# Deep Learning

*Neural networks, a beautiful biologically-inspired programming paradigm which enables a computer to learn from observational data*

Dr. Sarwan Singh

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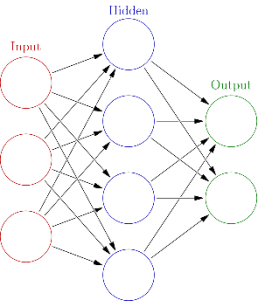
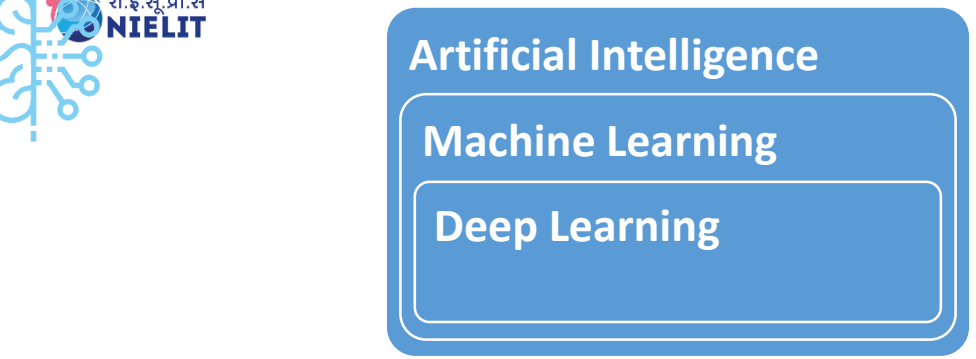
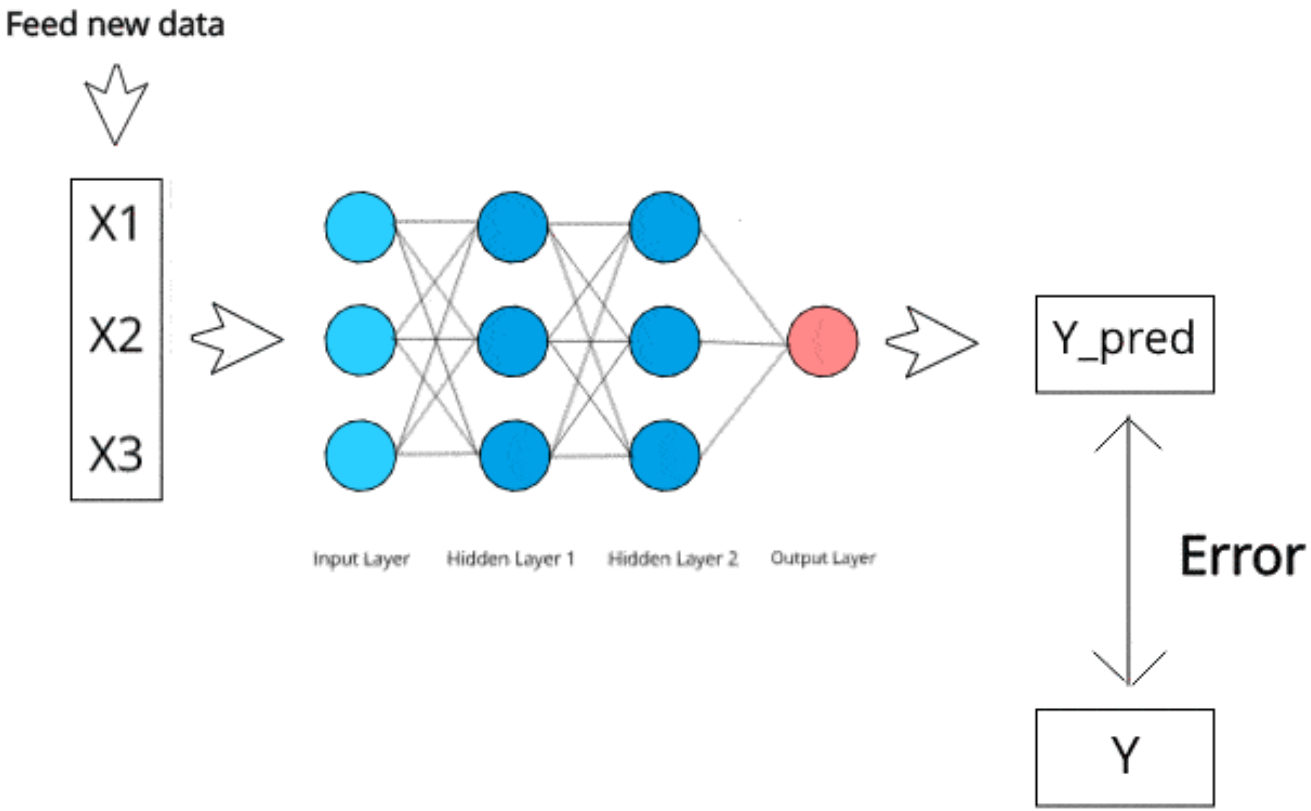




