

Artificial Intelligence (AI)

Machine Learning (ML)

Neural Networks (NNs)

Deep Learning (DL)

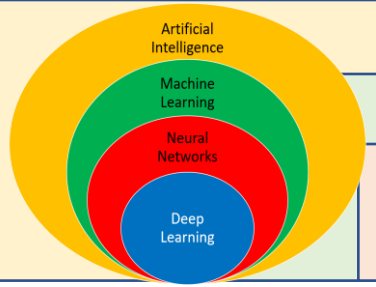
Artificial Neural Networks and Deep Learning

Dr. Rastgoo





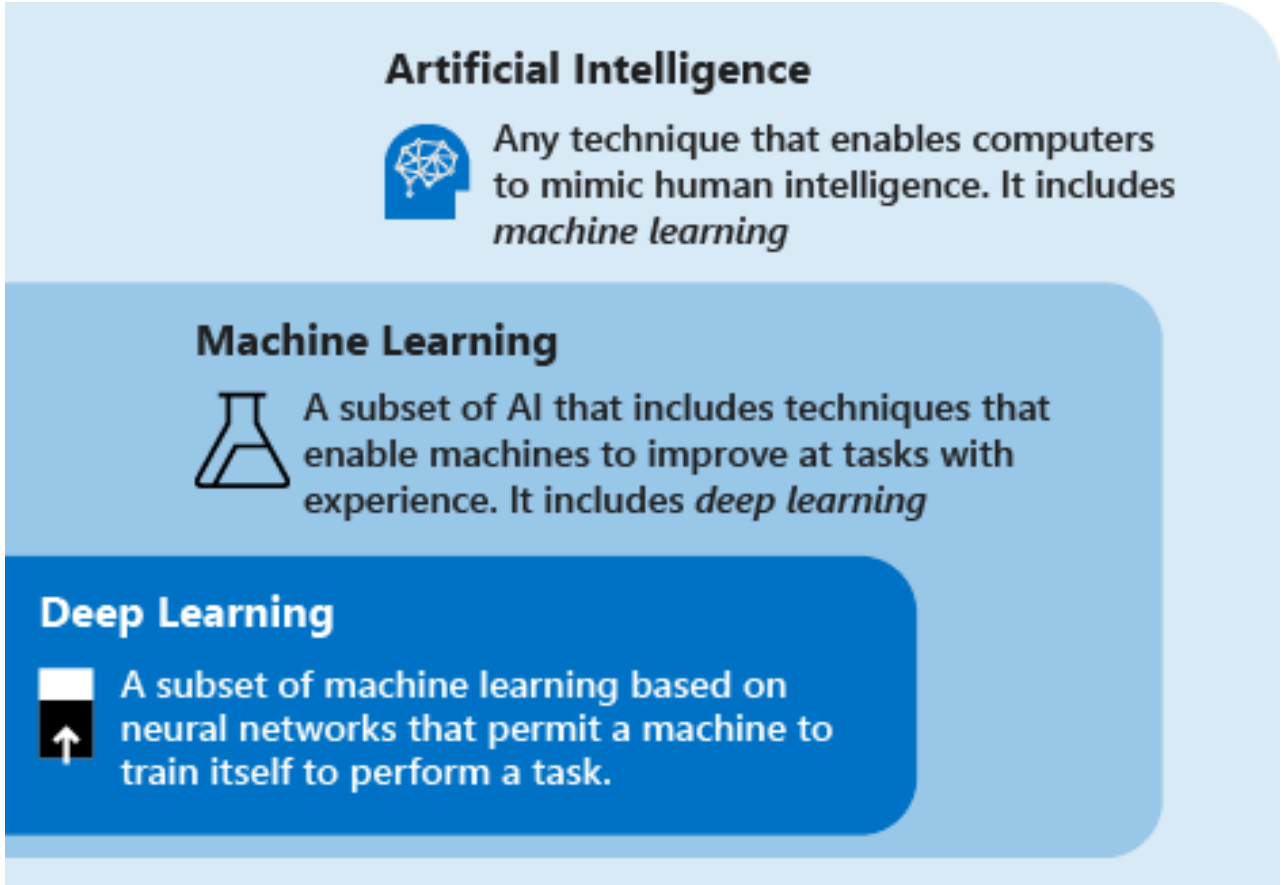


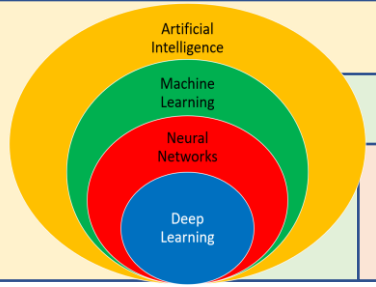


Outline

- Introduction to Artificial intelligence (AI) and Machine Learning (ML).
- Introduction to Neural Networks (NNs).
- Introduction to Deep Learning (DL).
- Programming.

