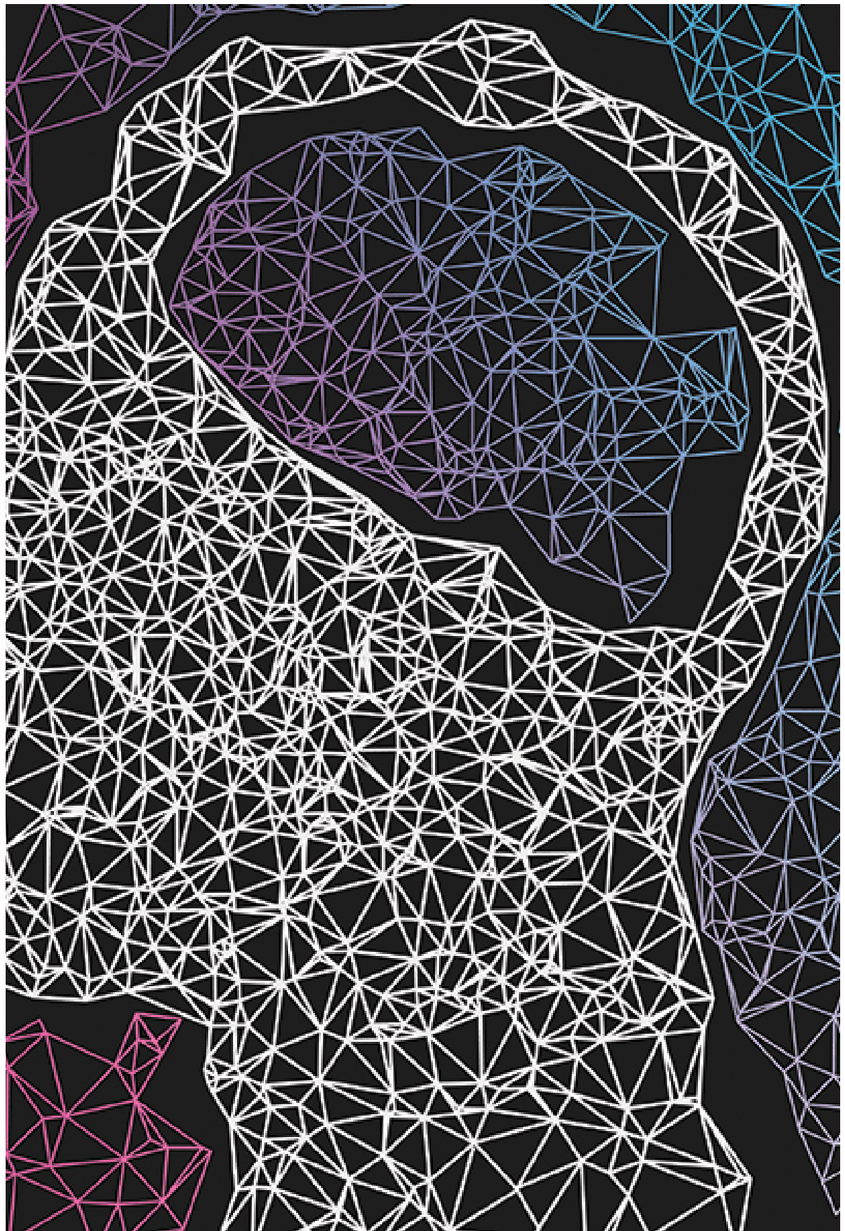
DEEP NEURAL NETWORKS



ENG19CS0367
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WHAT ARE DEEP NEURAL NETWORKS?

To start with, Deep Learning is a subfield of machine learning concerned with algorithms inspired by the structure and function of the brain called artificial neural networks.

