Unit 2

Artificial Neural Networks and Applications

Neural networks, a subset of machine learning and at the core of deep learning algorithms, their structure and nomenclature are modeled after the human brain, mirroring the communication between organic neurons. Computers can use this to build an adaptive system that helps them continuously improve by learning from their failures. As a result, artificial neural networks make an effort to tackle challenging issues like summarizing documents or identifying faces.

How Do Neural Networks Work?

Neural network-based machine learning algorithms typically do not require programming with precise rules defining what to anticipate from the input. Instead, the neural network learning algorithm learns by analyzing many labeled examples provided during training and by utilizing this answer key to determine what qualities of the input are required to generate the proper output.

Major Categories of Neural Networks

The following are some of the major categories of kinds of neural networks:

1. Classification

Classification tasks, which call for labeled datasets for supervised learning, are often where neural networks excel. For instance, neural networks can quickly and consistently apply labels while identifying visual patterns in hundreds of images. They master the art of tackling difficult, perplexing problems through training. The neural network learns to discern the most crucial aspects by itself. Thus the data scientist is not required to provide traits to differentiate between dogs and cats.

2. Sequence learning

Sequence learning is a machine learning category that uses data sequences as input or output. Text streams, audio files, video clips, measurements, and more are all examples of sequential learning.

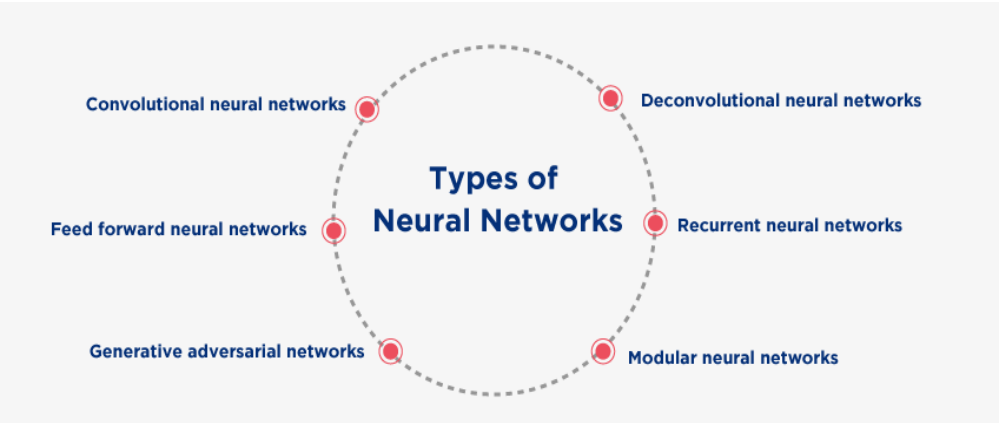
3. Function approximation

Function approximation is a technique for approximating an unknown underlying function using previous or current observations from the domain. A function is learned to be approximated by artificial neural networks.

Different Types of Neural Networks

The depth, number of hidden layers, and I/O capabilities of each node are a few criteria used to identify neural networks. Types of neural network models are:

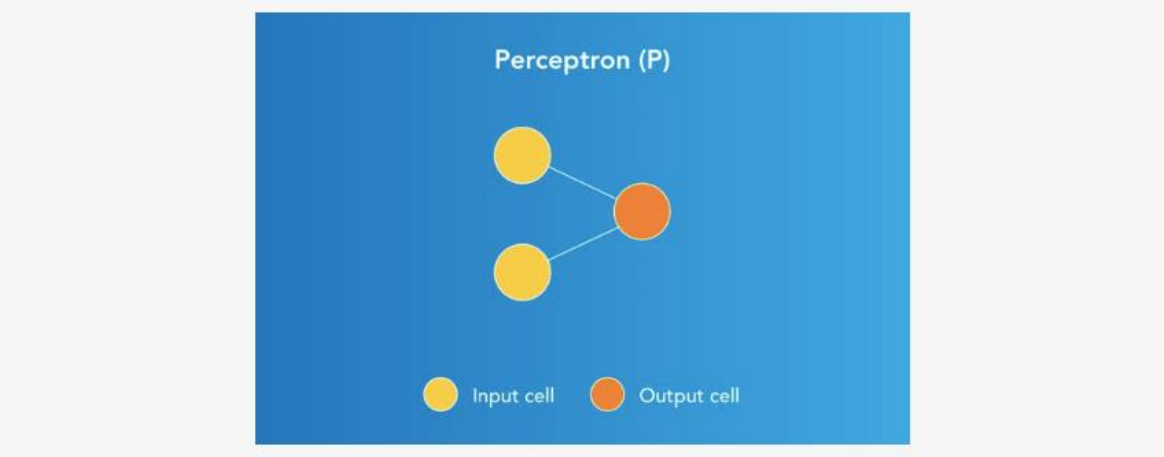
- Feed forward artificial neural networks.
- Perceptron and Multilayer Perceptron neural networks.
- Radial basis functions artificial neural networks.
- Recurrent neural networks.
- Modular neural networks.



The following are the different types of neural networks. So, let's check out the neural network types and uses:

1. Perceptron

Layers of connected nodes make up a neural network. Every node is a perceptron, which resembles a multiple linear regression. The signal obtained by multiple linear regression is fed into a non-linear activation function via the perceptron.

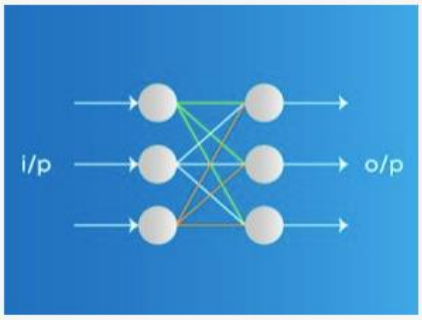


Applications:

- Data Compression: Encoding, reorganizing, or otherwise altering data to make it smaller is known as data compression. In its most basic form, it entails re-encoding data using fewer bits than the original representation.
- Streaming Encoding: The encoding technique whitens the real-valued input data given to the first hidden units of a fully-connected neural network, resulting in faster training.

2. Feed Forward Neural Network

Feed forward neural networks are among the most basic types of neural networks. Information is passed through several input nodes in one direction until it reaches the output node. The network may or may not include hidden node layers, which helps to explain how it functions.

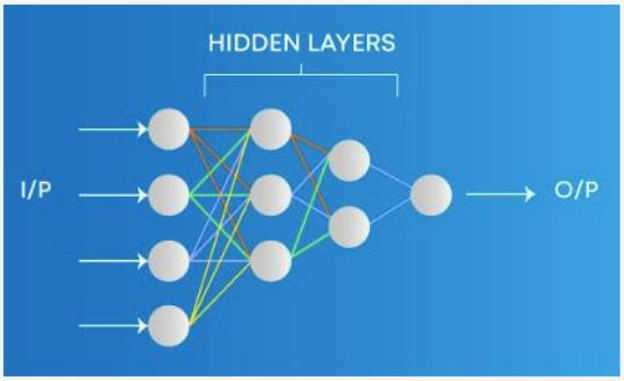


Applications:

- Pattern Recognition: Pattern recognition is the technique of recognizing patterns using a machine learning algorithm. Pattern recognition is data classification based on prior knowledge or statistical information taken from patterns and/or their representation.
- Computer Vision: Computer vision is a branch of artificial intelligence (AI) that allows computers and systems to derive relevant information from digital photos, videos, and other visual inputs and then act or recommend on that information.