Introduction to AI, ML, and DL





Artificial Intelligence (AI)

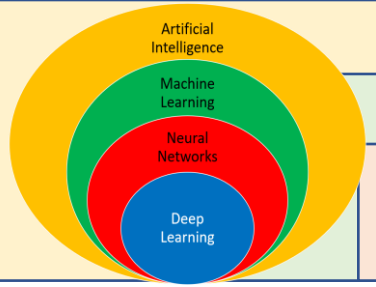
Machine Learning (ML)

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An Introduction to Artificial Neural Networks (ANNs)

- The human brain is capable of achieving many wonders, and the progress of mankind is a living testament to that fact.
- However, humans used their intelligence to create computers, which are capable of processing some tasks better than humans.
- For example, computers could calculate the square root of 0.000016 or bring you a web page instantly at your request.
- If you want to learn artificial neural networks (ANNs), you must understand the analogy between computers and the human brain.



Artificial Intelligence (AI)

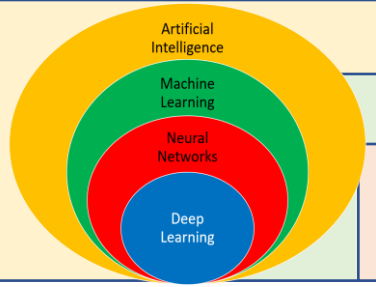
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An Introduction to Artificial Neural Networks (ANNs)

- While computers could process complex tasks instantaneously, the human brain could outperform computers in imagination, common sense, and creativity.
- Artificial neural networks (ANNs) have been designed by taking inspiration from the human brain structure.
- The objective of ANNs focuses on helping machines reason like humans.
- The brain works with numerous nerve cells or neurons working in coordination with each other.
- Neurons receive sensory inputs from the external world and process the inputs to provide the outputs, which could serve as inputs for the next neuron.



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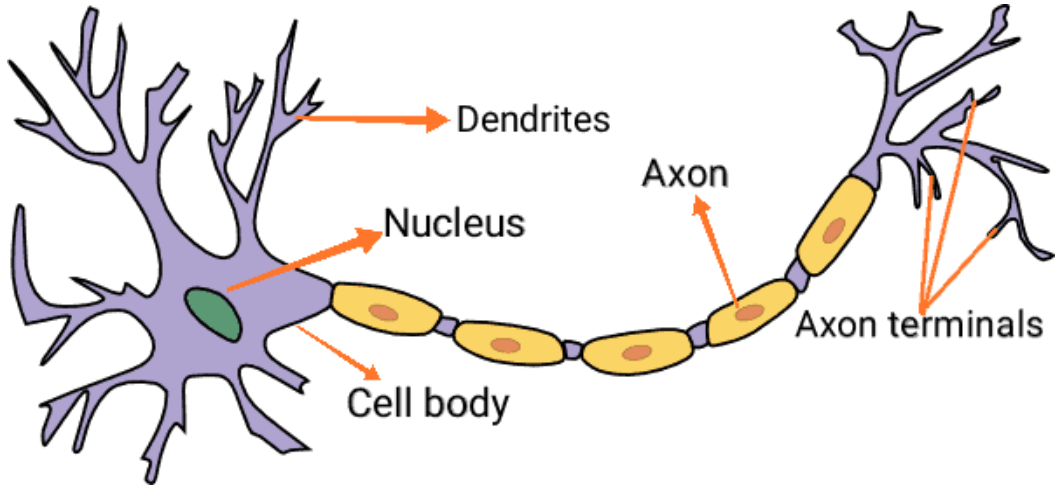
What is an Artificial Neural Network (ANNs)?

- Human brains can interpret the context in real-world situations comprehensively, unlike computers.
- Artificial neural networks are an attempt to simulate the network of neurons that are the basic blocks of the human brain.
- As a result, computers could learn things like humans and make decisions in a similar manner.
- In technical terms, artificial neural networks are computational models which have been tailored according to neural structure of the human brain.
- ANNs can be defined as algorithms that leverage brain function models for interpreting complicated patterns and forecasting issues.
- ANNs could also learn from historical data and offer responses as classifications or predictions.

How Do Artificial Neurons Compare Against Biological Neurons?