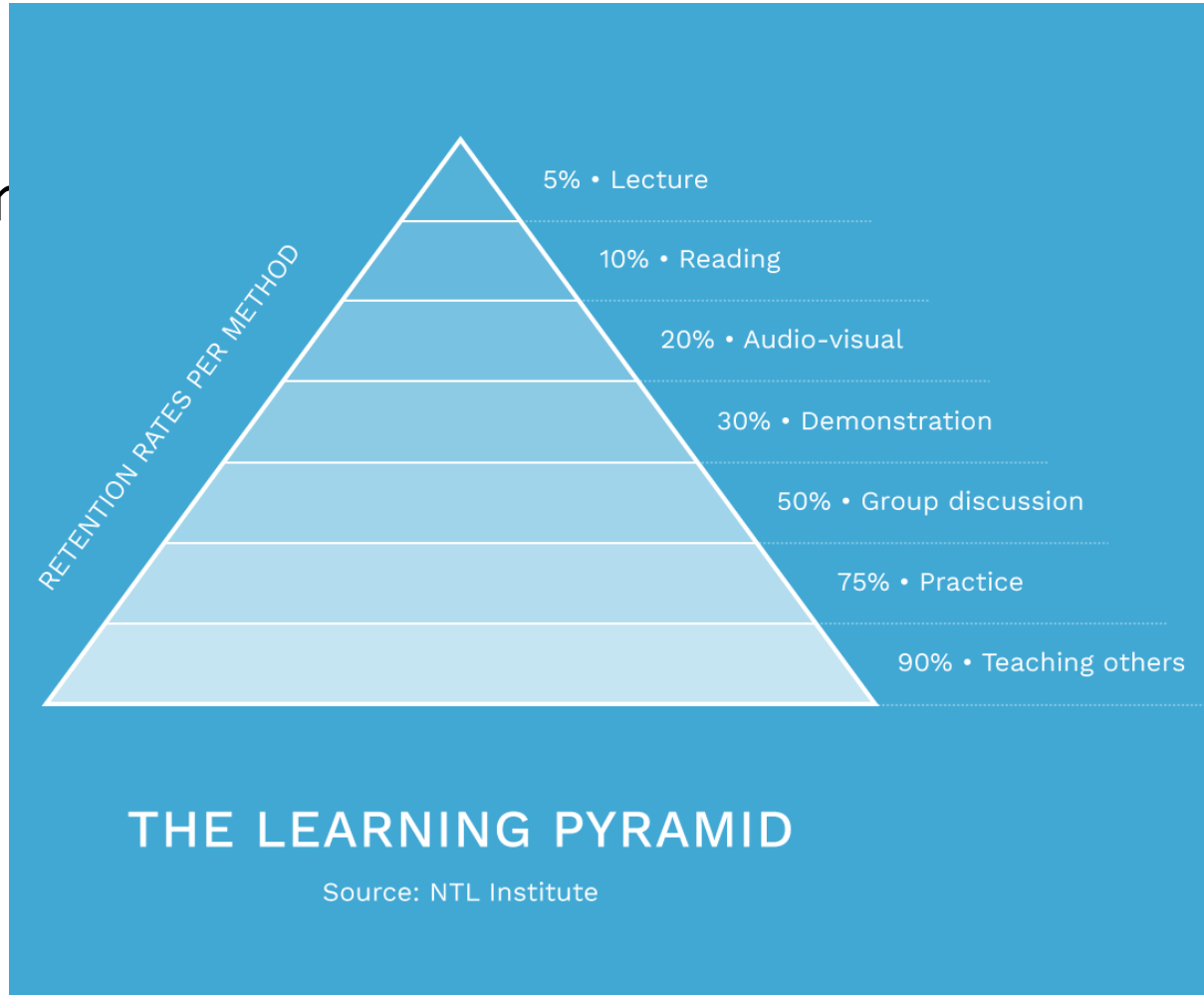

# agenda

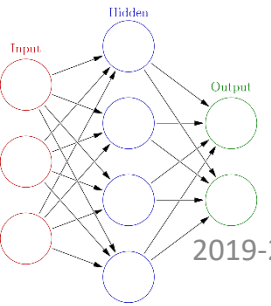
- Deep Learning –
  - Introduction, working, need
- Evolution of Human brain
- Deep learning models
- Road to Deep learning
- Perceptron, Artificial Neural Networks
- Working of Neural Network
- Learning of neural network vs human brain



# References

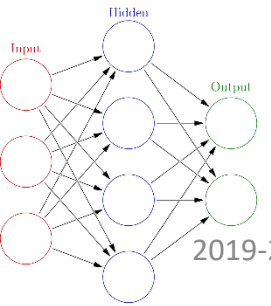
- Medium.com - Deeplearning
- neuralnetworksanddeeplearning.com
- Fundamentals of Deep Learning - *Designing Next-Generation Machine Intelligence Algorithms* … Nikhil B
- Website : Wikipedia , kdnuggets, youtube, simplilearn, mathworks
- Dive into Deep Learning {d2l.ai}



