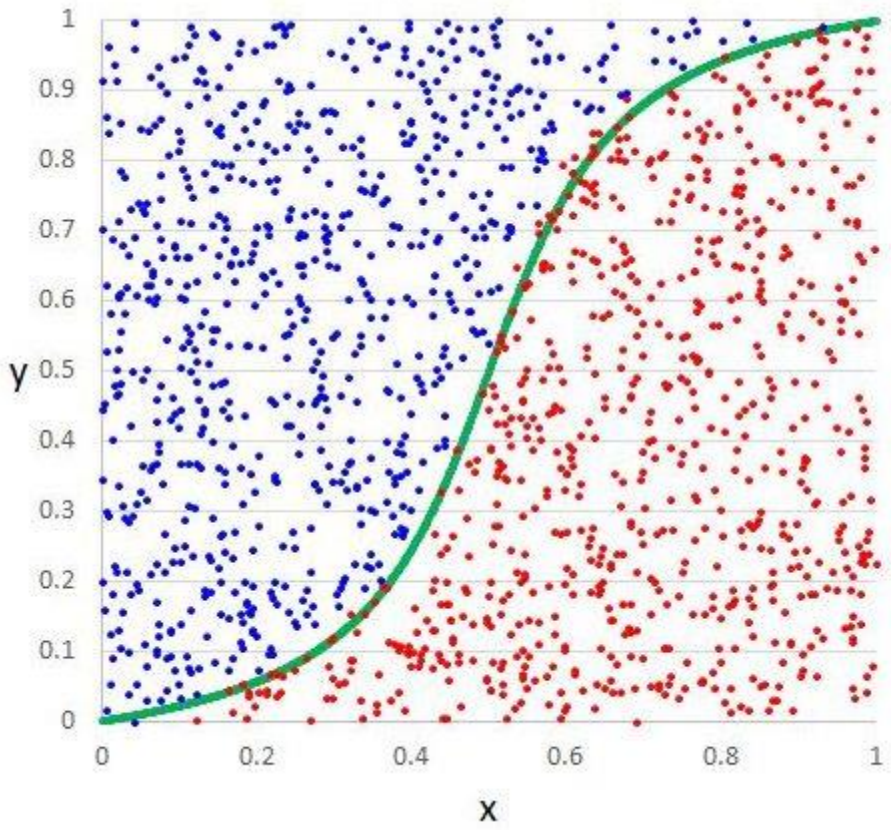
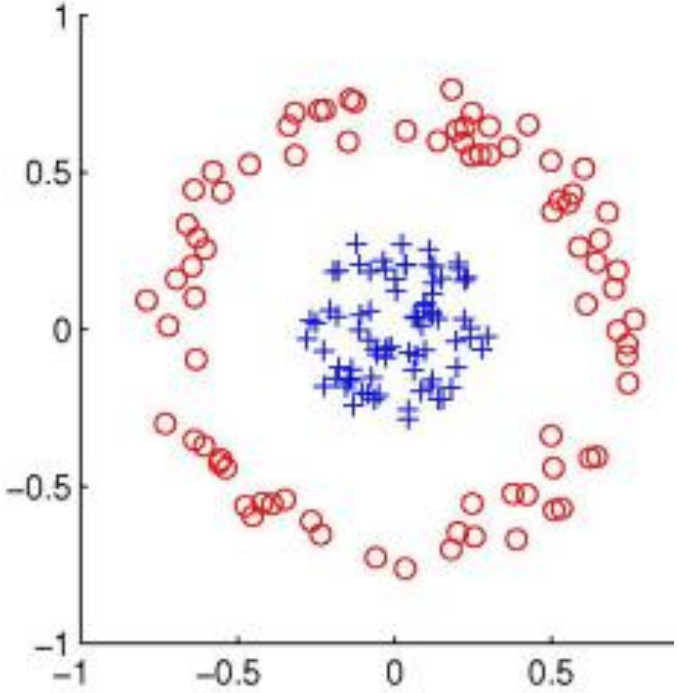
CNN vs. RNN vs. ANN

Machine Learning vs. Deep Learning: Decision Boundary



- For example, in the case of logistic regression, the learning function is a Sigmoid function that tries to separate the 2 classes

Machine Learning vs. Deep Learning: Decision Boundary



- As you can see here, the logistic regression algorithm learns the linear decision boundary. It cannot learn decision boundaries for nonlinear data like this one