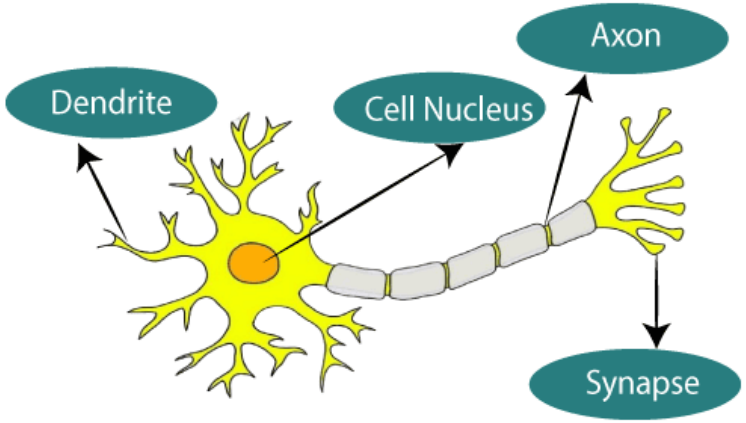
- There are multiple similarities in the structure and functions between artificial neurons and biological neurons as follows:
- Structure: Artificial neurons have been modeled after biological neurons. Biological neurons have a cell body for processing the impulses, dendrites for receiving impulses, and axons for transferring impulses to other neurons.

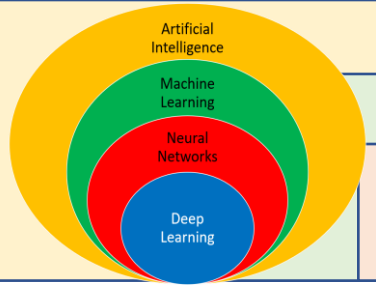
- On the other hand, input nodes in ANNs receive the input signals while the hidden layer processes the input signals. The output layer leverages activation functions for processing the results of the hidden layer to generate the final output.



How Do Artificial Neurons Compare Against Biological Neurons?

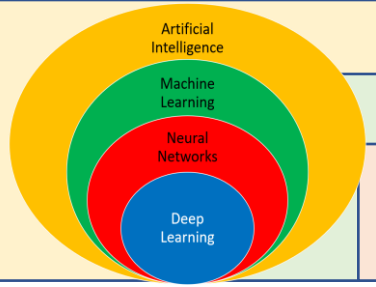
- There are multiple similarities in the structure and functions between artificial neurons and biological neurons as follows:
- Synapses: The responses to "What is artificial neural networks?" also point to the comparison of synapses in ANNs and biological neurons. Synapses serve as the link between biological neurons for transmitting impulses from the dendrites to the cell body. In the case of artificial neurons, synapses are the weights that connect one-layer nodes to the next-layer nodes. The weight value helps in determining the strength of the links.





How Do Artificial Neurons Compare Against Biological Neurons?

- There are multiple similarities in the structure and functions between artificial neurons and biological neurons as follows:
- Activation: Another crucial aspect for comparing artificial neurons with biological neurons points to activation. In the case of biological neurons, activation refers to the firing rate of neurons for strong impulses that can reach the threshold. On the contrary, activation in artificial neurons points to an activation function that facilitates mapping of inputs to outputs.



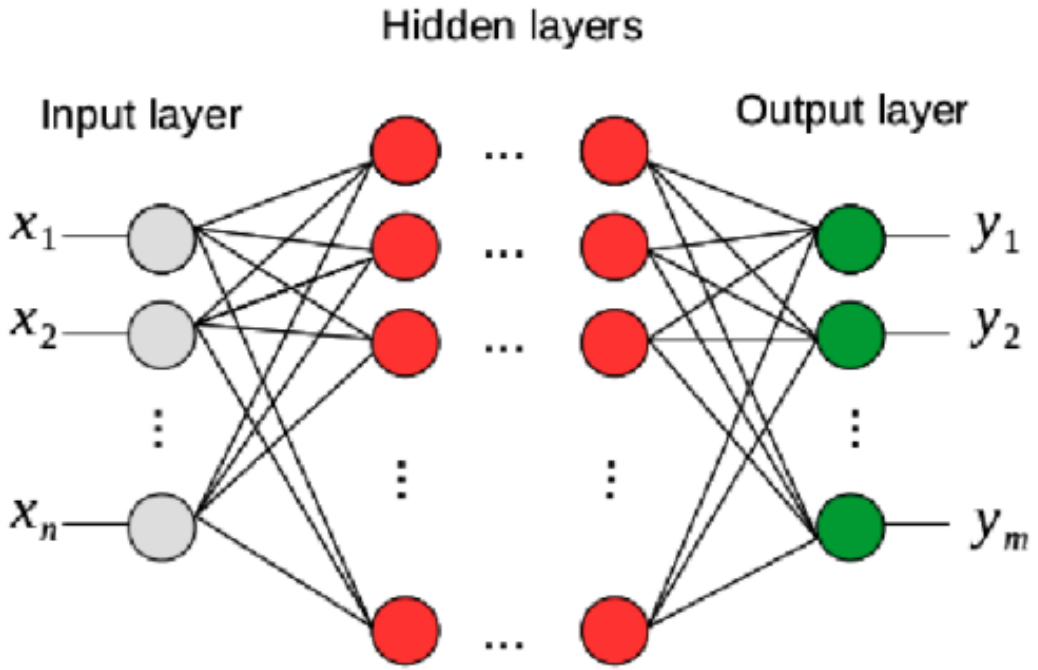
How Do Artificial Neurons Compare Against Biological Neurons?

