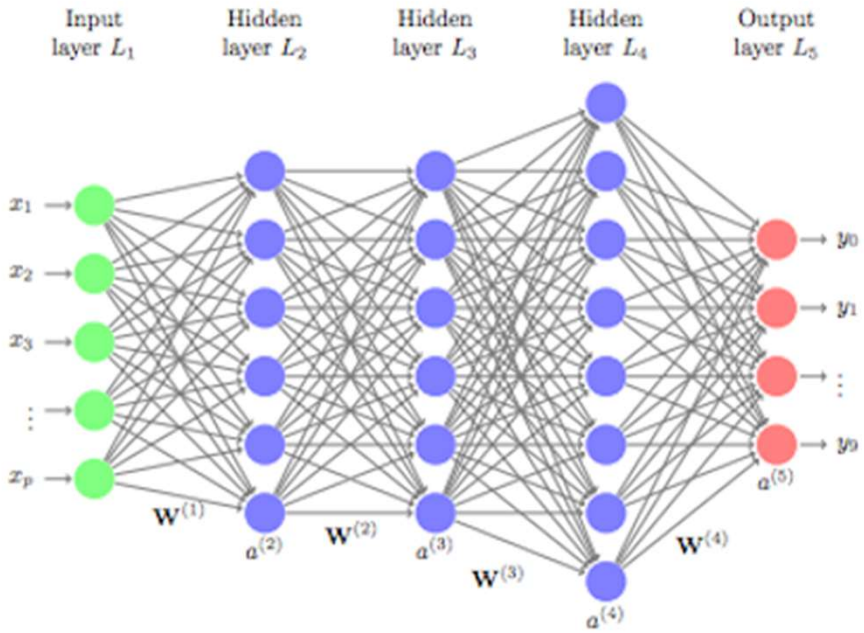
- Deep learning is a subset of machine learning
  - uses artificial neural networks with multiple layers to model and solve complex problems.
- The neural networks used in deep learning are inspired by the structure and function of the human brain
  - where each layer of neurons processes a different aspect of the input data and passes the output to the next layer.

Deep Learning

- Deep learning is a branch of machine learning which is completely based on artificial neural networks, as neural network is going to mimic the human brain so deep learning is also a kind of mimic of human brain.
- In deep learning, we don't need to explicitly program everything.
- It's on hype nowadays because earlier we did not have that much processing power and a lot of data.
- As in the last 20 years, the processing power increases exponentially, deep learning and machine learning came in the picture.
- A formal definition of deep learning is- neurons

"Deep learning is a particular kind of machine learning that achieves great power and flexibility by learning to represent the world as a nested hierarchy of concepts, with each concept defined in relation to simpler concepts, and more abstract representations computed in terms of less abstract ones".

Deep neural network

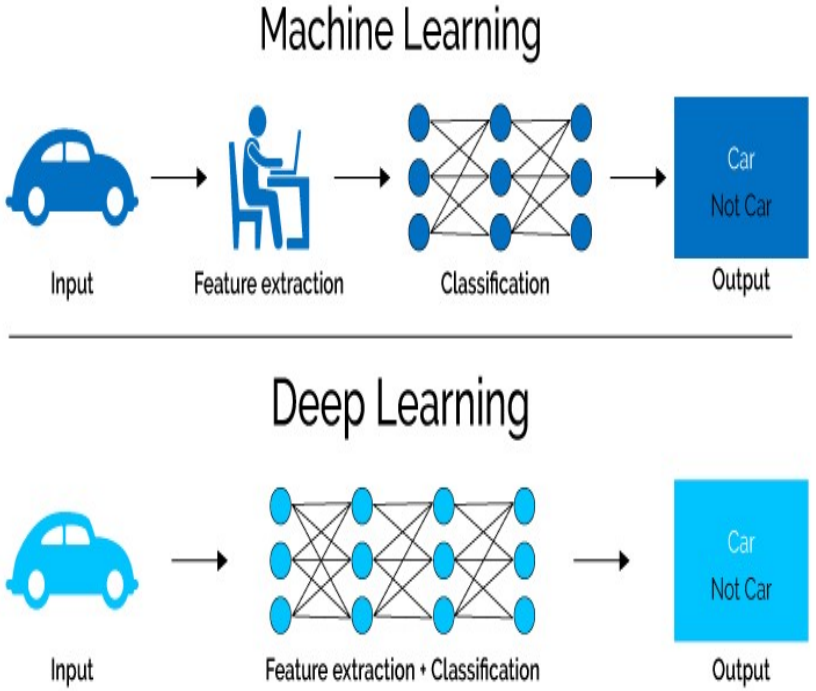


Types of Deep Neural Networks

- convolutional neural networks
  - Convolutional Neural Networks (CNNs) are a type of deep neural network that is commonly used for image and video analysis, natural language processing, and speech recognition.
  - CNNs are inspired by the organization of the visual cortex in the human brain, and they are designed to automatically learn and extract features from input data.
  - information from previous inputs.

Architectures:

- **Deep Neural Network** – It is a neural network with a certain level of complexity (having multiple hidden layers in between input and output layers).
- They are capable of modelling and processing non-linear relationships.



Deep Learning Applicatons

- Deep learning has been used successfully in a wide range of applications,
  - image and speech recognition
  - natural language processing
  - autonomous vehicles
  - drug discovery.

  Deep learning models are trained on large datasets using backpropagation which adjusts the weights of the network to minimize the difference between the predicted output and the true output.
- Some popular deep learning frameworks
  - TensorFlow, PyTorch, and Keras.
  - These frameworks provide a high-level interface for building and training deep learning models and are used by researchers and practitioners around the world.

Advantages:

- *Best in-class performance on problems.*
- *Reduces need for feature engineering.*
- *Eliminates unnecessary costs.*
- *Identifies defects easily that are difficult to detect.*

Disadvantages:

- *Large amount of data required.*
- *Computationally expensive to train.*
- *No strong theoretical foundation.*

Applications:

- **Automatic Text Generation** – Corpus of text is learned and from this model new text is generated, word-by-word or character-by-character. Then this model is capable of learning how to spell, punctuate, form sentences, or it may even capture the style.

- **Healthcare** – Helps in diagnosing various diseases and treating it.

- **Automatic Machine Translation** – Certain words, sentences or phrases in one language is transformed into another language (Deep Learning is achieving top results in the areas of text, images).

- **Image Recognition** – Recognizes and identifies peoples and objects in images as well as to understand content and context. This area is already being used in Gaming, Retail, Tourism, etc.