Neural Networks

These are Deep learning foundations deriving inspiration from the human brain and its working. It consists of neurons and neural networks. There is the input neural network, hidden layers and the output layer. It is used in image recognition, NLPs, medical diagnosis, etc.

The input layer serves as the entry point for data, where each node represents a feature or attribute of the input. Following the input layer are one or more hidden layers. These layers perform computations and transformations, allowing the network to learn complex patterns. The output layer is the final layer, producing the network's predictions or classifications based on the processed information. Each neuron takes input from the previous layer, performs calculations (a weighted sum), applies an activation function (like a mathematical transformation), and passes the result to the next layer. Connections between neurons have weights that determine their importance, while biases help adjust the output. These parameters are learned during the training process.

Neural networks learn through a process known as training. During this phase, the network adjusts its weights and biases based on input data and expected output. The most common training technique used is called backpropagation. This method involves several steps: first, the network feeds input data and calculates the output. Next, it computes the loss, which measures the difference between the predicted output and the actual output using a loss function. Finally, the network uses this information to adjust its weights and biases, gradually enhancing its accuracy.

There are many types, like ANNs, CNNs, etc.

1. Artificial Neural Network (ANN)

An Artificial Neural Network is the simplest form of neural network and forms the basis of all other types. It consists of nodes (neurons) organized in layers—input, hidden, and output layers. Each neuron takes an input, applies weights and biases, and then passes the result through an activation function.

Mathematics of ANN

- **Weighted Sum**: Each input is multiplied by a weight and summed with a bias term.
- **Activation Function**: Transforms the result into a non-linear output. Common choices are the sigmoid, ReLU, or tanh functions.

2. Convolutional Neural Network (CNN)

CNNs are specifically designed for image data. They use filters (or kernels) that slide across an image to extract features like edges, colors, and textures. This makes CNNs highly effective for tasks like image recognition and object detection.

Mathematics of CNN

- **Convolution Operation**: Each filter applies a convolution operation over the image to create feature maps, highlighting important patterns.
- **Pooling**: Reduces the size of the feature maps to retain the most important information, usually through max-pooling or average-pooling.

3. Recurrent Neural Network (RNN)

RNNs are great for sequence-based data, like time series and natural language. They have loops in their architecture, allowing them to retain information across time steps. This helps RNNs understand sequences better than regular neural networks.

Mathematics of RNN

- The hidden state at each time step depends on both the current input and the previous hidden state.