Machine Learning vs. Deep Learning: Decision Boundary

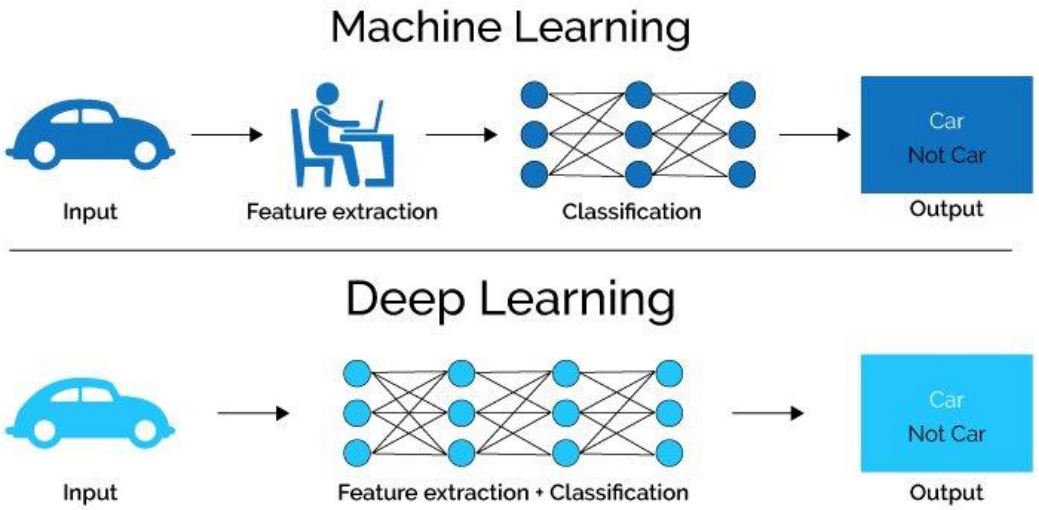
- Similarly, every Machine Learning algorithm is not capable of learning all the functions. This limits the problems these algorithms can solve that involve a complex relationship.

Machine Learning vs. Deep Learning: Feature Engineering

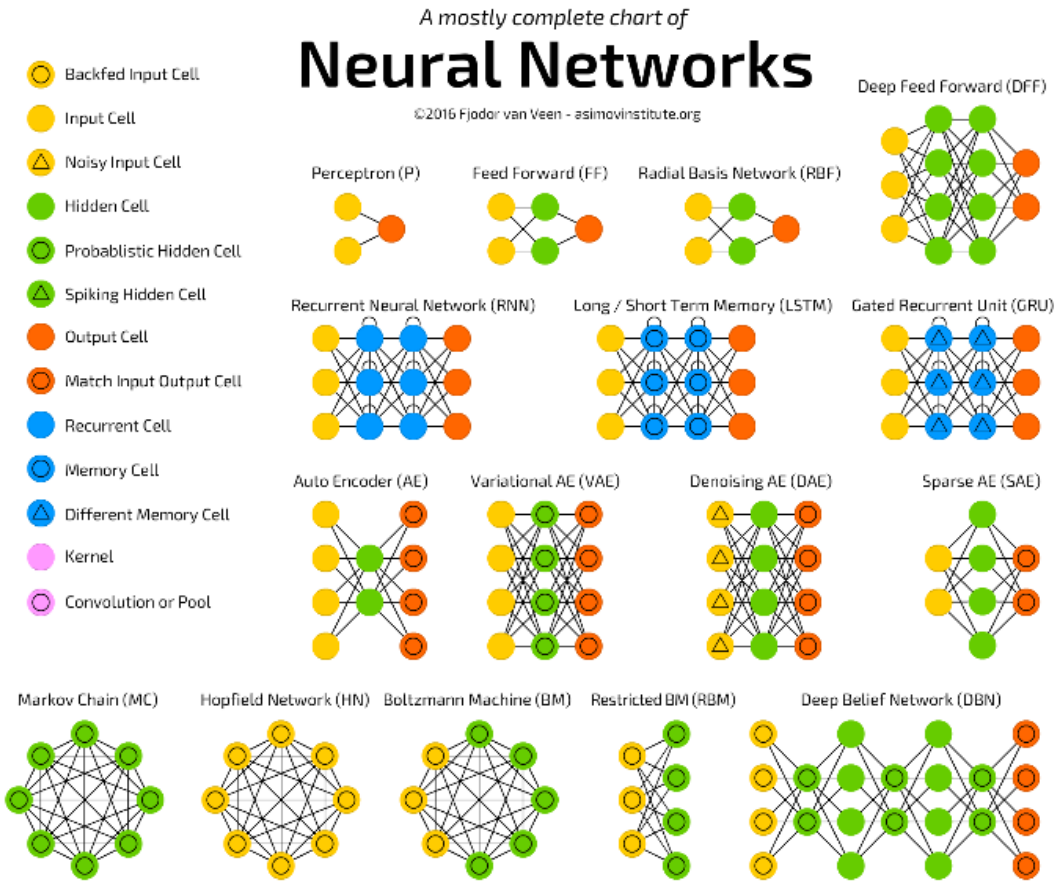
- Feature engineering is a key step in the model building process. It is a two-step process:
  - **Feature extraction**
  - **Feature selection**
- In feature extraction, we extract all the required features for our problem statement and in feature selection, we select the important features that improve the performance of our machine learning or deep learning model.

