Introduction to Neural Networks

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Agenda

- Introduction to Neural Networks

- Deep Learning

- Reinforcement Learning

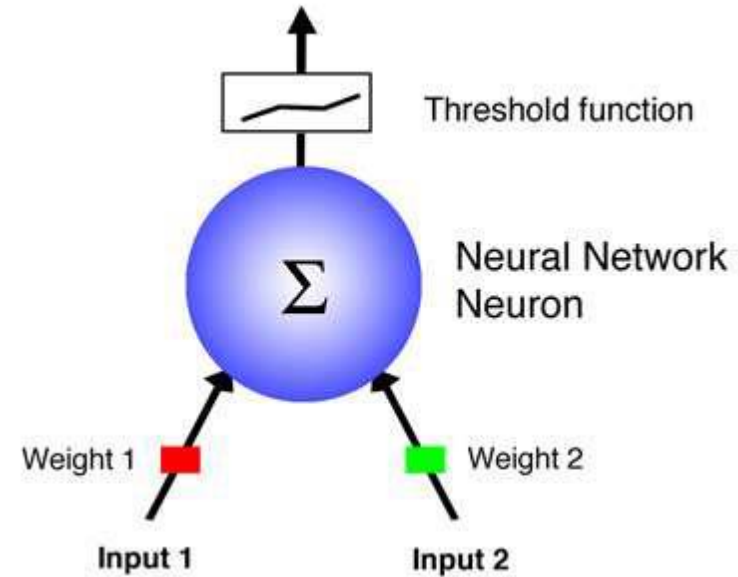# Introduction to Neural Networks

- A method of computing, based on the interaction of multiple connected processing elements.
- A powerful technique to solve many real world problems.
- The ability to learn from experience in order to improve their performance.
- Ability to deal with incomplete information
- Basics Of Neural Network