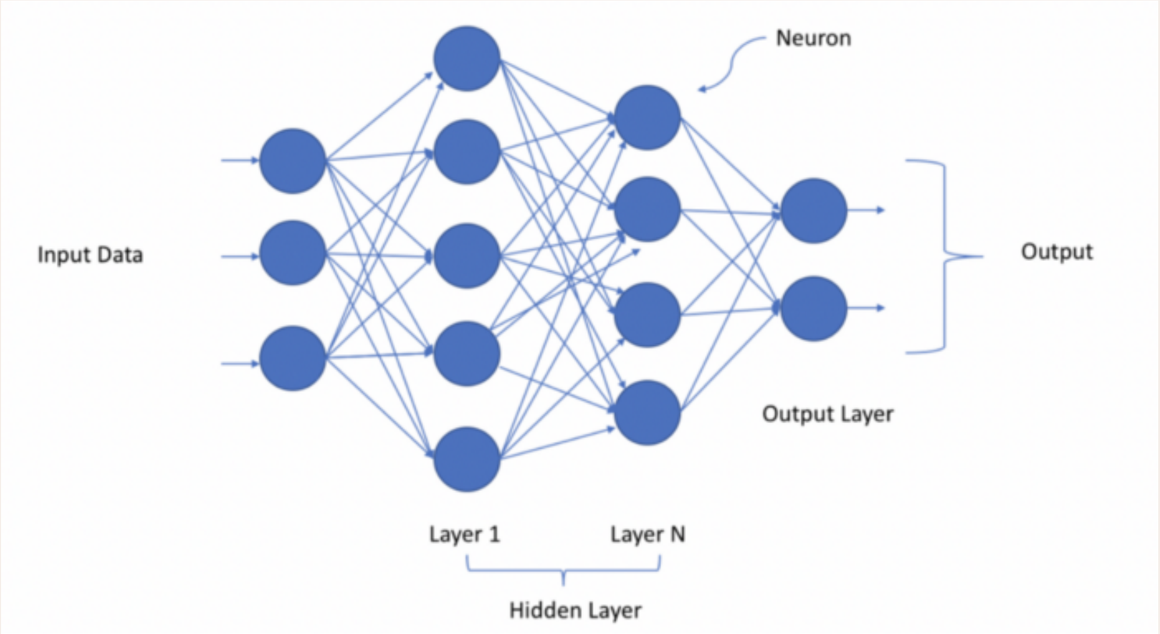
WHAT ARE NEURAL NETWORKS?

Their name and structure are inspired by the human brain, mimicking the way that biological neurons signal to one another.

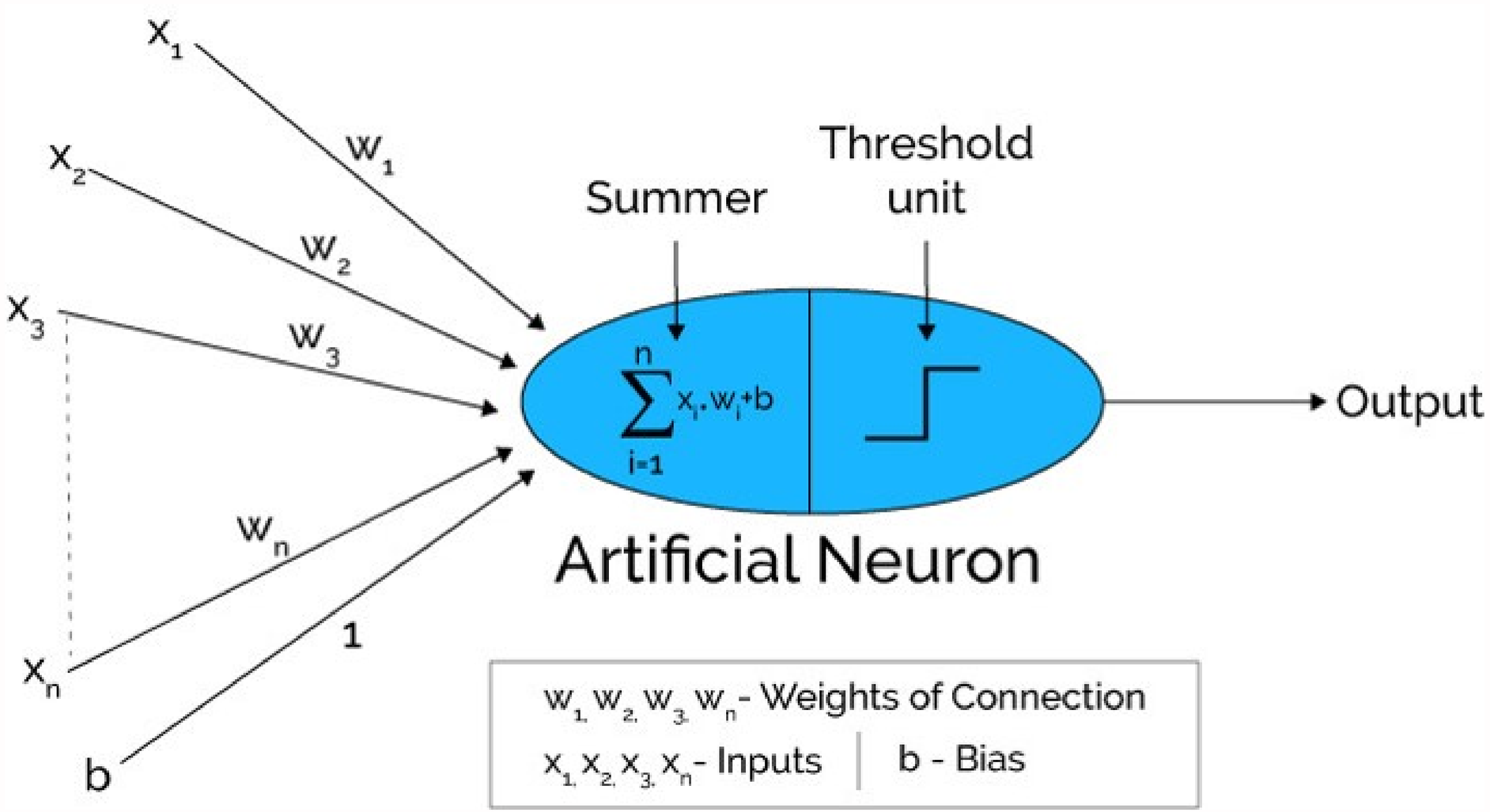
At its simplest, a neural network with some level of complexity, usually at least two layers, qualifies as a deep neural network (DNN)