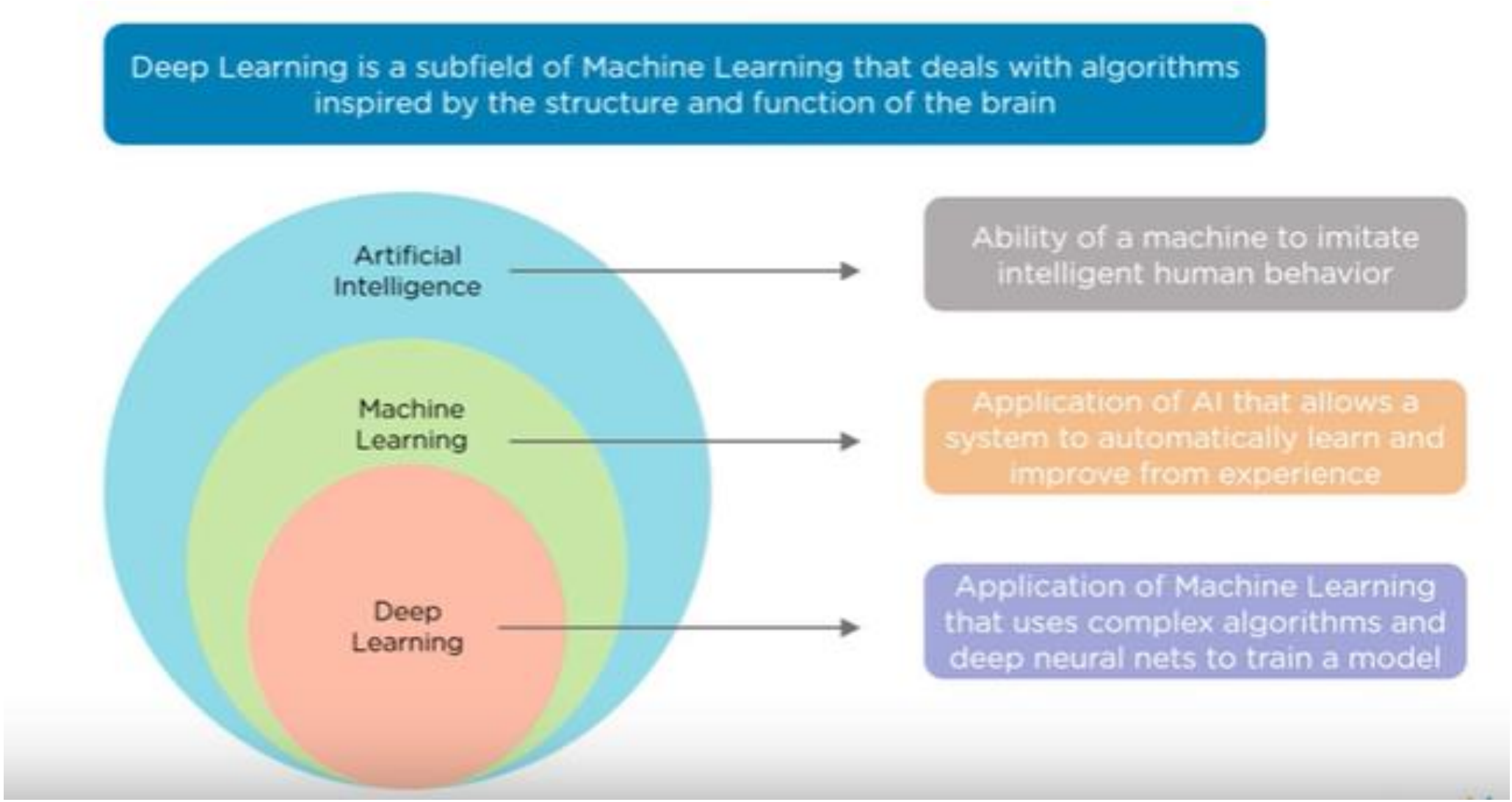



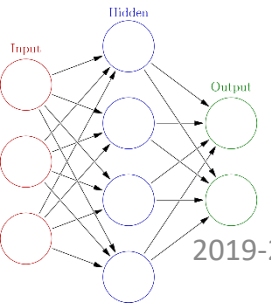
# Introduction

- Deep Learning is the most exciting and powerful branch of Machine Learning.
- It's a technique that teaches computers to do what comes naturally to humans: learn by example.
- Deep learning is a key technology behind driverless cars, enabling them to recognize a stop sign or to distinguish a pedestrian from a lamppost.
- It is the key to voice control in consumer devices like phones, tablets, TVs, and hands-free speakers.