3. Multilayer Perceptron

A multilayer perceptron is a fully convolutional network that creates a collection of outputs from a set of inputs. A directed graph connecting the input and output layers of an MLP is made up of multiple layers of input nodes

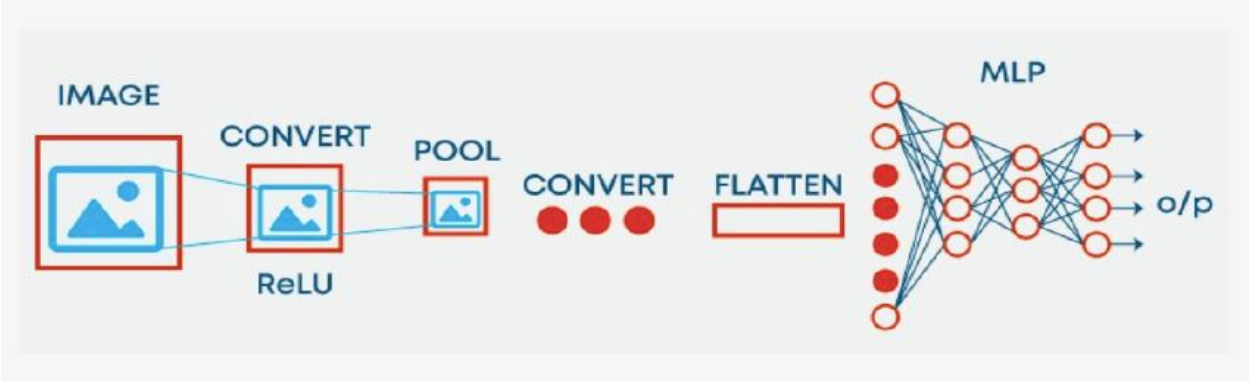


Applications:

- Machine Translation: To estimate the likelihood of a sequence of words, neural network techniques are used in neural machine translation, a cutting-edge approach to machine translation.
- Complex Classification: A group of quantitative techniques known as "complex classification" is used to examine the dynamics and structure of complex networked systems.

4. Convolutional Neural Network

The neurons in a convolution neural network are arranged in three dimensions rather than the typical two-dimensional array. The convolutional layer refers to the top layer. Each neuron in the convolutional layer processes only a small portion of the visual field.

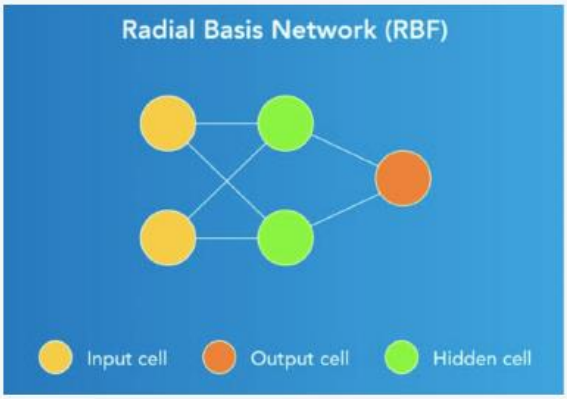


Applications:

- NLP: Natural language processing (NLP) is the branch of computer science—specifically related to artificial intelligence or AI that gives computers the ability to understand written and spoken words in the same way that humans do.
- Anomaly Detection: The process of identifying outlier values in a sequence of data is known as anomaly detection.

5. Radial Basis Functional Neural Network

A Radial Basis Function Network comprises an input vector, an output layer with one node for each category, a layer of RBF neurons, and a layer of RBF neurons

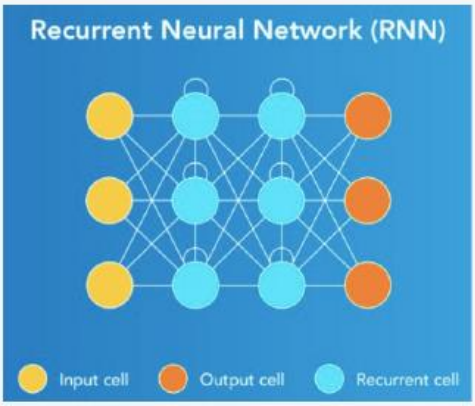


Applications:

- Function Approximation: Function approximation is an approach for measuring an unknown underlying function that is unknown using previous or current observations from the domain.
- Time Series Prediction: Making scientific projections based on data with historical time stamps is known as time series forecasting.