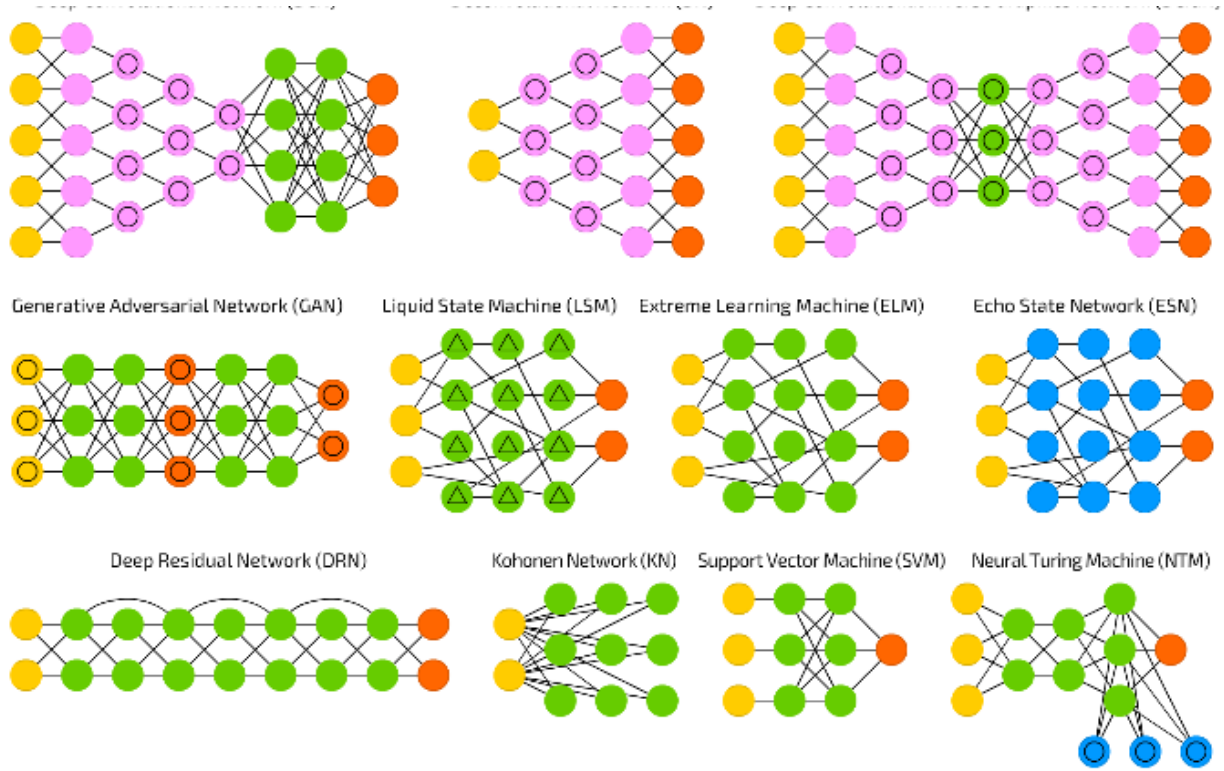
Machine Learning vs. Deep Learning: Feature Engineering

- Consider an image classification problem. Extracting features manually from an image needs strong knowledge of the subject as well as the domain. It is an extremely time-consuming process. Thanks to **Deep Learning**, we can automate the process of Feature Engineering!



Different types of Neural Networks in Deep Learning





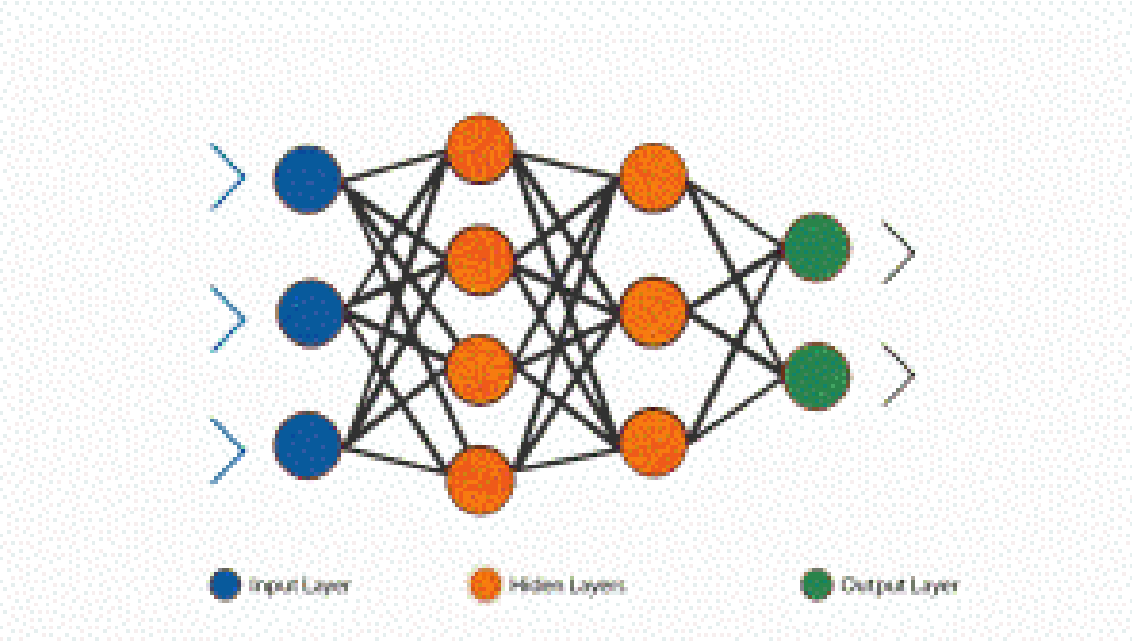
Different types of Neural Networks in Deep Learning