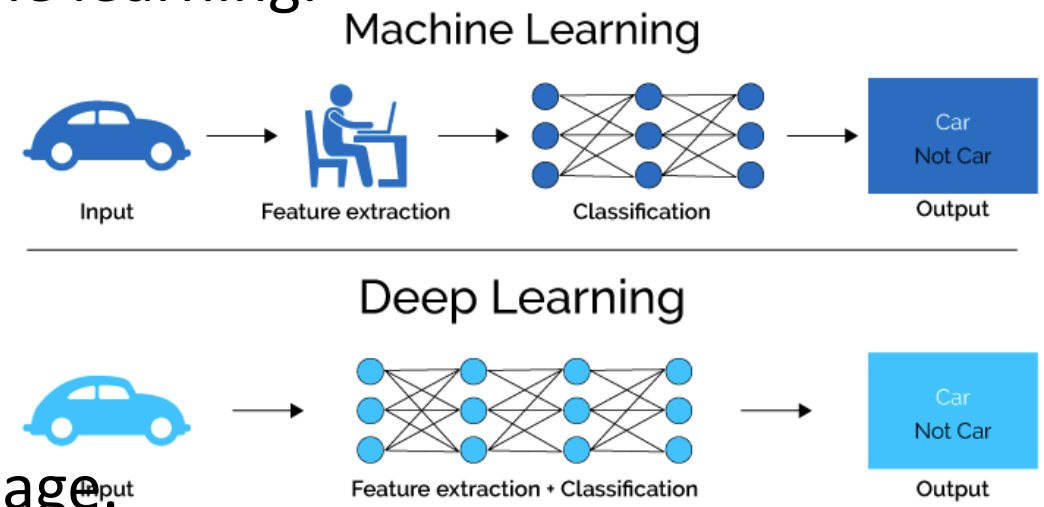
# Understanding Deep inside

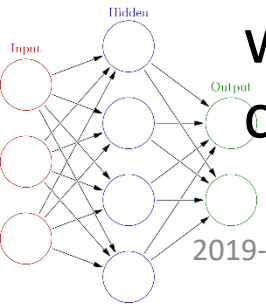


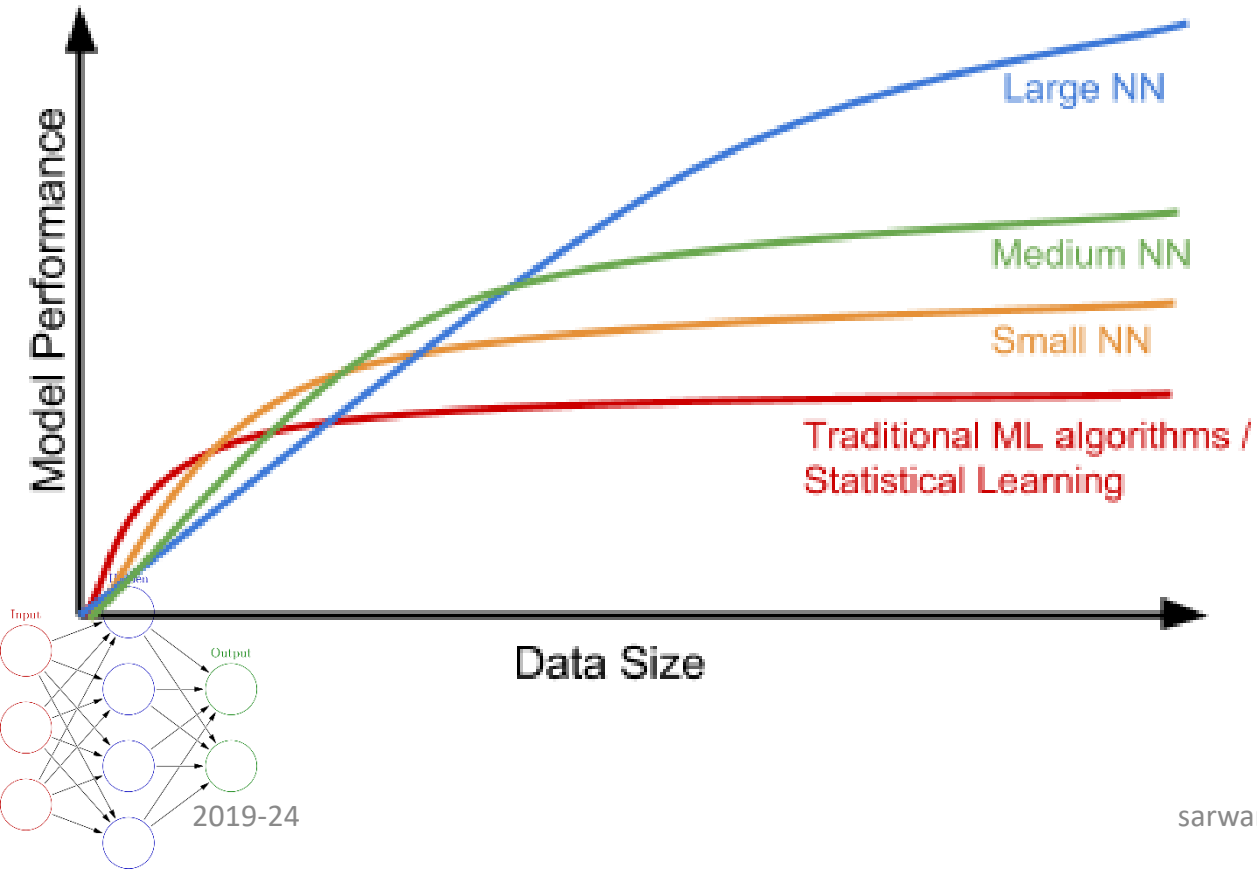
# Machine learning vs Deep Learning

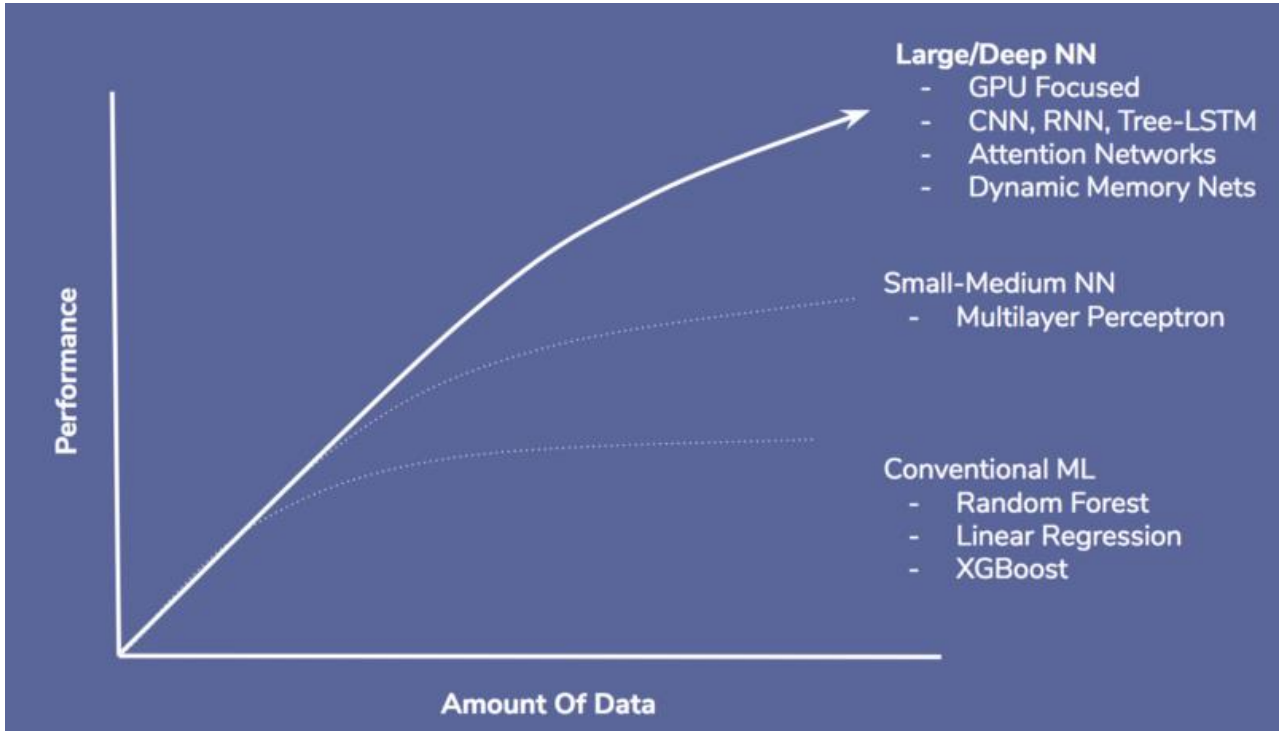
- Deep learning is a specialized form of machine learning.
- A machine learning workflow starts with relevant features being manually extracted from images.
- The features are then used to create a model that categorizes the objects in the image.
- With a deep learning workflow, relevant features are automatically extracted from images.
- In addition, deep learning performs "end-to-end learning" – where a network is given raw data and a task to perform, such as classification, and it learns how to do this automatically.