    input layer   hidden layer   output layer

    1. Biological approach to AI

    2. Developed in 1943

    3. Comprised of one or more layers of neurons

    4. Several types, we will focus on feed-forward and feedback
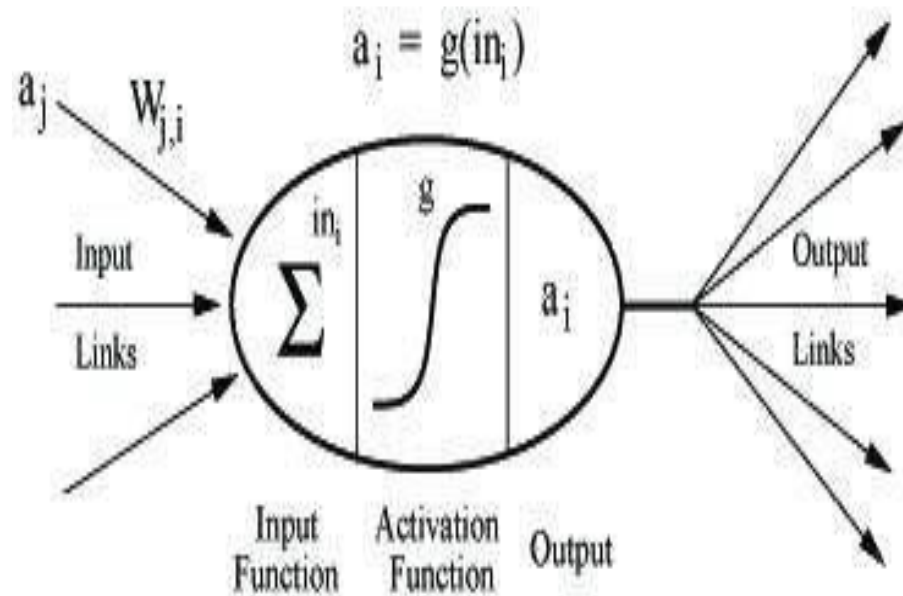   networks
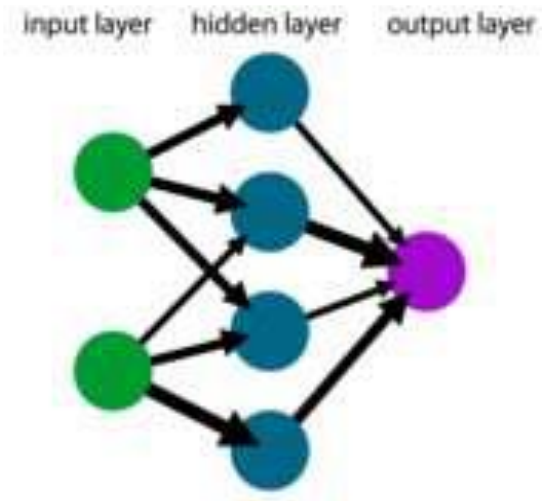
Neurons
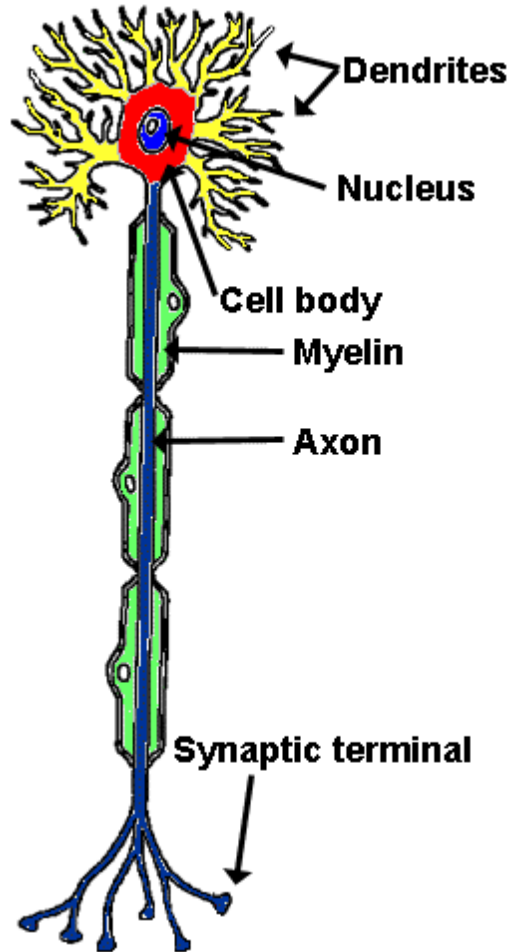
Biological

Artificial

Neural Network Neurons

$$a_i = g(in_i)$$

a_j, $W_{j,i}$

Input Links

Σ in_i

g

a_i

Output Links

Input Function

Activation Function

Output
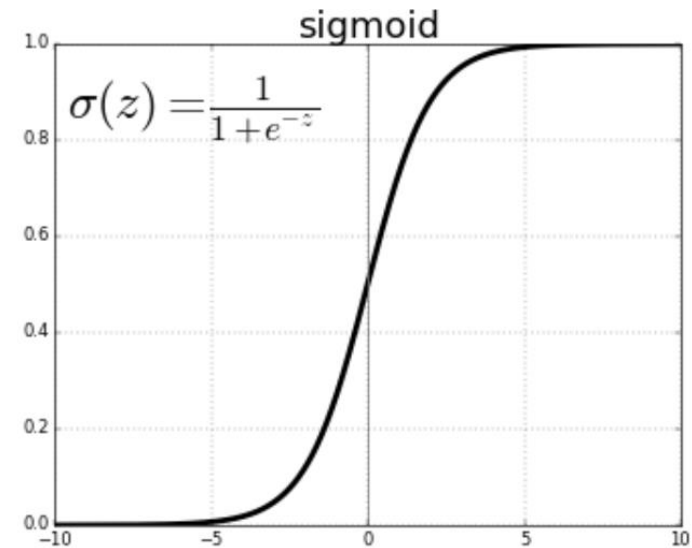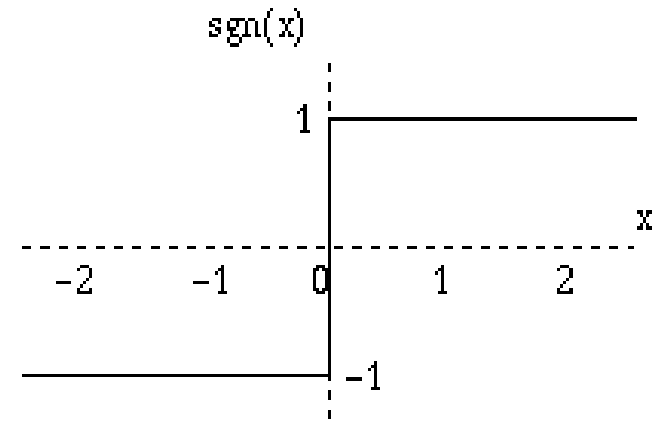
- Receives n-inputs
- Multiplies each input by its weight
- Applies activation function to the sum of results
- Outputs result