A BRIEF ON NEURAL NETWORKS

A simplified version of Deep Neural Network is represented as a hierarchical (layered) organization of neurons (similar to the neurons in the brain) with connections to other neurons. These neurons pass a message or signal to other neurons based on the received input and form a complex network that learns with some feedback mechanism.



HOW DOES A DNN WORK?



HOW DOES A DNN WORK?

Step 1 : Input units are passed i.e data is passed with some weights attached to it to the hidden layer.

Weights are the coefficient of each variable. It shows the strength of the particular input variable. A variable with greater weight means it must be given more importance by the model.

Step 2 : Each hidden layer consists of neurons. All the inputs are connected to each neuron. And all the operations/calculations are performed in the hidden layers. The blue oval in picture.

Step 3 : The computation is done as follows,

HOW DOES A DNN WORK?

Step 3 : First of all, all the inputs are multiplied by their weights.

$$Z1 = W1*In1 + W2*In2 + W3*In3 + W4*In4 + W5*In5 + B$$

Wi are the weights for Inputs 'In'
B is Bias, it is a constant that helps the model to fit in the best way possible.

After the first step, the activation function is applied to the linear equation Z1.

The activation function is a nonlinear transformation that is applied to the input before sending it to the next layer of neurons. The importance of the activation function is to introduce nonlinearity in the model.

HOW DOES A DNN WORK?

Step 4 : The whole process described in Step 3 is performed in each hidden layer. After passing through every hidden layer, we move to the last layer i.e our output layer which gives us the final output.

The process explained above is known as **Forwarding Propagation**.

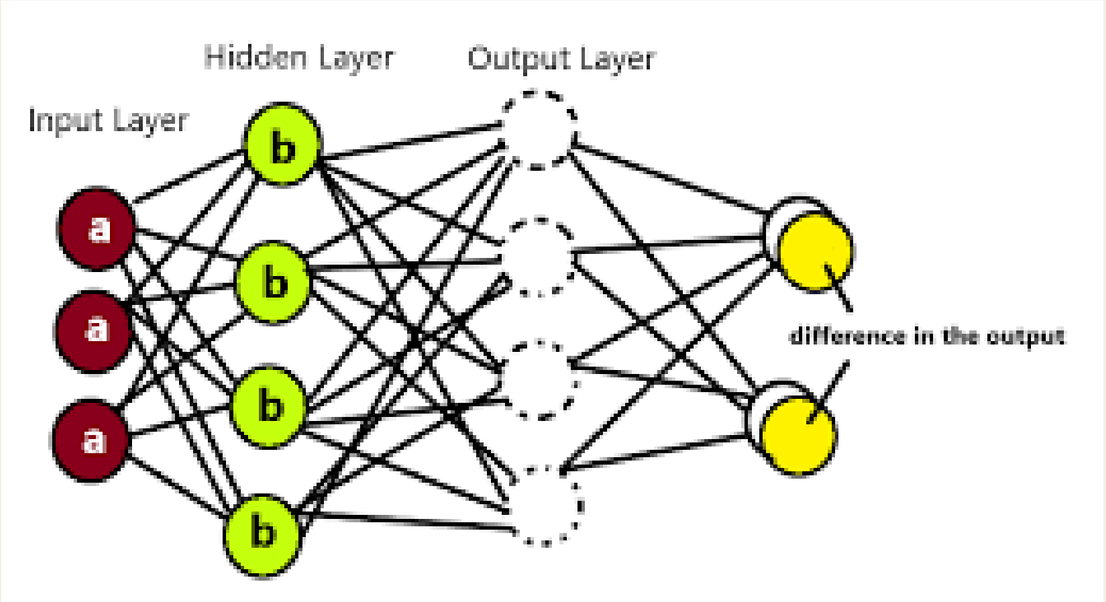
Step 5 : After getting the predictions from the output layer, the error is calculated i.e the difference between the actual and the predicted output.

If the error is large then we perform **Backward Propagation**, which is used to minimize the error.

WHAT IS BACK PROPOGATION?

Back Propagation is the process of updating and finding the optimal values of weights or coefficients which helps the model to minimize the error i.e difference between the actual and predicted values.

Initial weights are w1,w2,w3



Weights after backward propagation are W1,W2,W3

Because of the difference in output, we use back propagation to tune weights

WHAT ARE THE DIFFERENT ACTIVATION FUNCTIONS?