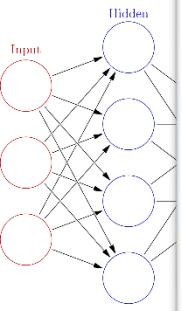
# Machine Learning vs Deep Learning

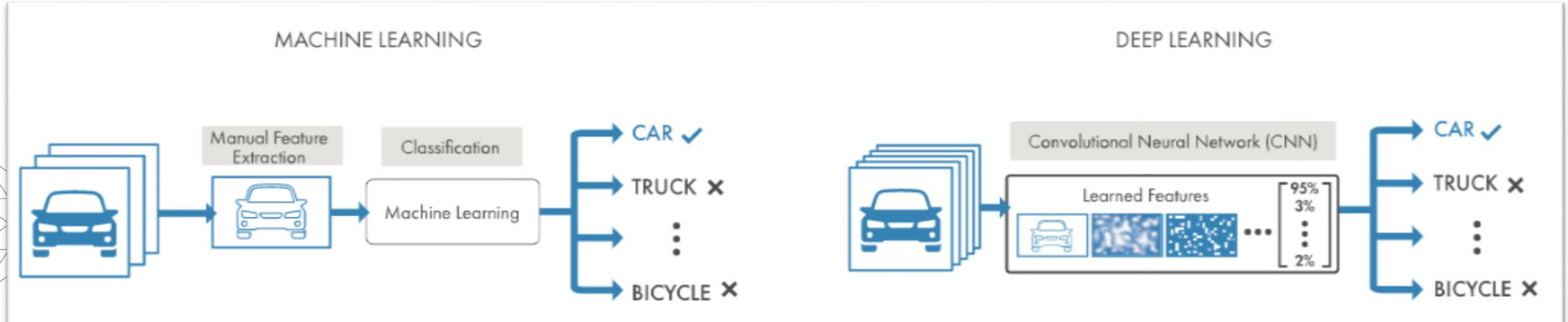


# Machine Learning vs Deep Learning

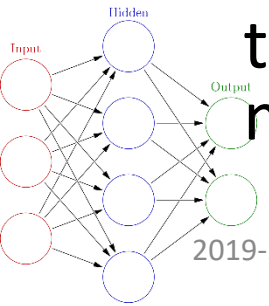
- Another key difference is deep learning algorithms scale with data, whereas shallow learning converges.
- Shallow learning refers to machine learning methods that plateau at a certain level of performance when you add more examples and training data to the network.
- A key advantage of deep learning networks is that they often continue to improve as the size of your data increases.
- In machine learning, you manually choose features and a classifier to sort images. With deep learning, feature extraction and modeling steps are automatic.



# Choosing Between Machine Learning & Deep Learning

- Machine learning offers a variety of techniques and models you can choose based on your application, the size of data you're processing, and the type of problem you want to solve.
- A successful deep learning application requires a very large amount of data (thousands of images) to train the model, as well as GPUs, or graphics processing units, to rapidly process your data.
- When choosing between machine learning and deep learning, consider whether you have a high-performance GPU and lots of labeled data. If you don’t have either of those things, it may make more sense to use machine learning instead of deep learning.
- Deep learning is generally more complex, so you’ll need at least a few thousand images to get reliable results. Having a high-performance GPU means the model will take less time to analyze all those images.



# Why we need Deep Learning

## Process huge amount of data

Machine Learning algorithms work with huge amount of structured data but Deep Learning algorithms can work with enormous amount of structured and unstructured data

## Perform complex algorithms

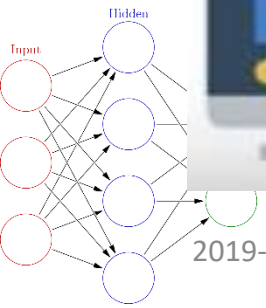
Machine Learning algorithms cannot perform complex operations, to do that we need Deep Learning algorithms

## To achieve the best performance with large amount of data

As the amount of data increases, the performance of Machine Learning algorithms decreases, to make sure the performance of a model is good, we need Deep Learning

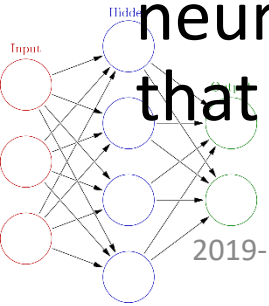
## Feature Extraction

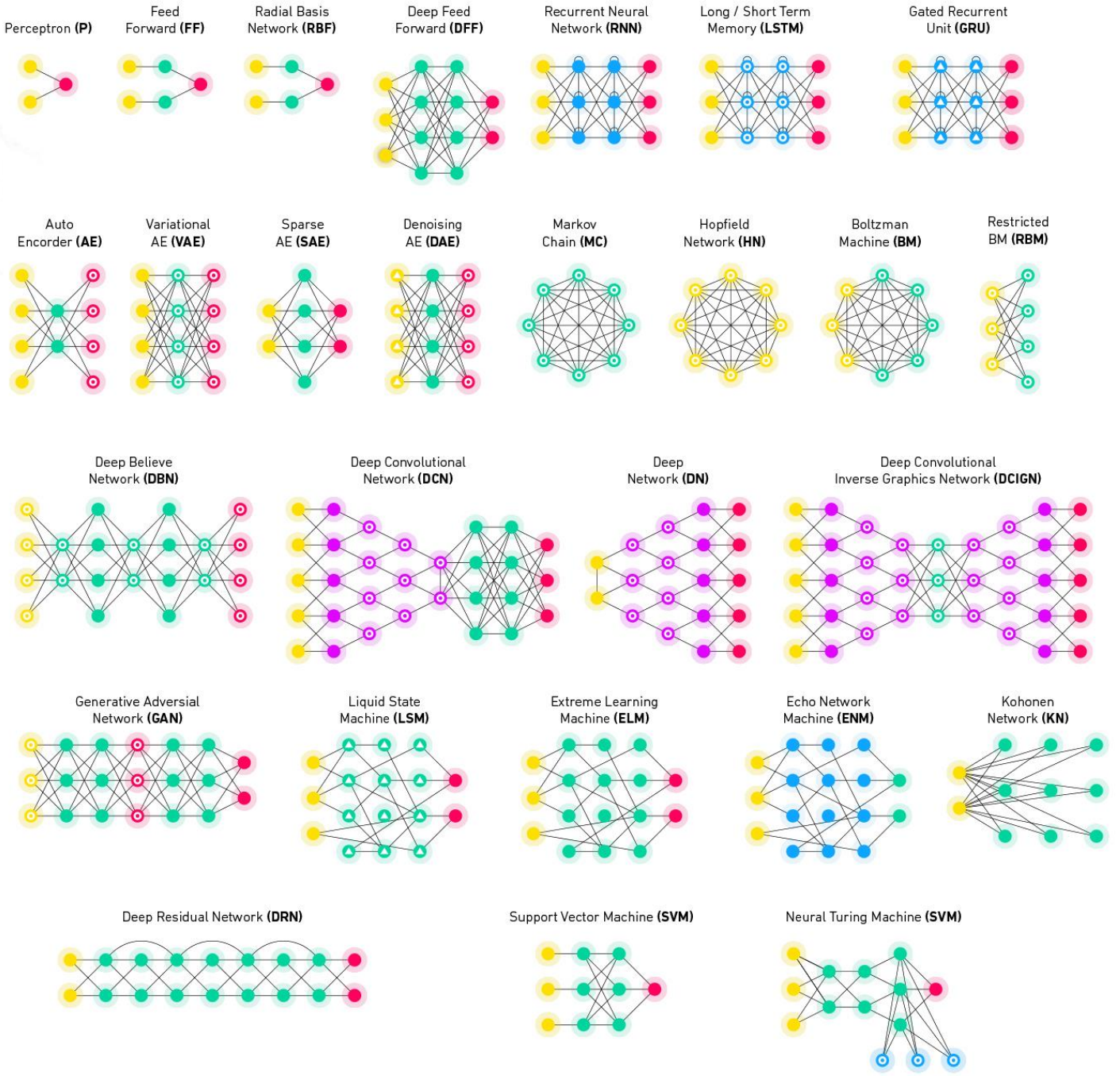
Machine Learning algorithms extract patterns based on labelled sample data, while Deep Learning algorithms take large volumes of data as input, analyze the input to extract features out of an object and identifies similar objects