Activation Functions

- Controls when unit is "active" or "inactive"
- Threshold function outputs 1 when input is positive and 0 otherwise
- Sigmoid function

$$= 1 / (1 + e{\text{-}}x)$$

sgn(x)

$$\sigma(z) = \frac{1}{1+e^{-z}}$$

sigmoid

Neural Network types can be classified based on following attributes:

- **Connection Type**
  - Static (feed-forward)
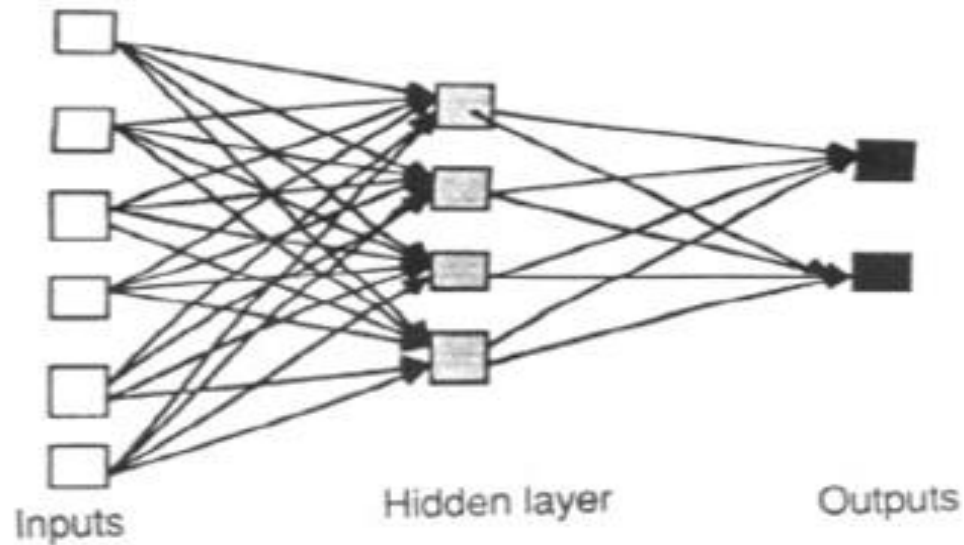 - Dynamic (feed-back)
- **Topology**
  - Single layer
  - Multilayer
  - Recurrent
- **Learning Methods**
  - Supervised
  - Unsupervised
  - Reinforcement