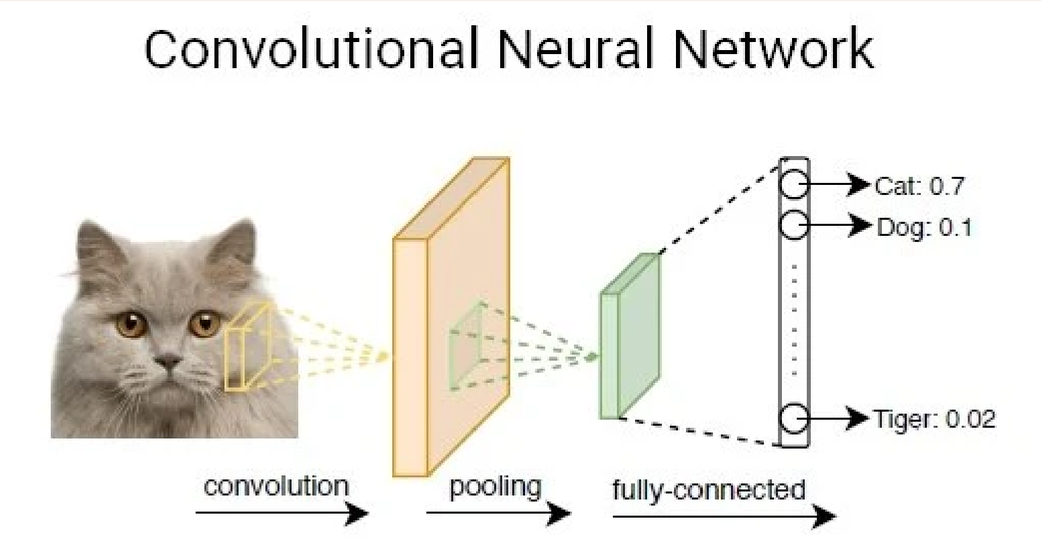
Activation functions are functions used in a neural network to compute the weighted sum of inputs and biases, which is in turn used to decide whether a neuron can be activated or not. It manipulates the presented data and produces an output.

Common activation functions are:

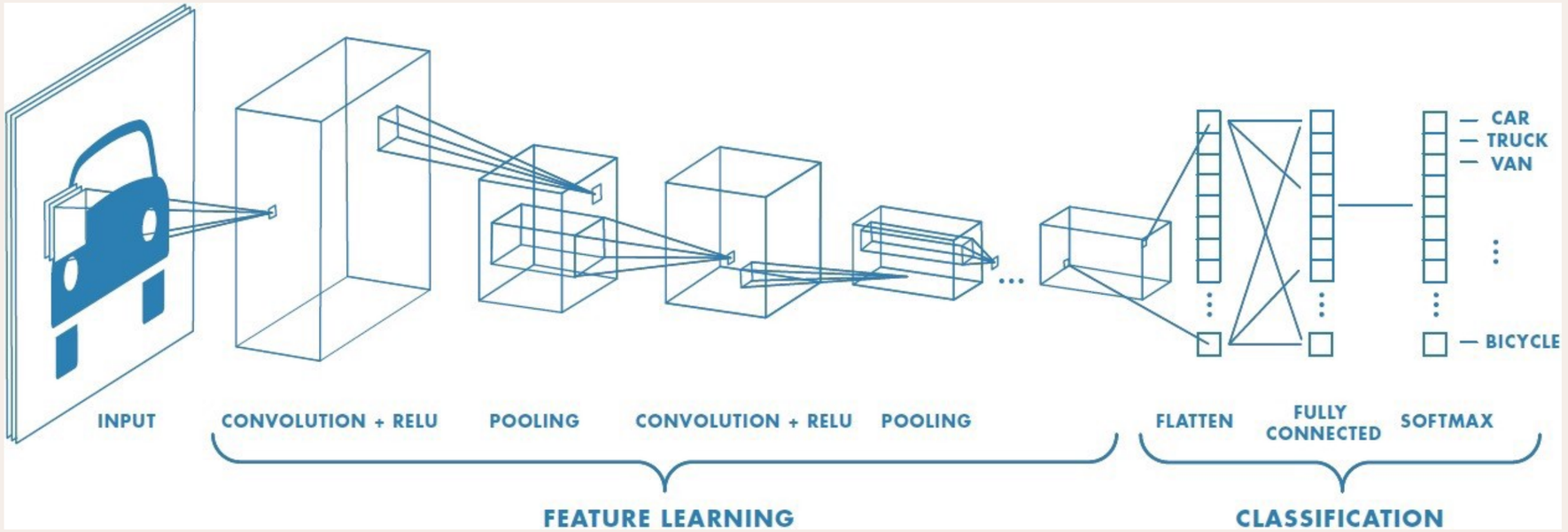
- **Sigmoid**: sigmoid takes a real value as the input and outputs another value between 0 and 1.
- **TanH**: Unlike a sigmoid function that will map input values between 0 and 1, the Tanh will map values between -1 and 1.
- **ReLU**: The formula is deceptively simple: max(0,z).