- Artificial Neural Networks (ANN)
- Convolution Neural Networks (CNN)
- Recurrent Neural Networks (RNN)

ANN (Feed Forward)

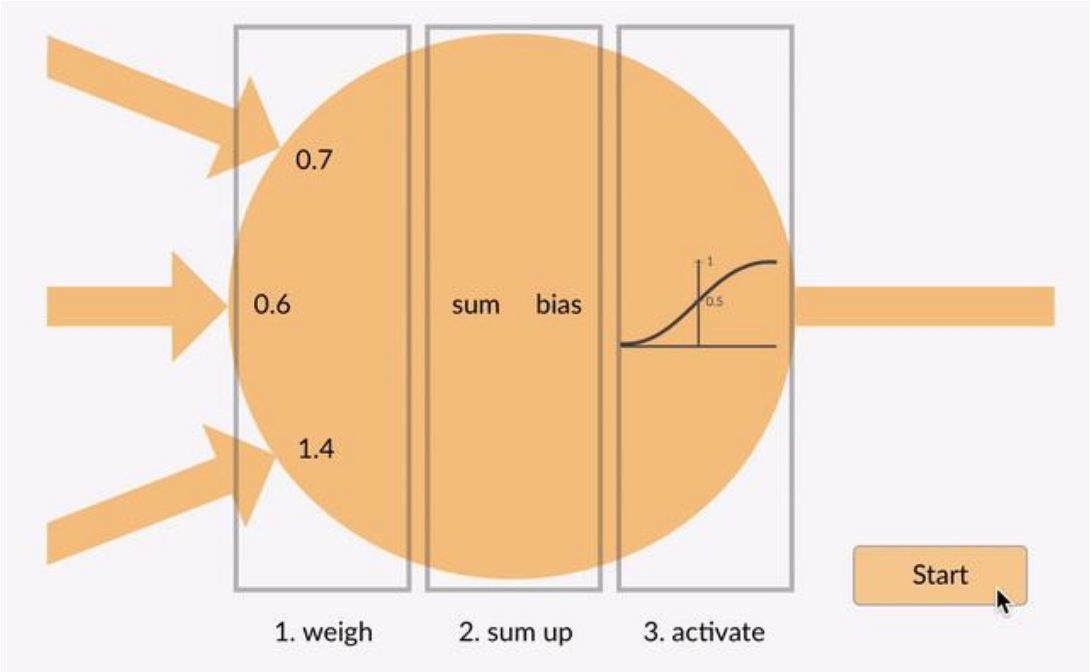
Artificial Neural Network (ANN) – What is a ANN and why should you use it?

- A single perceptron (or neuron) can be imagined as a Logistic Regression. Artificial Neural Network, or ANN, is a group of multiple perceptrons/ neurons at each layer. ANN is also known as a **Feed-Forward Neural network** because inputs are processed only in the forward direction



Advantages of Artificial Neural Network (ANN)

- One of the main reasons behind universal approximation is the **activation function**. Activation functions introduce nonlinear properties to the network. This helps the network learn any complex relationship between input and output.



Challenges with Artificial Neural Network (ANN)

Advantages

- Storing information on the entire network.
- Ability to work with incomplete knowledge.
- Having fault tolerance.
- Having a distributed memory.

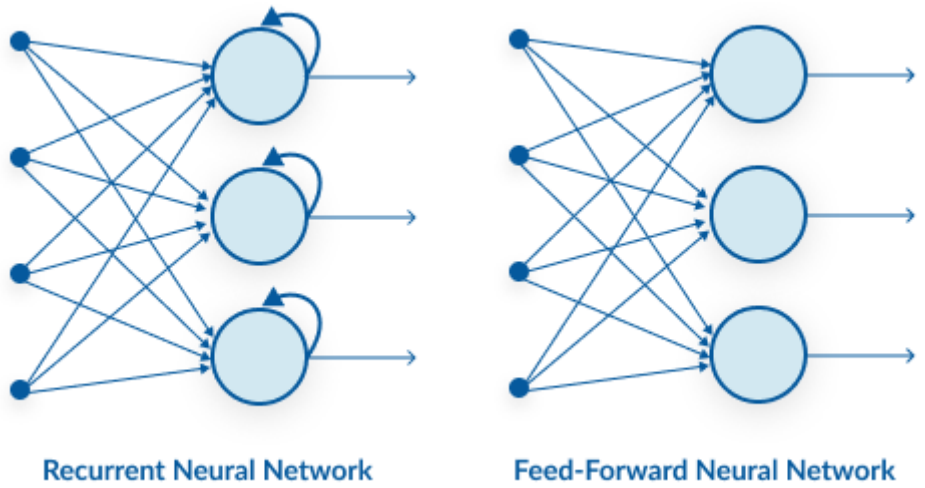
Disvantages

- Hardware dependence.
- Unexplained behavior of the network.
- Determination of proper network structure.