6. Recurrent Neural Network

Recurrent neural networks are constructed to comprehend temporal or sequential data. RNNs improve their predictions by using additional data points in a sequence.

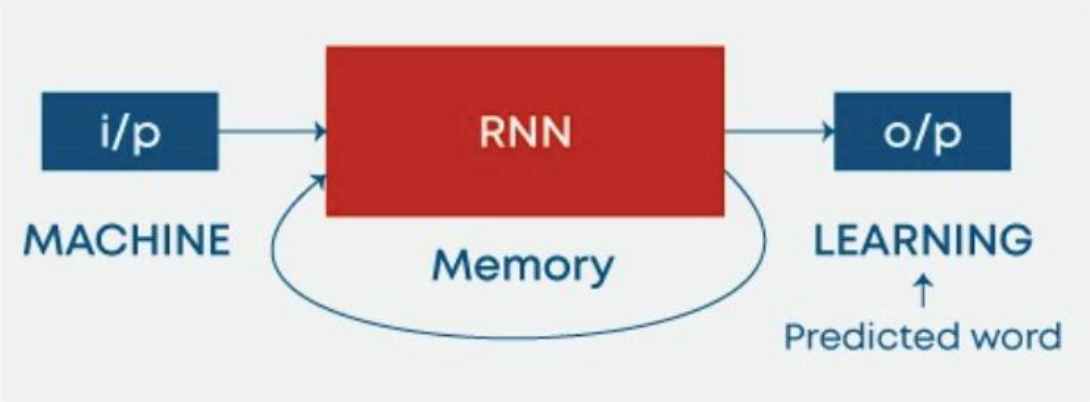


Applications:

- Image captioning: The process of creating a written description of an image is called image captioning.
- Predicting stock market fluctuations: You can determine the future worth of business stock and other financial assets traded on an exchange by utilizing stock price prediction powered by machine learning.

7. LSTM: Long Short-Term Memory

LSTM networks introduce a memory cell. They can handle data that has memory gaps. The time delay is a factor that may be taken into account when using RNNs.

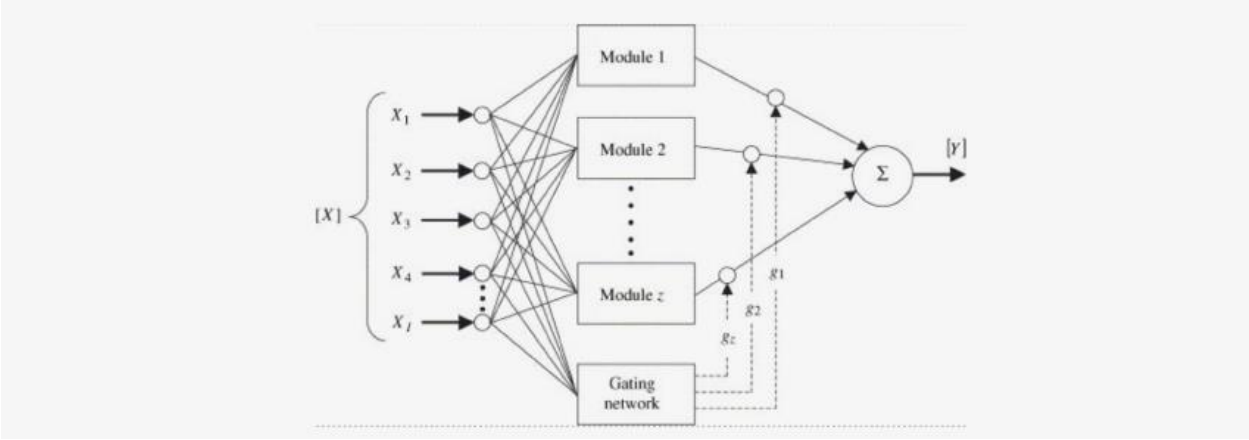


Applications:

- Speech Recognition: Speech recognition software is a technology that can process natural language speech and convert it into readable text with high accuracy.
- Writing Recognition: A computer's capacity to recognize and understand understandable handwritten input from sources like paper documents, photos, touch screens, and other devices is known as handwriting recognition (HWR), also referred to as handwritten text recognition (HTR)