CONVOLUTIONAL NEURAL NETWORKS

A convolutional neural network (CNN, or ConvNet) is another class of deep neural network. CNN's are most commonly employed in computer vision. Given a series of images or videos from the real world, with the utilization of CNN, the model learns to automatically extract the features of these inputs to complete a specific task, e.g., **image classification, face authentication, and image semantic segmentation.**



HOW DOES CNN WORK?

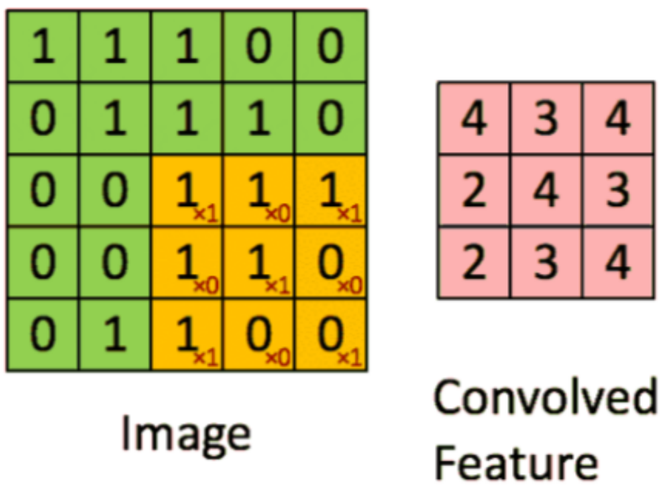


A ConvNet is able to successfully capture the dependencies in an image through the application of relevant filters. The architecture performs a better fitting to the image dataset which means the network can be trained to understand the sophistication of the image better.

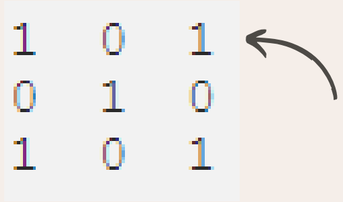
HOW DOES CNN WORK?

The role of the CNN is to reduce the images into a form that is easier to process, without losing features that are critical for getting a good prediction.

This is important when we are to design a model that is not only good at learning features but also is scalable to massive datasets.



The 5x5 image matrix is reduced to 3x3 matrix, by using a 3x3 kernel. The whole kernel matrix traverses through the image matrix and multiplies the respective values to obtain a convoluted matrix.



Kernel Matrix for reducing dimensions

HOW DOES CNN WORK?

The kernel matrix shifts according to the stride length, so if a neural network's stride is set to 1, the filter will move one pixel, or unit, at a time.

CNN must extract important features that are present in the corners and for this, we use the concept of padding. This is used to not lose information in corners.

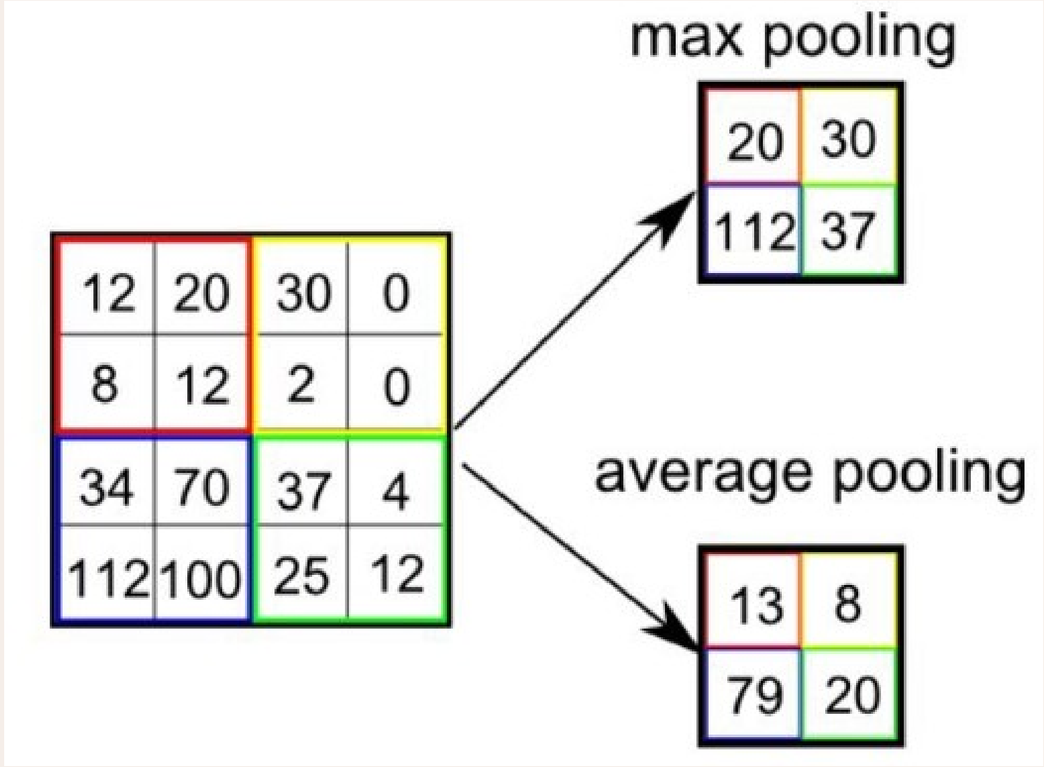
After this we obtain a convoluted matrix, the convoluted matrix will further be reduced to a compact matrix using pooling. It can be **max pooling** or **average pooling**.