RNN

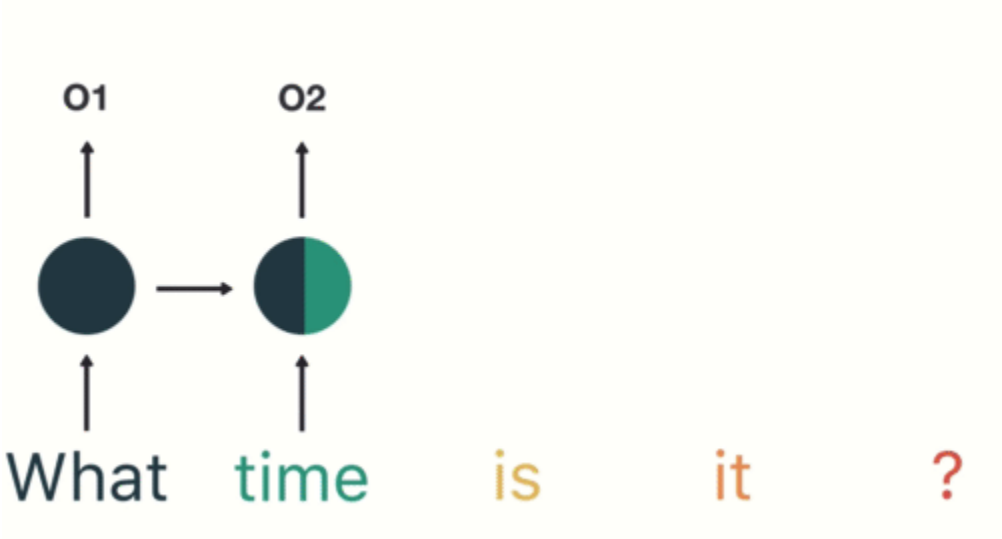
Recurrent Neural Network (RNN) – What is an RNN and why should you use it?

- RNN has a recurrent connection on the hidden state. This looping constraint ensures that sequential information is captured in the input data.

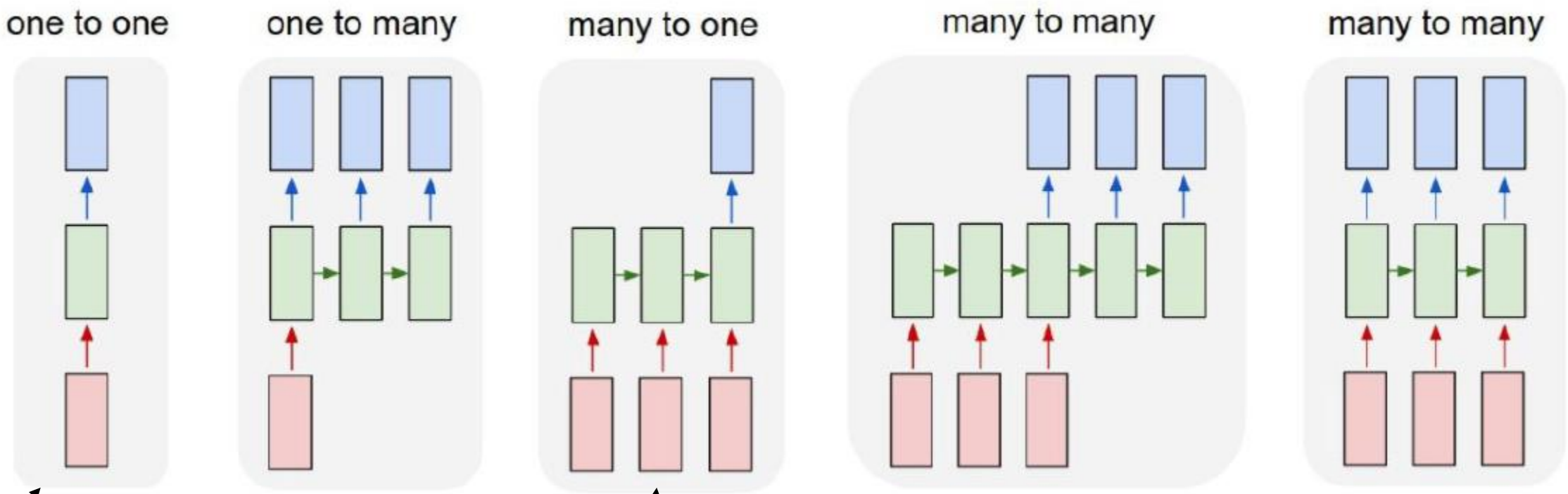


Advantages of Recurrent Neural Network (RNN)

- RNN captures the sequential information present in the input data i.e. dependency between the words in the text while making predictions.