8. Modular Neural Network

A modular neural network consists of several distinct networks that each carry out a specific task. Throughout the calculation process, there isn't much communication or interaction between the various networks



Applications:

- Stock market prediction systems: You can determine the future worth of business stock and other financial assets traded on an exchange by utilizing stock price prediction powered by machine learning.
- Adaptive MNN: With an emphasis on the operation and inference of deep neural network models, an Adaptive Mobile Neural Network (MNN) is a compact mobile-side deep learning inference engine.

Learning in Artificial Neural Networks

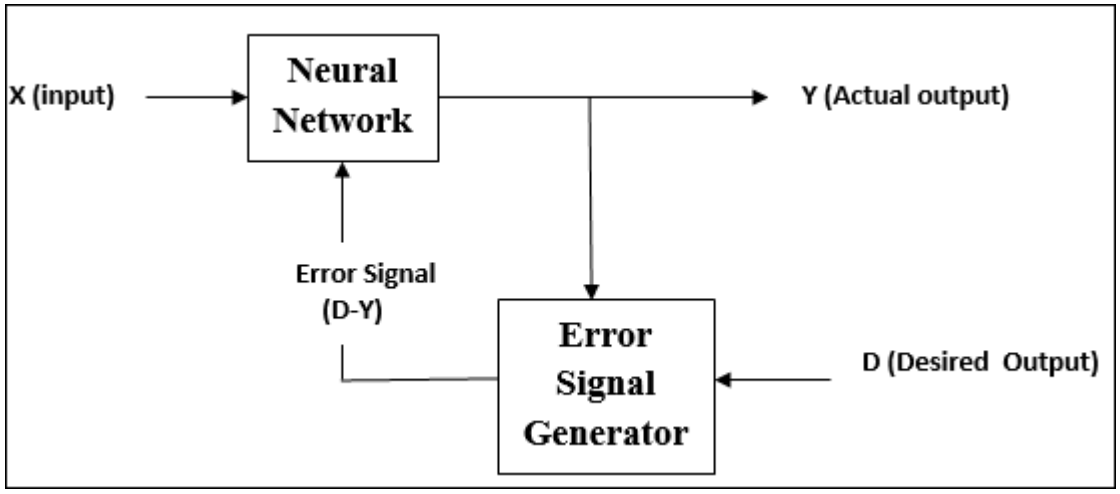
Learning means to do and adapt the change in itself as and when there is a change in environment. ANN is a complex system or more precisely we can say that it is a complex adaptive system, which can change its internal structure based on the information passing through it.

Learning in ANN can be classified into three categories namely supervised learning, unsupervised learning, and reinforcement learning.

- **Supervised Learning**

  As the name suggests, this type of learning is done under the supervision of a teacher. This learning process is dependent.

During the training of ANN under supervised learning, the input vector is presented to the network, which will give an output vector. An error signal is generated, if there is a difference between the actual output and the desired output vector. On the basis of this error signal, the weights are adjusted until the actual output is matched with the desired output.

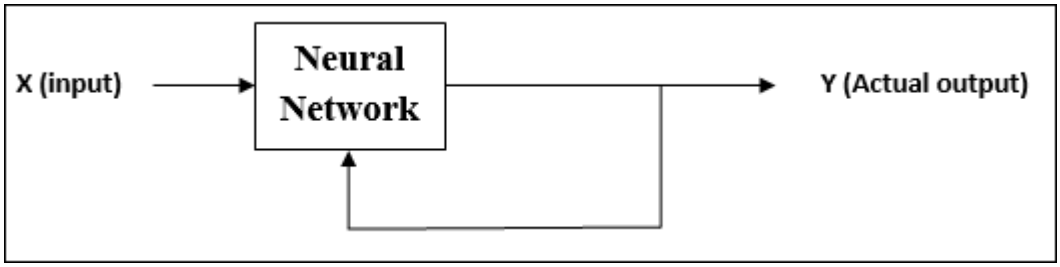


- **Unsupervised Learning**

As the name suggests, this type of learning is done without the supervision of a teacher. This learning process is independent.