- There are multiple similarities in the structure and functions between artificial neurons and biological neurons as follows:
- Learning: Learning in biological neurons takes place in the nucleus of the cell body, which helps in processing the impulses. The impulse processing stage leads to generation of an action potential, which travels through axons for powerful impulses.

- The transfer of impulses is possible due to the ability of synapses to change their strength according to modifications in activity. On the other hand, ANNs utilize back-propagation techniques for learning. It involves adjustment of weights between the nodes on the basis of errors or discrepancies between desired and actual outputs.

Architecture of Artificial Neural Networks

- The architecture of artificial neural networks includes three layers such as the input layer, the hidden layer, and the output layer.

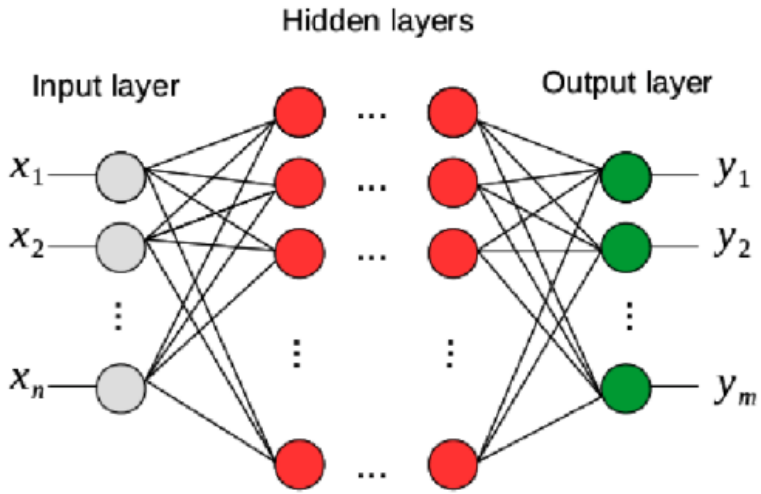


Architecture of Artificial Neural Networks

- Input Layer: The input layer is the foremost layer in an artificial neural network. It works on receiving the input information from external sources. The input data could be available in the form of text, numbers, images, or audio files.

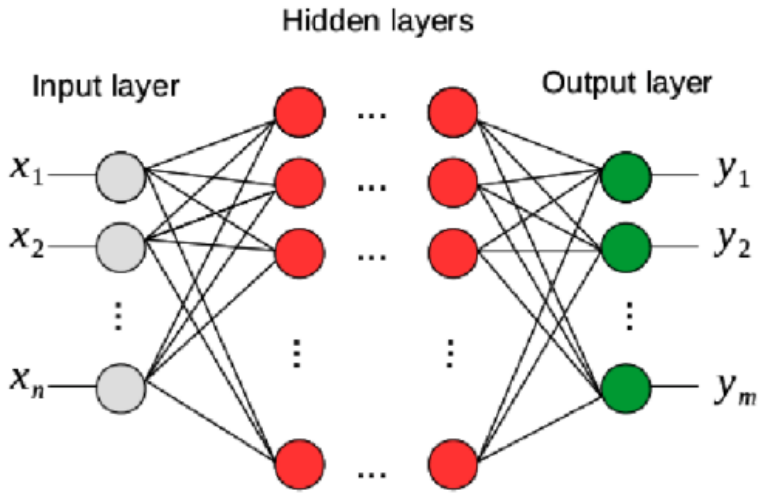
- Hidden Layer: The middle layer of artificial neural networks includes the hidden layers. You could find one or multiple hidden layers in ANNs. The hidden layer works on extracting the relevant patterns from input data and transfers them to the next layer for analysis.

- It can help accelerate and improve the efficiency of the artificial neural network by identifying only the most important patterns from the input. As a result, the hidden layer serves as the ideal choice for performing different types of mathematical computation tasks on input data.