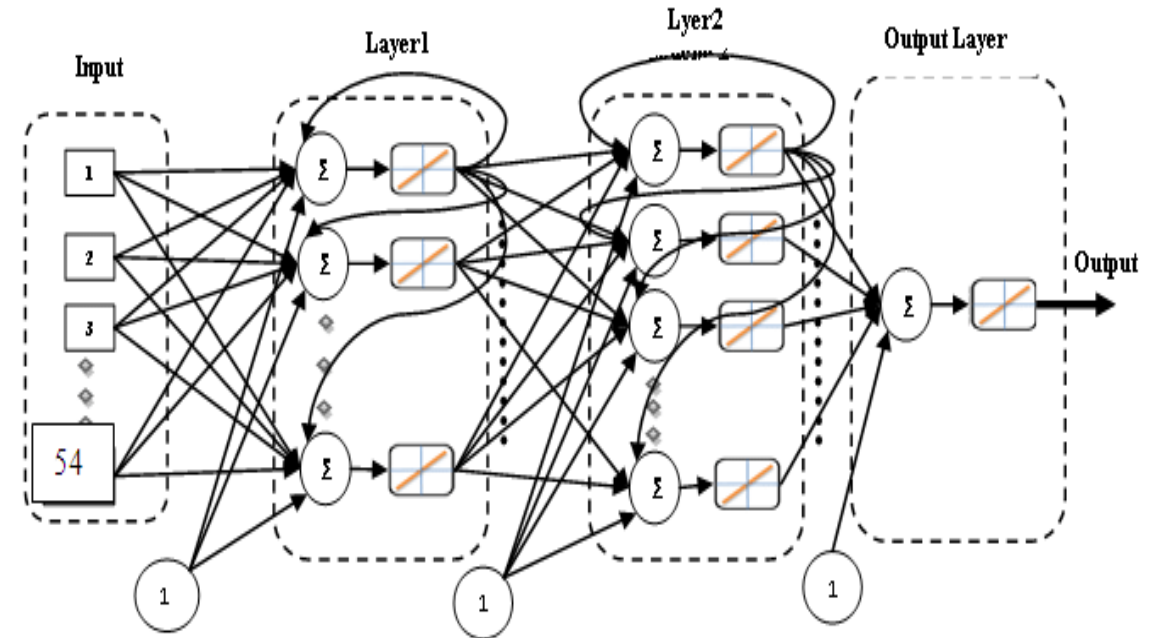# Classification Based On Connection Types

Static(Feed-forward)

Dynamic(Feedback)

The output is calculated directly from the input through Feed-forward connections

The output depends also on the previous inputs, outputs or States of the network

Classification Based On Topology

- Topology defines how a neuron in neural network connected with another neurons.

- There are three types topologies that every neural network must follow the one of the following:

> 1. single-level topology

> 2. multi-level topology

> 3. recurrent topology

1. single-level topology:

The simplest kind of neural network is a single-layer

network, which consists of equal no.of input and

output nodes.