This is to decrease the computational power required to process the data through dimensionality reduction.

HOW DOES CNN WORK?

There are two types of Pooling: Max Pooling and Average Pooling.

- **Max Pooling** returns the maximum value from the portion of the image covered by the Kernel.
- **Average Pooling** returns the average of all the values from the portion of the image covered by the Kernel.



HOW DOES CNN WORK?

Activation functions introduce non-linearity to the model which allows it to learn complex functional mappings between the inputs and response variables.

There are quite a few different activation functions like sigmoid, tanh, RelU, Leaky RelU, etc.

RelU function is a piecewise linear function that outputs the input directly if is positive i.e. > 0, otherwise, it will output zero.

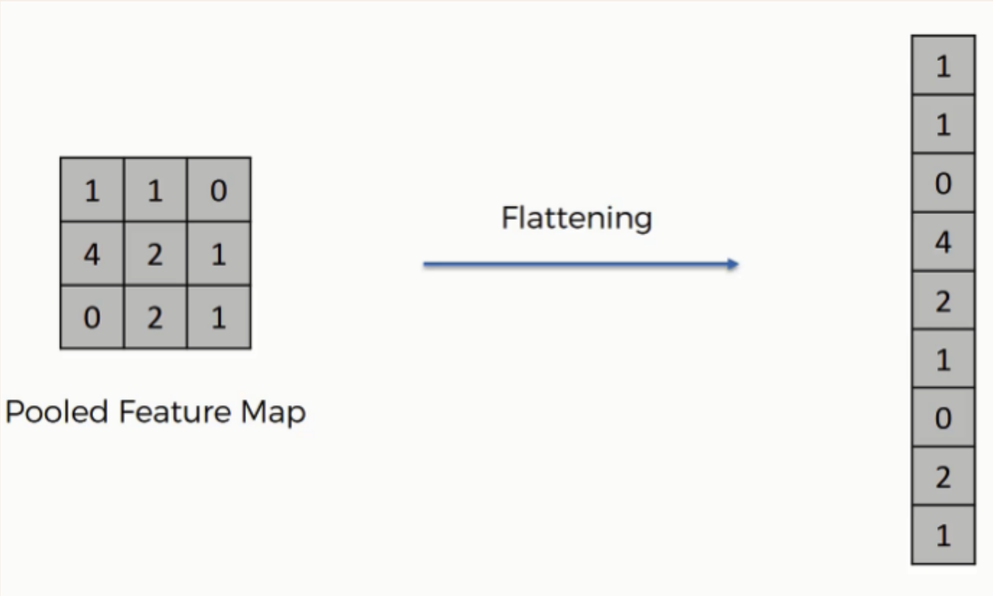
$$ReLU(x)=max(0,x)$$

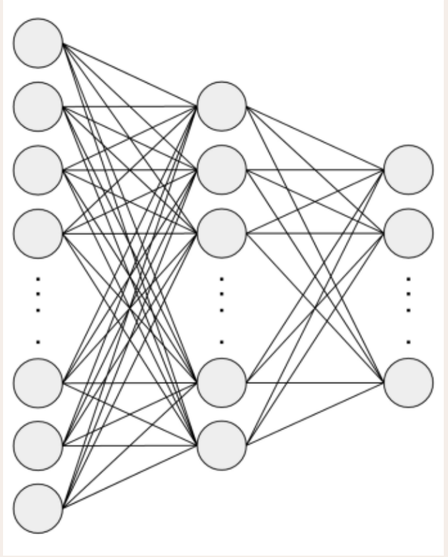
HOW DOES CNN WORK?

After doing Convolution, Pooling, ReLU we move on to flattening and fully connecting the layers.

Flattening converts a double dimensional array to a single dimensional array.

In a fully connected layer the input layer nodes are connected to every node in the second layer.





Connecting the layers

APPLICATIONS OF CNN

Image Classification – Search Engines, Social Media, Recommender Systems
The major use of convolutional neural networks is image recognition and classification. It is also the only use case involving the most advanced frameworks (especially, in the case of medical imaging).