Flexibility of Recurrent Neural Networks



Vanilla Neural Networks

e.g. **Image Captioning**
image -> sequence of words

e.g. **Sentiment Classification**
sequence of words -> sentiment

e.g. **Machine Translation**
seq of words -> seq of words

e.g. **Video classification on frame level**

Image Captioning

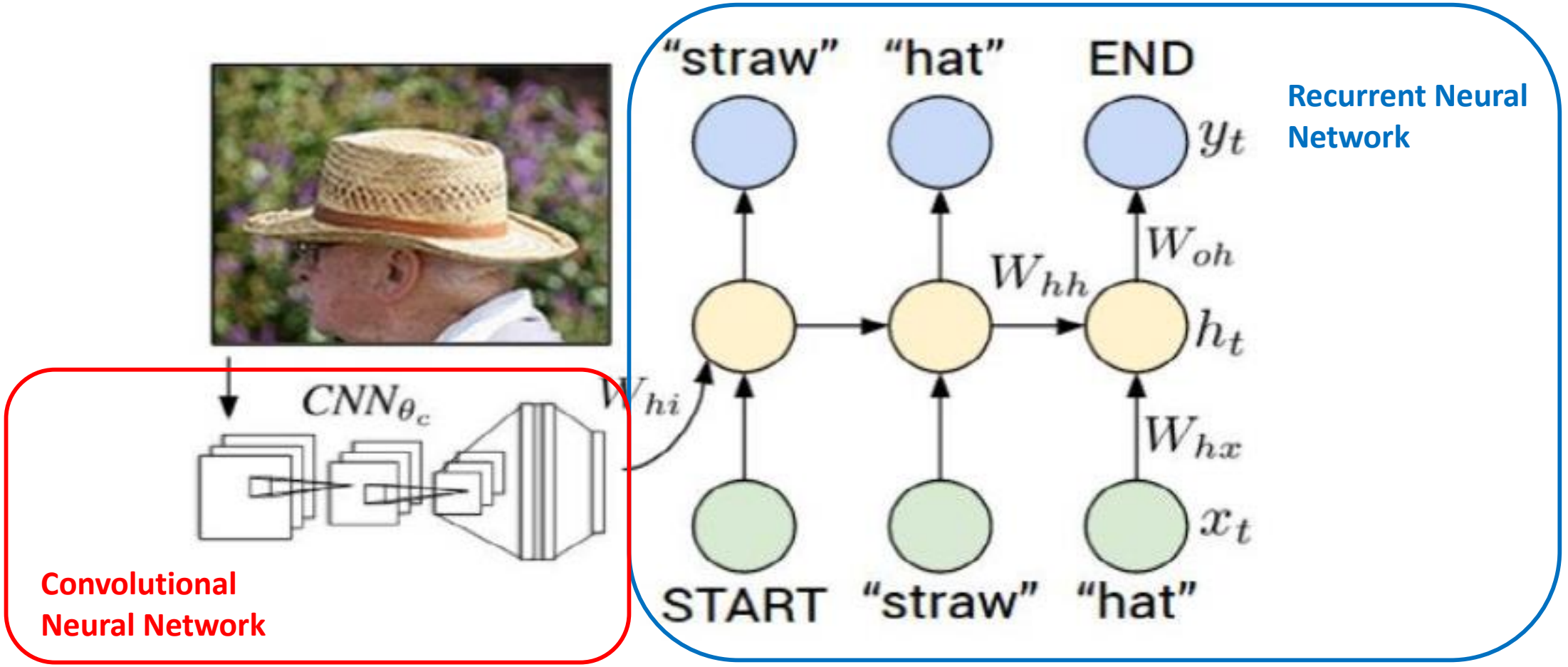


Image Sentence Datasets

a man riding a bike on a dirt path through a forest.
bicyclist raises his fist as he rides on desert dirt trail.
this dirt bike rider is smiling and raising his fist in triumph.
a man riding a bicycle while pumping his fist in the air.
a mountain biker pumps his fist in celebration.

Microsoft COCO
[Tsung-Yi Lin et al. 2014]
mscoco.org

Challenges with Recurrent Neural Network (RNN)

Advantages

- An RNN remembers each and every information through time. It is useful in time series prediction only because of the feature to remember previous inputs as well. This is called Long Short Term Memory.
- Recurrent neural network are even used with convolutional layers to extend the effective pixel neighborhood.

Disvantages

- Gradient vanishing and exploding problems.
- Training an RNN is a very difficult task.
- It cannot process very long sequences if using tanh or relu as an activation function.