Input Layer

Hidden Layer

Output Layer
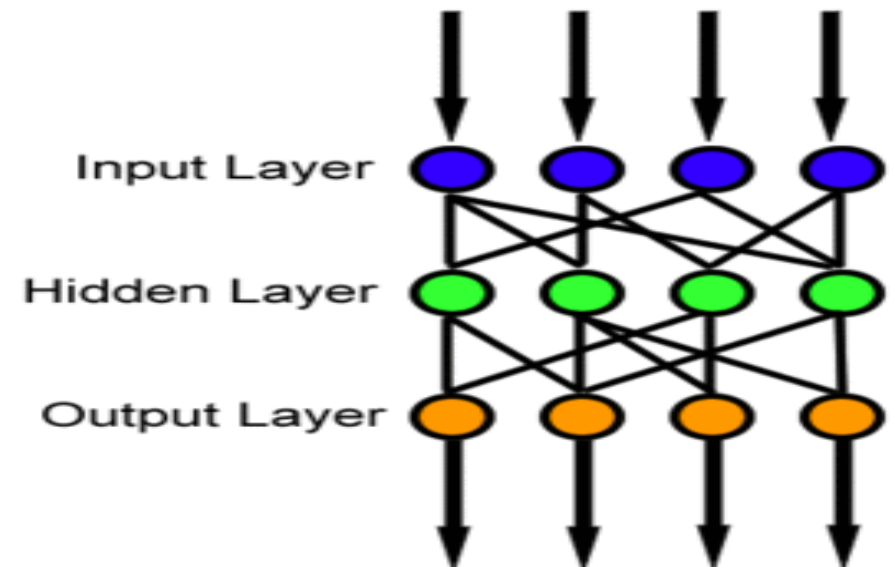
2. multi-level topology

In multi-level, each neuron in one layer has directed connections to the neurons of the subsequent layer
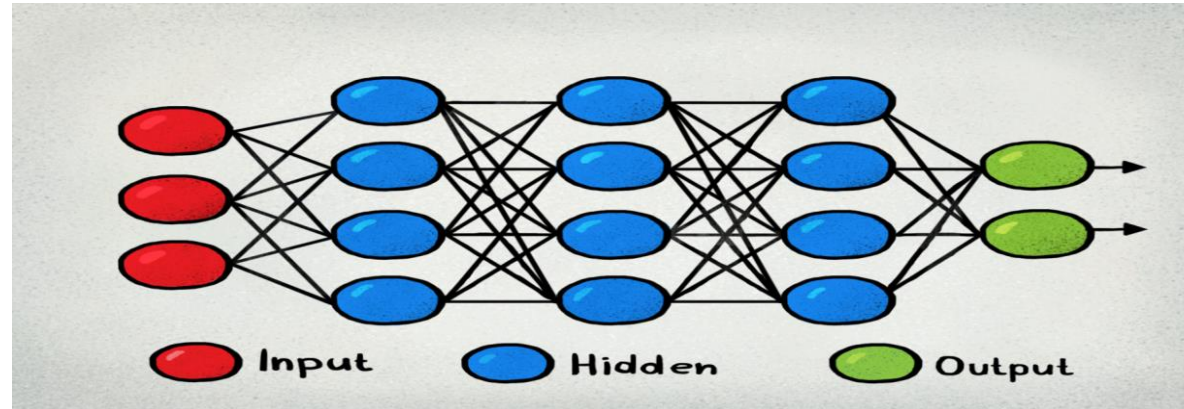
3. recurrent topology

A recurrent neural network (RNN) is a class of artificial neural networks where connections between units form a directed cycles.

Recurrent Neural Network structure

Recurrent Neural Network   Feed-Forward Neural Network

Learning methods of Neuron:

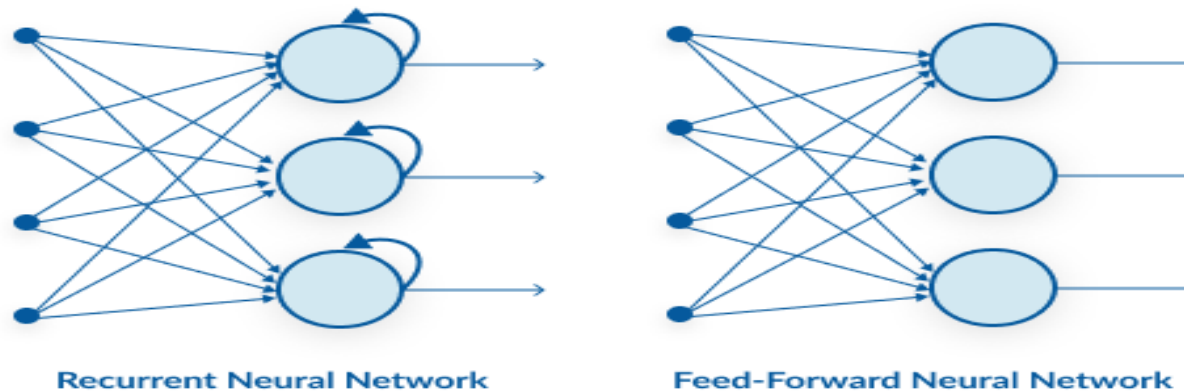- Neurons in neural networks will learn about the working pattern of the new task.

- Next time, when the same task is given to perform, it automatically generates output without wasting of time.