# Working

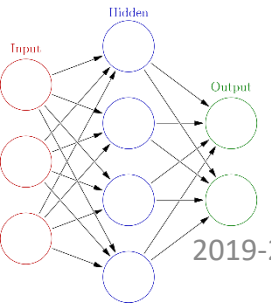
- In deep learning, a computer model learns to perform classification tasks directly from images, text, or sound.
- Deep learning models can achieve state-of-the-art accuracy, sometimes exceeding human-level performance. Models are trained by using a large set of labeled data and neural network architectures that contain many layers.





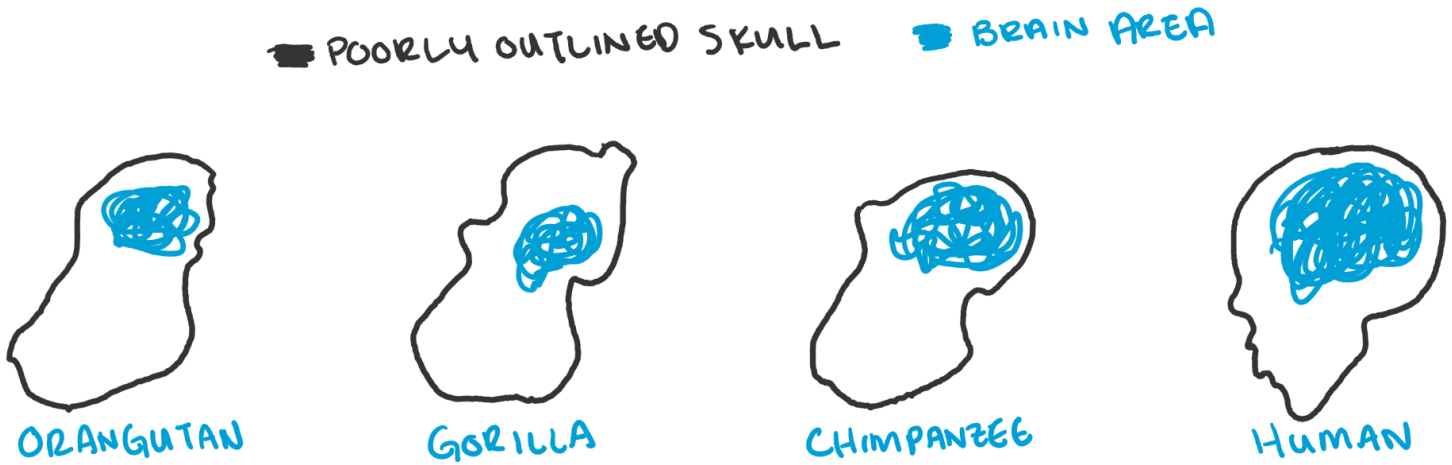
# Road to Deep Learning

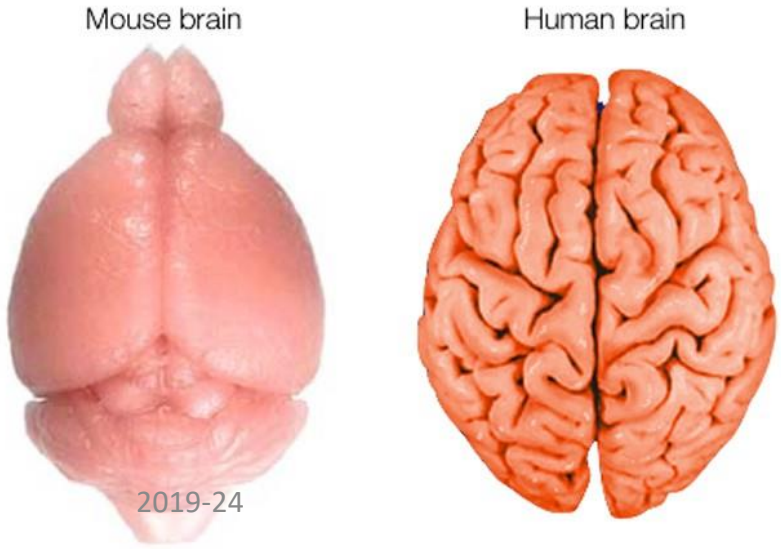
- Much of this changed with the ready availability of large amounts of data, due to the World Wide Web, the advent of companies serving hundreds of millions of users online, a dissemination of cheap, high-quality sensors, cheap data storage (Kryder's law), and cheap computation (Moore's law), in particular in the form of GPUs, originally engineered for computer gaming.
- Suddenly algorithms and models that seemed computationally infeasible became relevant (and vice versa)



# Our Evolutionary History

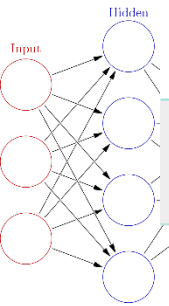
- Humans have the largest relative cerebral cortex size of all mammals



# Dataset vs. computer memory and computational power

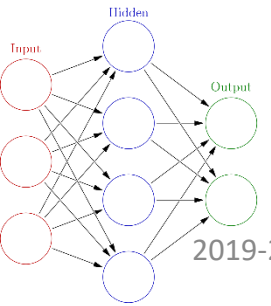
| Decade | Dataset | Memory | Floating Point Calculations per Second |
|---|---|---|---|
| 1970 | 100 (Iris) | 1 KB | 100 KF (Intel 8080) |
| 1980 | 1 K (House prices in Boston) | 100 KB | 1 MF (Intel 80186) |
| 1990 | 10 K (optical character recognition) | 10 MB | 10 MF (Intel 80486) |
| 2000 | 10 M (web pages) | 100 MB | 1 GF (Intel Core) |
| 2010 | 10 G (advertising) | 1 GB | 1 TF (Nvidia C2050) |
| 2020 | 1 T (social network) | 100 GB | 1 PF (Nvidia DGX-2) |