During the training of ANN under unsupervised learning, the input vectors of similar type are combined to form clusters. When a new input pattern is applied, then the neural network gives an output response indicating the class to which the input pattern belongs.

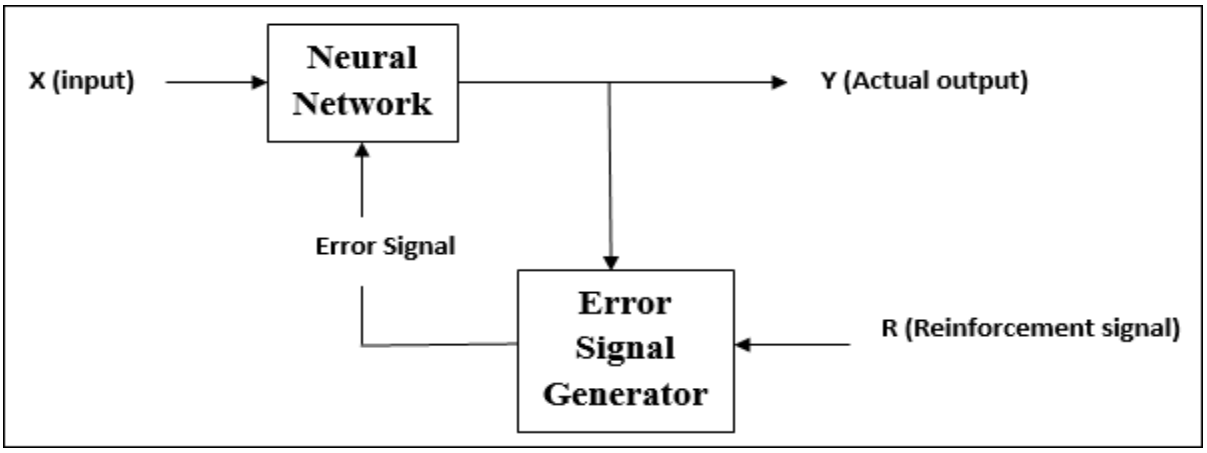
There is no feedback from the environment as to what should be the desired output and if it is correct or incorrect. Hence, in this type of learning, the network itself must discover the patterns and features from the input data, and the relation for the input data over the output.



- **Reinforcement Learning**

As the name suggests, this type of learning is used to reinforce or strengthen the network over some critic information. This learning process is similar to supervised learning, however we might have very less information.

During the training of network under reinforcement learning, the network receives some feedback from the environment. This makes it somewhat similar to supervised learning. However, the feedback obtained here is evaluative not instructive, which means there is no teacher as in supervised learning. After receiving the feedback, the network performs adjustments of the weights to get better critic information in future.



Difference between supervised unsupervised and reinforcement learning -

Criteria	Supervised Learning	Unsupervised Learning	Reinforcement Learning
Input Data	Input data is labeled.	Input data is not labeled.	Input data is not predefined.
Problem	Learn pattern of inputs and their labels.	Divide data into classes.	Find the best reward between a start and an end state.
Solution	Finds a mapping equation on input data and its labels.	Finds similar features in input data to classify it into classes.	Maximizes reward by assessing the results of state-action pairs
Model Building	Model is built and trained prior to testing.	Model is built and trained prior to testing.	The model is trained and tested simultaneously.
Applications	Deal with regression and classification problems.	Deals with clustering and associative rule mining problems.	Deals with exploration and exploitation problems.
Algorithms Used	Decision trees, linear regression, K-nearest neighbors	K-means clustering, k-medoids clustering, agglomerative clustering	Q-learning, SARSA, Deep Q Network
Examples	Image detection, Population growth prediction	Customer segmentation, feature elicitation, targeted marketing, etc	Drive-less cars, self-navigating vacuum cleaners, etc