- There are three types of learning methods. they are

  1. supervised learning

  2. unsupervised learning

  3. reinforcement learning

Neural Network Applications

- Pattern recognition
- Investment analysis
- Control systems & monitoring
- Mobile computing
- Marketing and financial applications
- Forecasting – sales, market research, meteorology

Advantages:

- A neural network can perform tasks that a linear program can not.
- When an element of the neural network fails, it can continue without any problem by their parallel nature.
- A neural network learns and does not need to be reprogrammed.
- It can be implemented in any application.
- It can be implemented without any problem

Disadvantages:

- The neural network needs training to operate.
- The architecture of a neural network is different from the architecture of microprocessors therefore needs to be emulated.
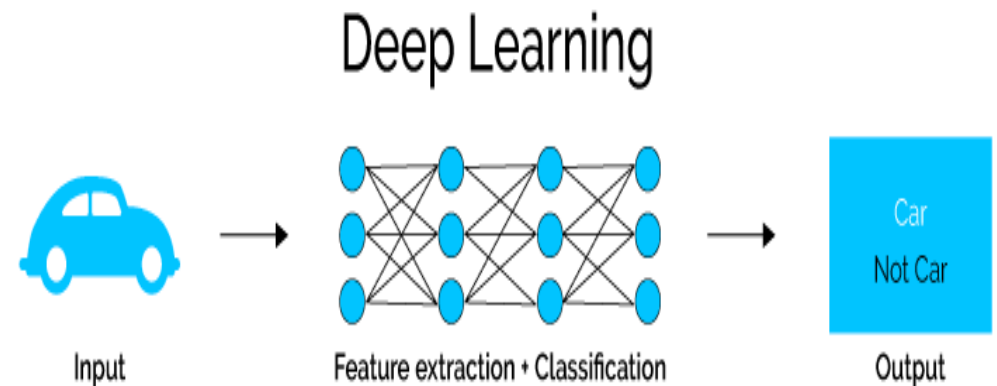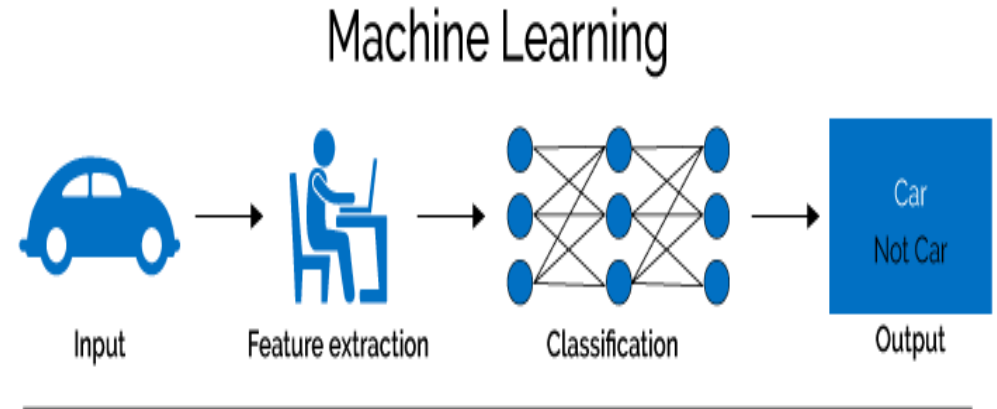- Requires high processing time for large neural networks.

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".

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 Belief Network(DBN)** – It is a class of Deep Neural Network. It is multi-layer belief networks.