# Deep Learning models usuage

Deep Learning models can be used for a variety of complex tasks:

- Artificial Neural Networks(ANN) for Regression and classification
- Convolutional Neural Networks(CNN) for Computer Vision
- Recurrent Neural Networks(RNN) for Time Series analysis
- Self-organizing maps for Feature extraction
- Deep Boltzmann machines for Recommendation systems
- Auto Encoders for Recommendation systems

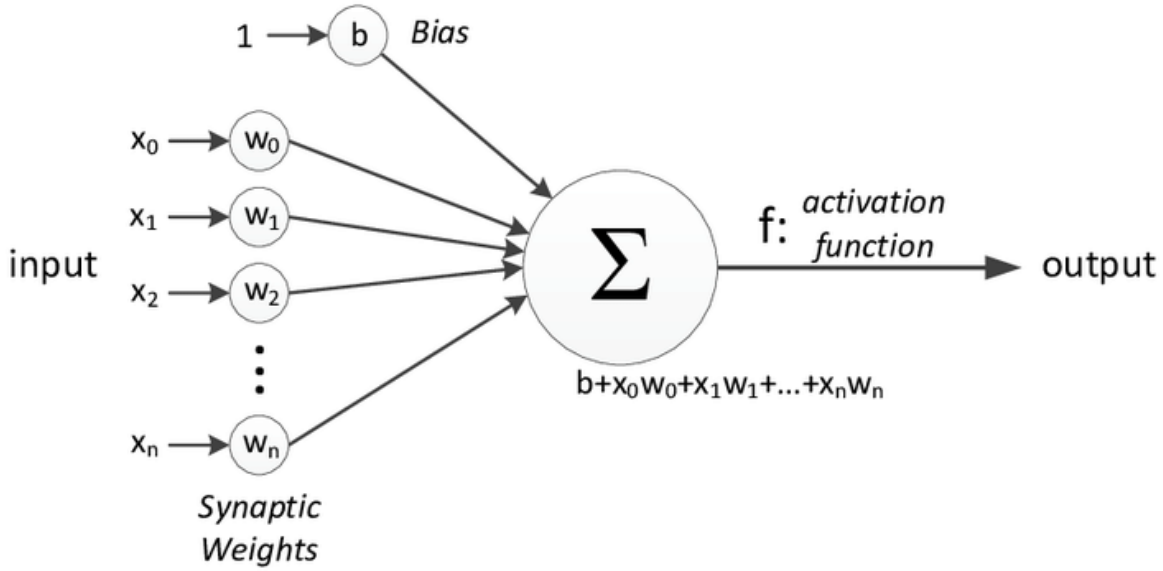


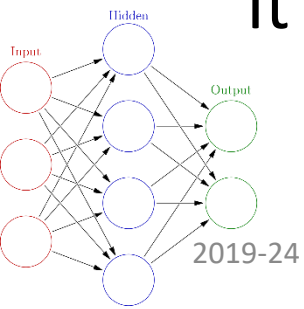
# Artificial Neural Networks

- Artificial Neural Networks or ANN is an information processing paradigm that is inspired by the way the biological nervous system such as brain process information.
- It is composed of large number of highly interconnected processing elements(neurons) working in unison to solve a specific problem.
- *general model of ANN which is inspired by a biological neuron. It is also called Perceptron.*
- A single layer neural network

  is called a Perceptron.

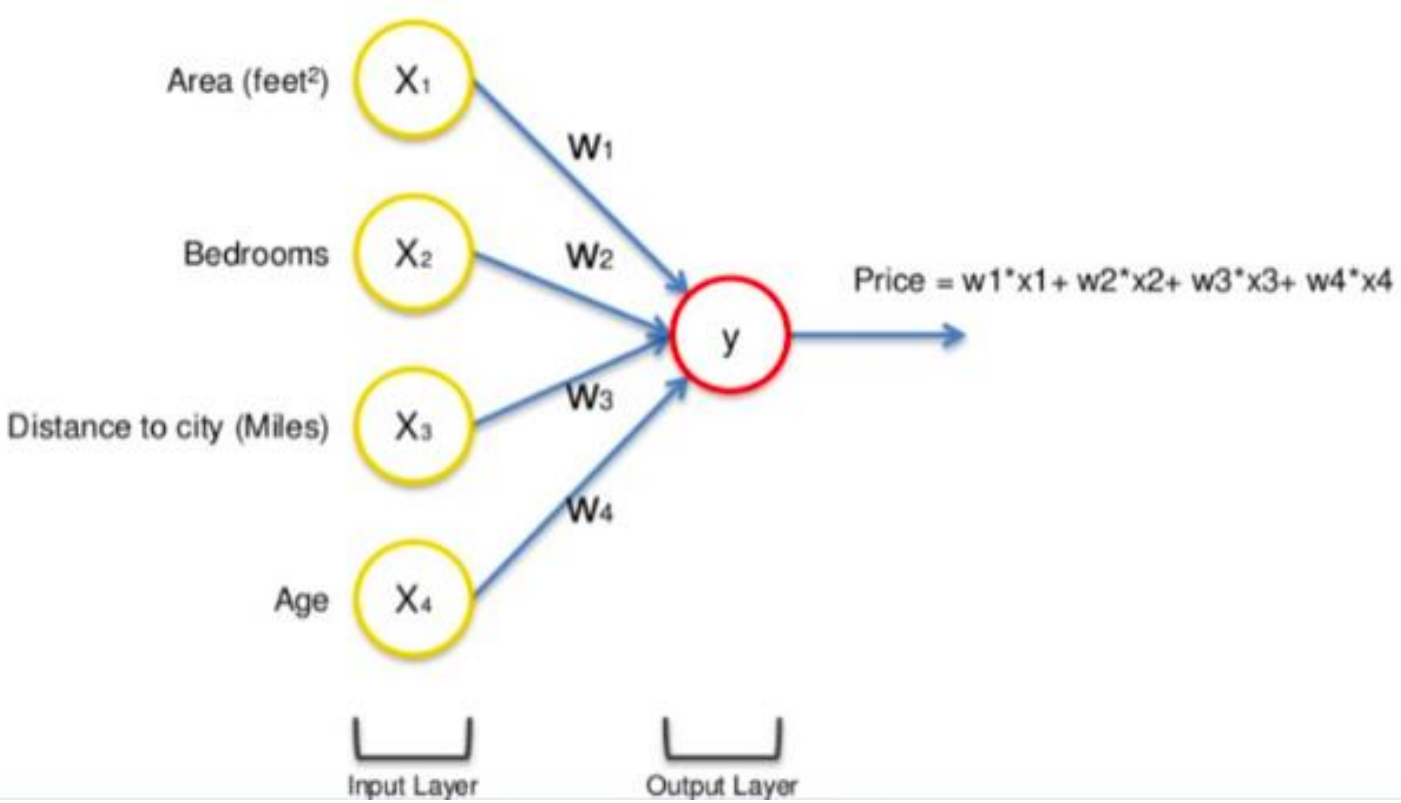
  It gives a single output.