- **Face recognition** deserves its own section. This subset of image recognition deals with more complex images. Such images could include human faces or other living beings such as animals, fish, and insects.
- The most fascinating image recognition CNN use case is **medical image computing**. The medical image includes a whole lot of further data analysis that arises from initial image recognition. CNN medical image classification detects anomalies in X-ray and MRI images with better accuracy than the human eye.

WHAT IS RNN?

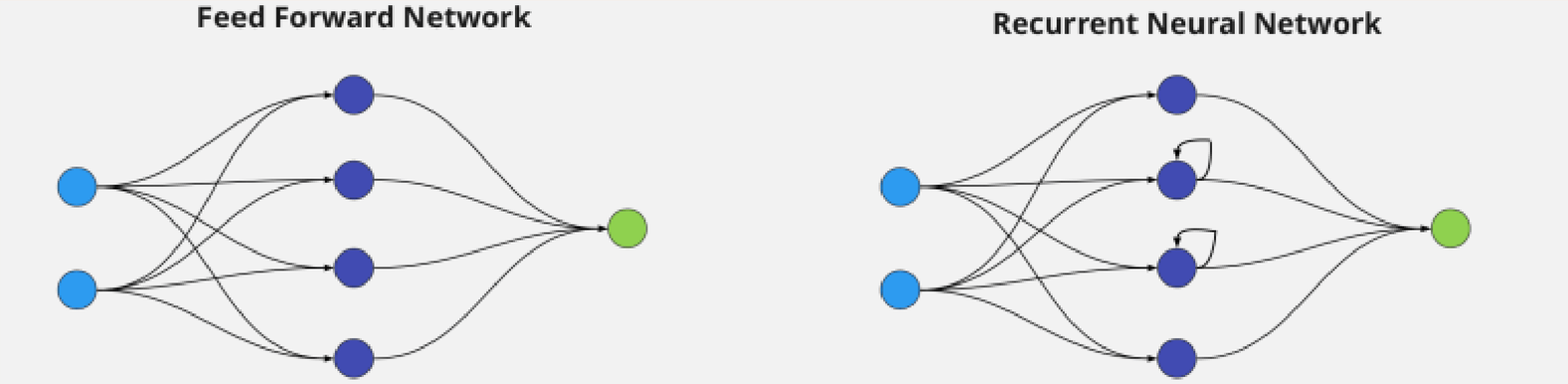
For instance, have you wondered Google voice search and Siri works?

In simple terms, sequential data is used for the voice search mechanism behind such technology. To implement sequential data efficiently, the algorithm responsible for making it a possibility is Recurrent neural networks (RNN).

What is sequential data? It is a text message, voice data, audio data, and time series.

Such "predicting the sequence" is possible because RNN has the concept of internal memory. Due to internal memory, **RNN's are capable of remembering essential information about an input they have received.** This is crucial for predicting outcomes more precisely.

HOW DOES RNN WORK?



- In a feed-forward neural network, the information can move in one direction only.
- i.e., from the input layer to the hidden layer and then to the output layer. You need to note that once the information passes, it moves in a straight direction.
- It has no perception of what has happened in the past except the training procedures.

- In RNN, the information that passed through the architecture goes through a loop.
- Each input is dependent on the previous one for making decisions. RNN assigns the same and equal weight and bias for each of the layers in the network.
- Therefore all, the independent variables are converted to dependent variables.
- The loops in RNN ensures the information is preserved in its memory

