Deep Learning Concepts Overview

1. Artificial Neural Networks (ANN)

Artificial Neural Networks are the foundational architecture of deep learning, inspired loosely by the biological neural networks of the human brain. An ANN consists of three main types of layers:

- **Input Layer:** This layer receives the raw data (features) from the dataset. No computation happens here; it simply passes the information to the next layer.
- **Hidden Layers:** These are the layers between the input and output. A network can have multiple hidden layers (which makes it "deep"). Each neuron in a hidden layer applies a weighted sum to the inputs it receives, adds a **bias**, and then passes the result through an **activation function** (such as ReLU or Sigmoid). This non-linearity allows the network to learn complex patterns.
- **Output Layer:** The final layer produces the prediction or classification.

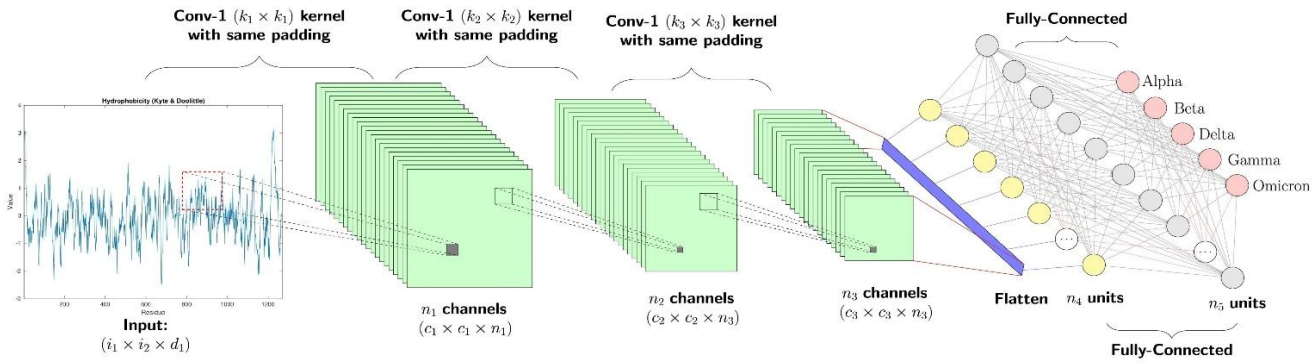
The learning process involves **Forward Propagation** (calculating the output) and **Backpropagation** (calculating the error and updating weights via an optimizer like Gradient Descent to minimize loss).

2. Convolutional Neural Networks (CNN)

Convolutional Neural Networks are specialized neural networks designed primarily for processing grid-like data, such as images. They are distinct from standard ANNs because they preserve the spatial relationship between pixels. Key components include:

- **Convolutional Layer:** This layer applies a set of learnable filters (kernels) to the input image. As the filter slides (convolves) across the image, it creates a "feature map" that detects specific features like edges, textures, or shapes.
- **Pooling Layer:** Pooling reduces the dimensionality of the feature maps (down-sampling) while retaining the most important information. **Max Pooling** is the most common type, taking the largest value in a specific window. This makes the model more robust to variations in the position of features.
- **Fully Connected Layer:** After several convolution and pooling layers, the data is flattened into a vector and fed into a standard dense network for final classification.

CNNs have revolutionized computer vision, powering technologies like facial recognition, medical image analysis, and self-driving cars.



3. Recurrent Neural Networks (RNN)

Recurrent Neural Networks are designed for sequential data. Unlike feedforward networks where inputs are independent, RNNs use information from previous inputs to influence the current input and output. This makes them useful for tasks like language translation and speech recognition.

The core idea is that the network has a "memory" loop. It takes the output from the previous step and feeds it back into the network along with the current input. This allows the network to handle sequences of varying lengths.

4. Generative Adversarial Networks (GAN)

A Generative Adversarial Network is a framework used to generate new data instances that resemble training data. For example, GANs can create realistic images of human faces that do not actually exist.

The system consists of two neural networks:

1. **The Generator:** Tries to create fake data.
2. **The Discriminator:** Tries to determine if the data is real or fake.

They work together to improve the quality of the generated output.

5. Transformers and Attention Mechanisms