Machine Learning

Input → Feature extraction → Classification → Car Not Car Output

Deep Learning

Input → Feature extraction + Classification → Car Not Car Output

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.*

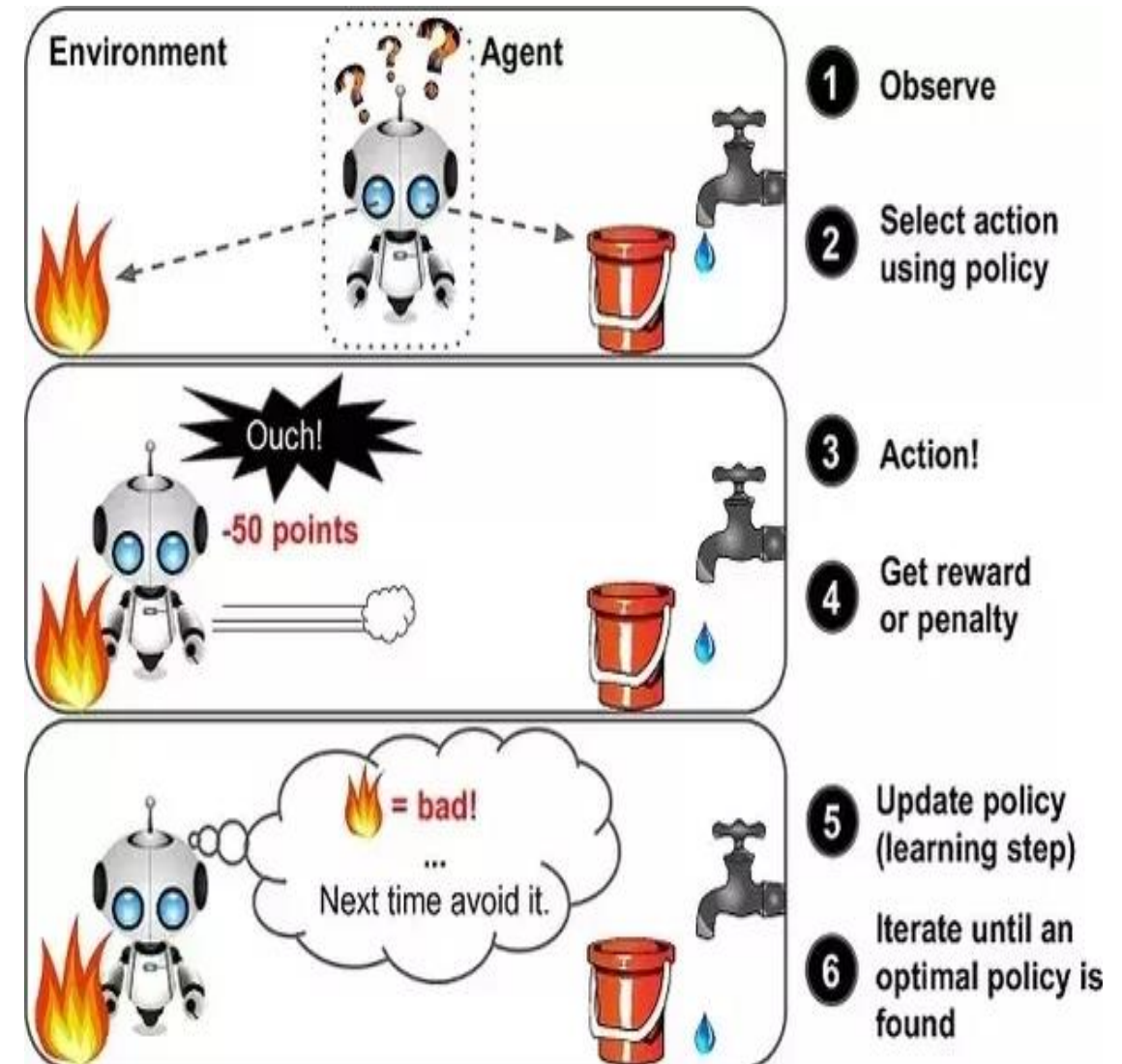- *No strong theoretical foundation.*

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.

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.

Environment   ? ? ?   Agent

1 Observe

2 Select action using policy

Ouch!
-50 points

3 Action!

4 Get reward or penalty

🔥 = bad!
...
Next time avoid it.

5 Update policy (learning step)

6 Iterate until an optimal policy is found