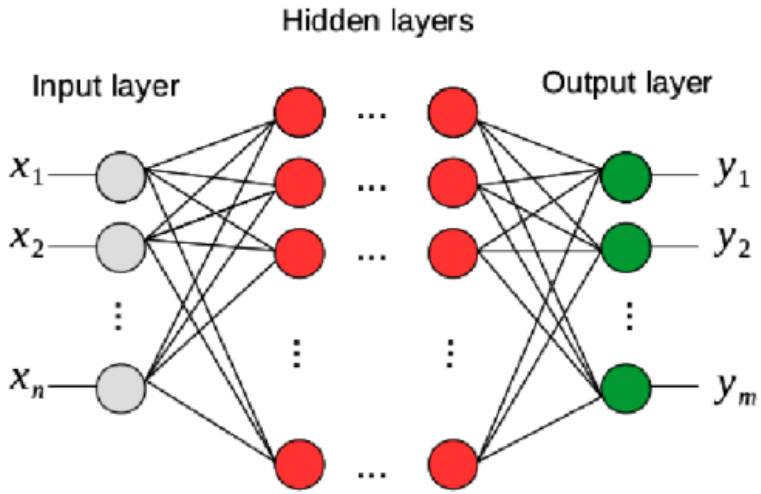
Architecture of Artificial Neural Networks

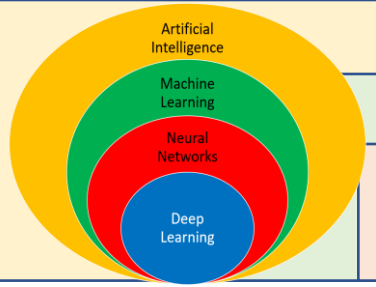
- Output Layer: The output layer focuses primarily on obtaining the results on the basis of rigorous mathematical computations by the hidden layer.
- Parameters and hyperparameters: The parameters and hyperparameters are responsible for influencing the performance of the neural network. As a matter of fact, the output of artificial neural networks depends on these parameters. Some of the notable examples of parameters for ANNs include weights, batch size, biases, and learning rate. It is important to note that every node in the ANN has some weights.



Architecture of Artificial Neural Networks

- Activation function : Artificial neural networks utilize a activation function for determining the weighted sum of inputs alongside the bias. Examples of popular activation functions for ANNs include Softmax, Sigmoid, and RELU.





Artificial Intelligence (AI)

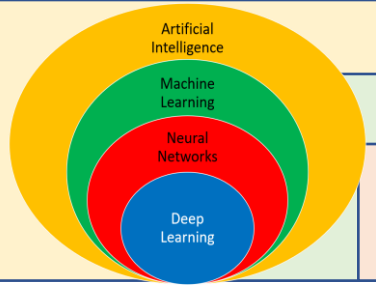
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What is Back-propagation in Artificial Neural Networks?

- ANNs generate the final output value by using activation functions.
- In addition, the working of an ANN algorithm would also involve error functions.
- The error functions can help in calculating the differences between the desired and actual output for adjusting the weights of the neural network.
- The process of adjusting weights is back-propagation.



Artificial Intelligence (AI)

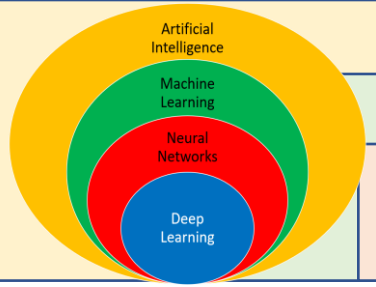
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What is Back-propagation in Artificial Neural Networks?

- The training process of ANNs involves providing examples of input-output mappings.
- For example, you can teach an ANN to recognize a dog.
- First of all, you have to show thousands of images of dogs to help the ANN in identifying a dog.
- After training the ANN with multiple images of dogs, you should check whether it can identify dogs in an image.
- You can achieve this by classification of images to help in deciding whether a specific image includes a dog.
- The output of the ANN is then checked against a human description of whether the image has a dog in it.