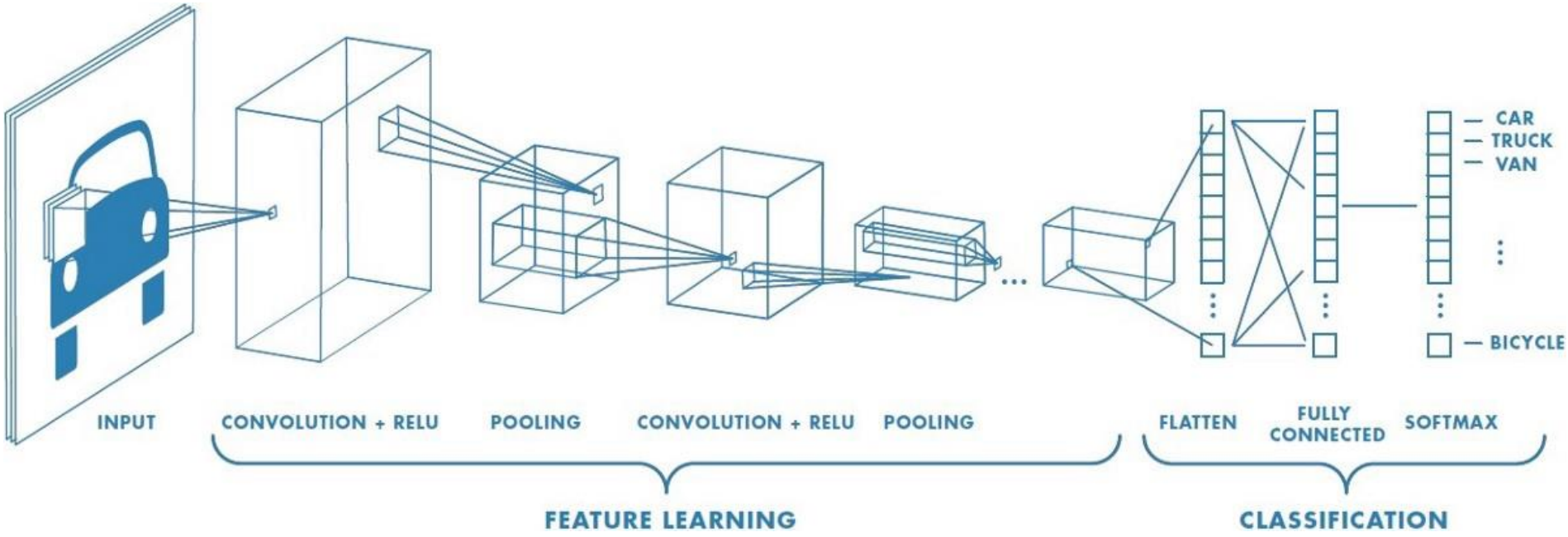
CNN

Convolution Neural Network (CNN) – What is a CNN and Why Should you use it?

- **The building blocks of CNNs are filters a.k.a. kernels.** Kernels are used to extract the relevant features from the input using the convolution operation. Let's try to grasp the importance of filters using images as input data. Convolving an image with filters results in a feature map

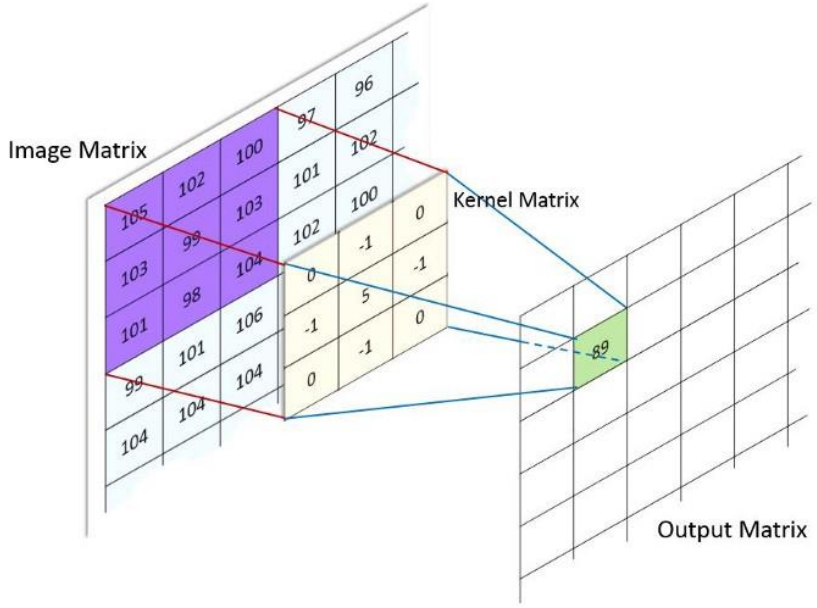
Architecture (CNN)