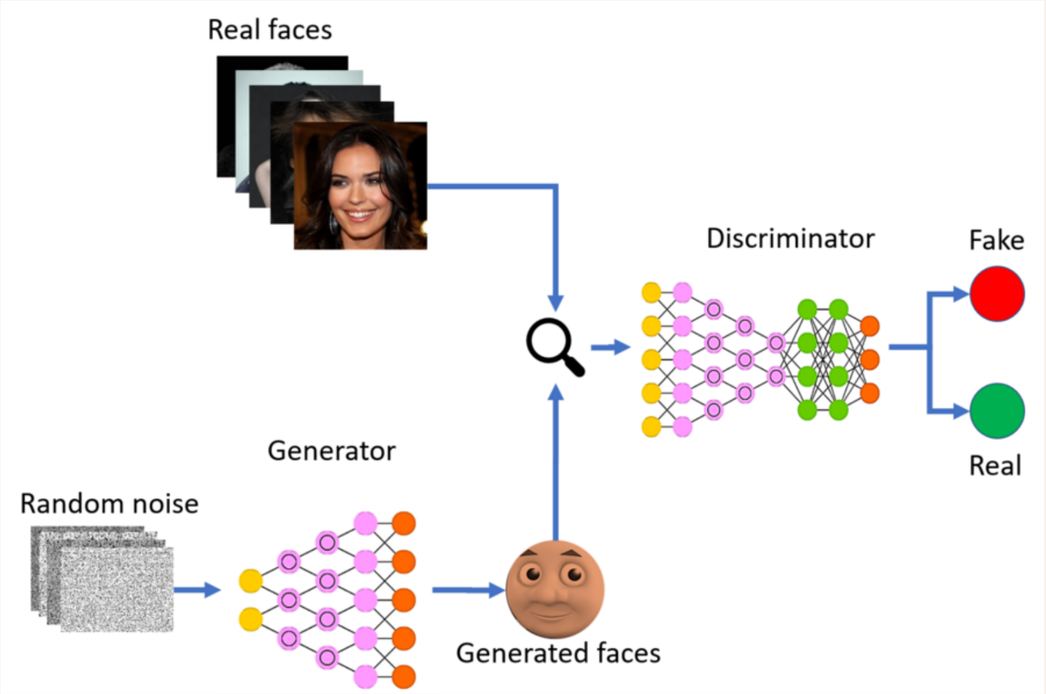
APPLICATIONS OF RNN

RNNs have shown the great potential of being a reliable neural network.

- **Speech Recognition**: You may be surprised to discover that some of the most popular personal assistants are powered by speech recognition technology. They are used for Google Assistant, Alexa by Amazon, Apple's Siri, and your smart driving assistance systems as well.
- **Machine Translation**: Machine Translation allows us to have automation in the process of language translation tasks. This is possible with the help of deep learning technologies. RNNs are useful for tasks that help to learn patterns from a dataset.
- **Sentiment analysis** is among the most common applications in the field of natural language processing. This is a method to identify whether a writer's viewpoint towards a topic is positive or negative.

WHAT IS GAN?

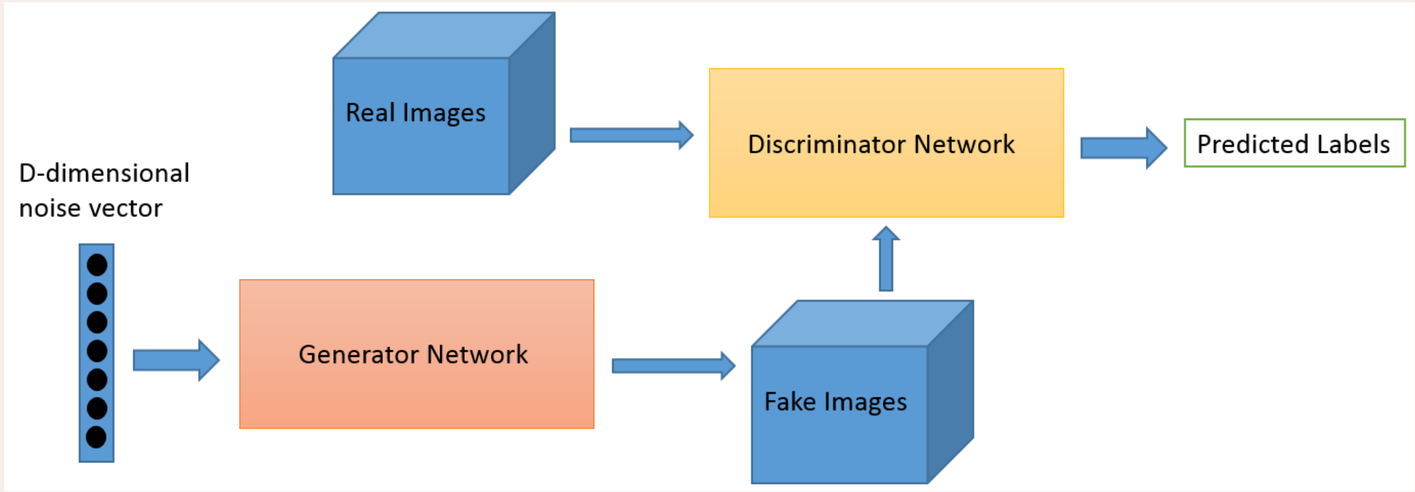
Generative adversarial networks (GANs) consists of two models that compete with each other to analyze, capture and copy the variations within a dataset. They are used widely in image generation, video generation and voice generation.



HOW DOES GAN WORK?

A GAN is a generative model that is trained using two neural network models. One model is called the "generator" or "generative network" model that learns to generate new plausible samples. The other model is called the "discriminator" or "discriminative network" and learns to differentiate generated examples from real examples.

The two models are set up in a contest or a game (in a game theory sense) where the generator model seeks to fool the discriminator model, and the discriminator is provided with both examples of real and generated samples.



APPLICATIONS OF GAN

GANs have very specific use cases and those are:

- **Generating Cartoon Characters** - Using DCGAN, you can create faces of anime and Pokemon characters.
- **Generating Human Faces** - can be trained on the images of humans to generate realistic faces.
- **Text to image translation** - can build realistic images from textual; descriptions of simple objects like birds.
- **3-D generation** - can generate 3-dimensional models from 2-dimensional pictures of objects from multiple perspectives.

IMPLEMENT CNN NETWORK FOR HANDWRITTEN DIGITS

THANK YOU