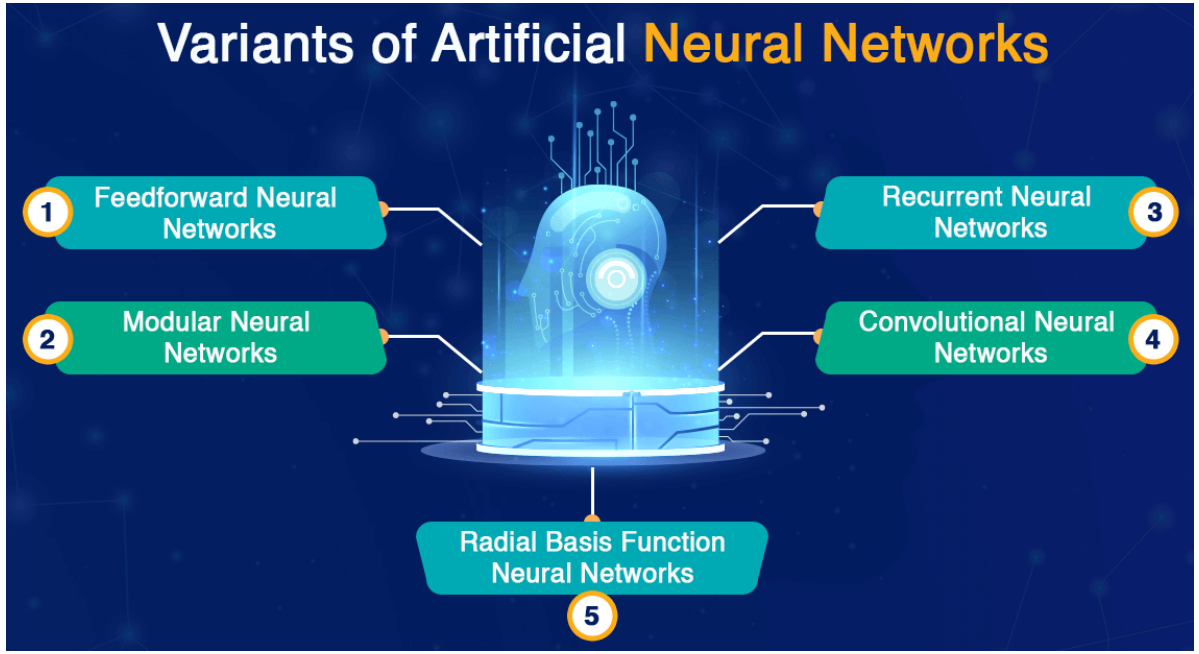


What is Back-propagation in Artificial Neural Networks?

- In the case of incorrect responses by the ANN, you have to use back-propagation to adjust the weights learned in the training process.
- The process of back-propagation focuses on fine-tuning the weights of connections in ANN units according to the error rate.
- Subsequently, the process must continue iteratively until the ANN successfully recognizes an image with a dog in it.

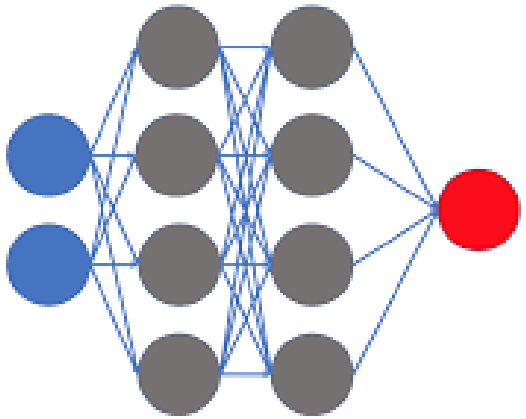
Variants of Artificial Neural Networks

- There are different variants of ANNs, such as feedforward neural networks, convolutional neural networks, modular neural networks, recurrent neural networks, and radial basis function neural networks.



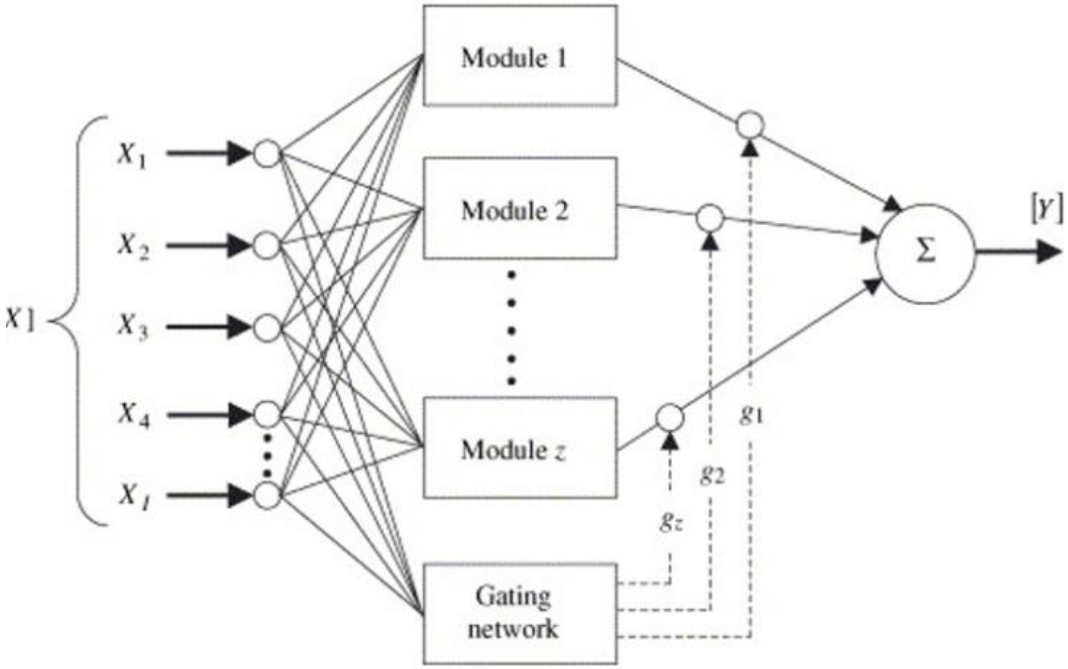
Variants of Artificial Neural Networks: Feedforward Neural Networks