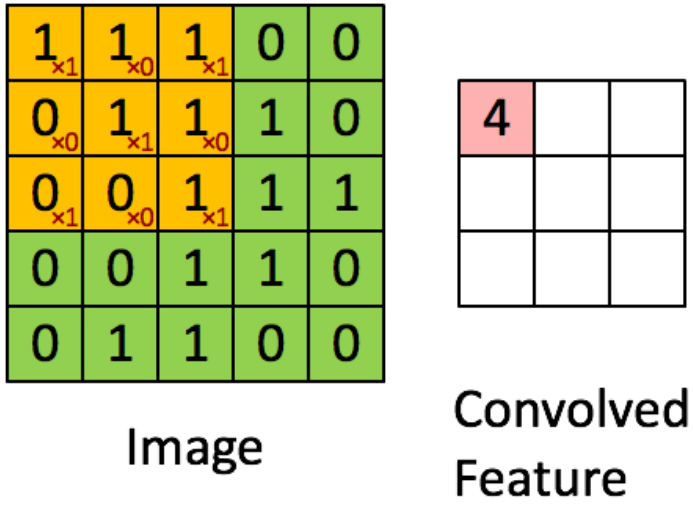
- CNN learns the filters automatically without mentioning it explicitly. These filters help in extracting the right and relevant features from the input data



Convolution (CNN)

- Convolution operates on two signals (in 1D) or two images (in 2D): you can think of one as the "**input**" signal (or image), and the other (called the **kernel**) as a "**filter**" on the input image, producing an output image (so convolution takes two images as input and produces a third as output).



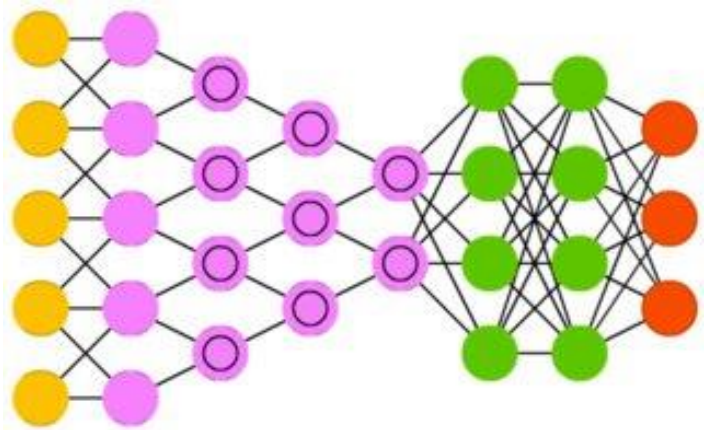


3 layers in the CNN set-up

- **Math Layer**: It's the top layer and understands the number of patterns it sees in the number. The convolutional layer scans and reads the image part and assigns a single number to every unit. The data is stored in a 3D Array.
- **The Rectified Linear Unit Layer- ReLU**: The processed output of the data applied at each level is dealt with ReLU. Less computationally expensive compared to sigmoid and tanh because of simpler computations, ReLU also aids in the declining magnitude of the error.
- **The Fully Connected Layer**: We all need a final layer before we arrive at a definite conclusion regarding the image classification accurately. This layer takes the input from the previous layer such as a ReLU or a convolutional layer and provides an N-dimensional vector output. 'N' here is the number of classes the program picks from.

3 layers in the CNN set-up

- **Math Layer**: If the program is looking at an image of a dog
- **The Rectified Linear Unit Layer- ReLU**: Features found out -> Tail, 4 Legs, Nose, Ears
- **The Fully Connected Layer**: The Fully Connected Layer role is to observe the distinct features and connect with the image provided and gives the output to the user that the above image is of a **dog**



DOG

Challenges with Convolutional Neural Network (CNN)

Advantages

- Very High accuracy in image recognition problems.
- Automatically detects the important features without any human supervision.
- Weight sharing.

Disvantages

- CNN do not encode the position and orientation of object.
- Lack of ability to be spatially invariant to the input data.
- Lots of training data is required.

Comparison

Comparing the Different Types of Neural Networks (MLP(ANN) vs. RNN vs. CNN)

	MLP	RNN	CNN
Data	Tabular Data, Text Data	Sequence data (Time series, Text, Audio)	Image data
Recurrent connections	No	Yes	No
Parameter sharing	No	Yes	Yes
Spatial sharing	No	No	Yes
Spatial relationship	No	No	Yes
Vanishing & Exploding Gradient	Yes	Yes	Yes
Performance	ANN is considered to be less powerful than CNN, RNN.	RNN includes less feature compatibility when compared to CNN.	CNN is considered to be more powerful than ANN, RNN.
Application	Facial recognition and Computer vision, caption generation.	Facial recognition, text digitization and Natural language processing.	Text-to-speech conversions, caption generation.

How can I create a Neural Network?

Languages

- Python
- C/C++
- R
- Matlab
- Java
- Others …

Cloud

- Tensor Flow

https://playground.tensorflow.org

- Colab

https://colab.research.google.com

Libraries & Frameworks

- Tensor flow
- Keras
- PyThorch
- Others …