- Feedforward neural networks are the most fundamental variant of artificial neural networks.
- In such types of ANN, the input data travels in a single direction and exits through the output layer.
- Feedforward neural networks may or may not have hidden layers and do not rely on back-propagation.



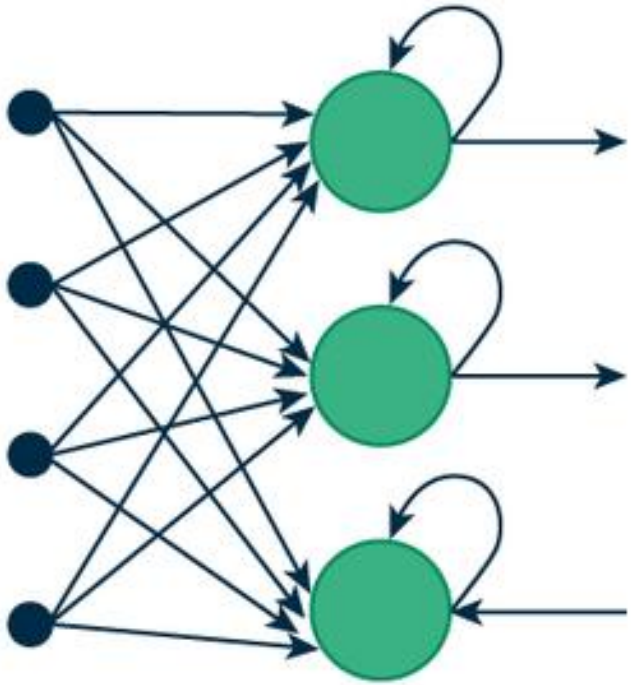
Variants of Artificial Neural Networks: Modular Neural Networks

- Modular neural networks include a collection of multiple neural networks working independently to achieve the output.
- The different neural networks perform a unique sub-task with unique inputs.
- The advantage of modular neural networks is the ability to reduce complexity by breaking down complex and large computational processes.



Variants of Artificial Neural Networks: Recurrent Neural Networks

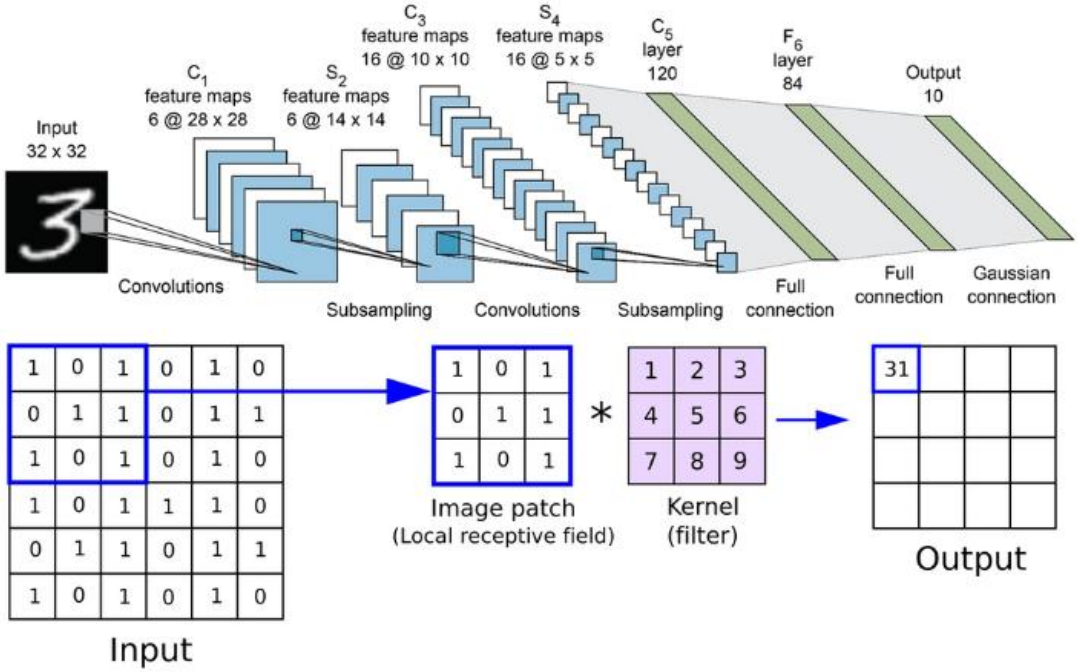
- The recurrent neural networks work by saving the output of a layer and feeding back the output to the input to provide better predictions for outcomes of the layer.



Variants of Artificial Neural Networks: Convolutional Neural Networks

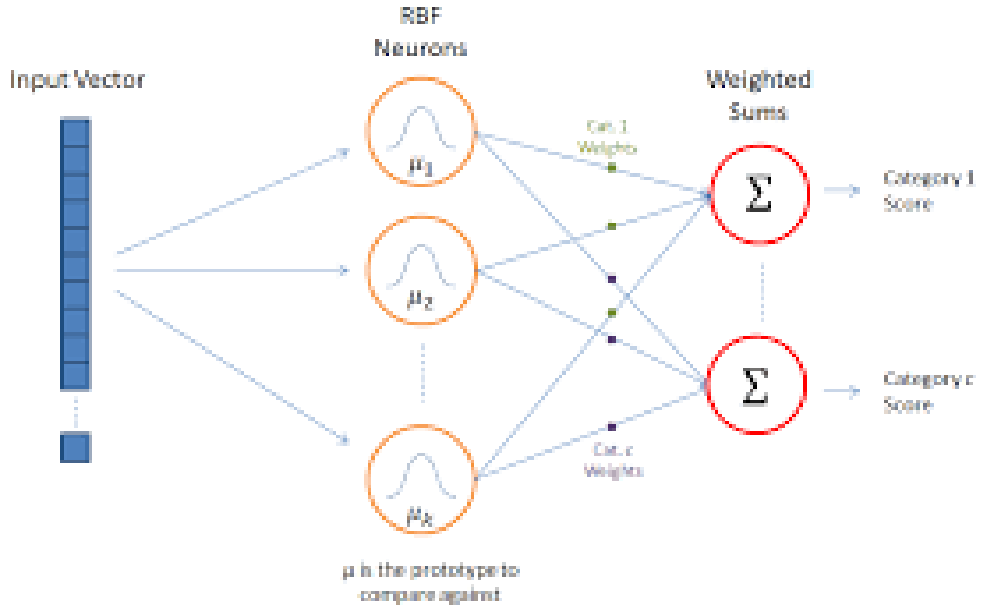
- Convolutional neural networks share some similarities with feedforward neural networks.

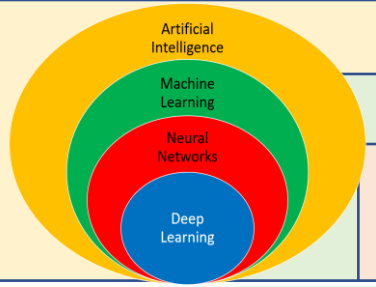
- However, convoluted neural networks have one or multiple convolutional layers that utilize a convolution operation for the input before passing the result.



Variants of Artificial Neural Networks: Radial Basis Function Neural Networks

- The radial basis functions work by accounting for the distance of a point with respect to the center. Radial basis functions feature two distinct layers which have distinct functionalities. Such types of neural networks also use radial basis function nets for modeling data that could represent underlying functions or trends.





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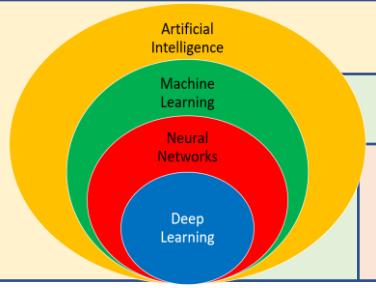
Deep Learning (DL)

What are the Prominent Examples of Artificial Neural Networks?

- The unique properties of artificial neural networks make them one of the most trusted choices for different use cases. Here are some of the notable use cases of artificial neural networks.

- Recognizing handwritten characters.
- Speech recognition.
- Signature classification.
- Facial recognition.

- The applications of artificial neural networks ensure that you can implement them in different sectors, such as healthcare, social media marketing, and sales.



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