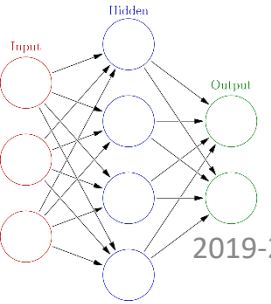


# How Neural Network work

- example of the price of a property

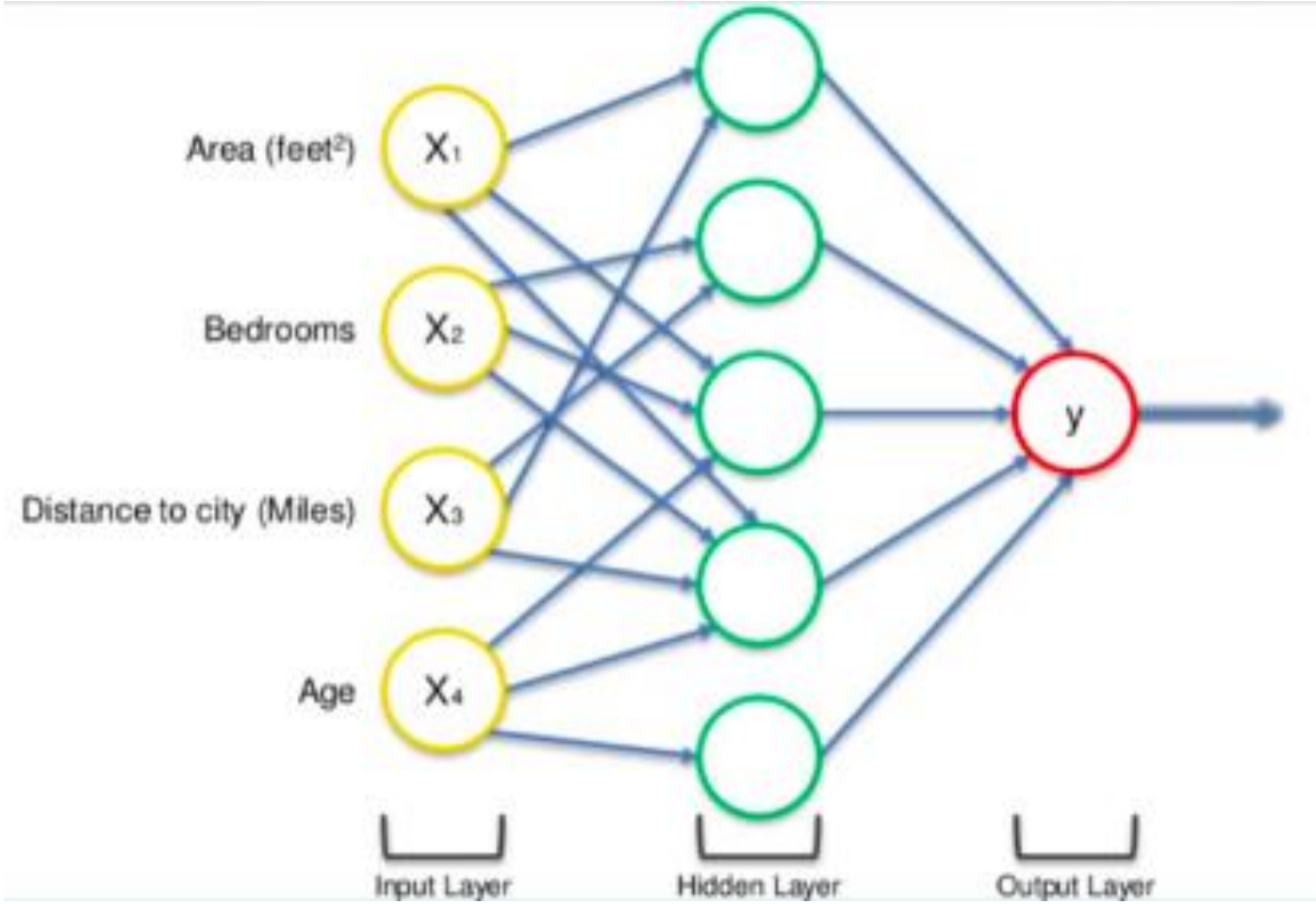


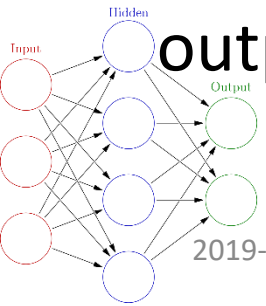



non-0 value → indicates the importance
0 value → They will be discarded.

# How Neural Network work

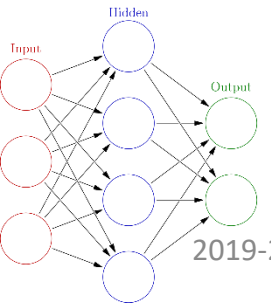
- The input values go through the weighted synapses straight over to the output layer. All four will be analyzed, an activation function will be applied, and the results will be produced.
- This is simple enough but there is a way to amplify the power of the Neural Network and increase its accuracy by the addition of a hidden layer that sits between the input and output layers.

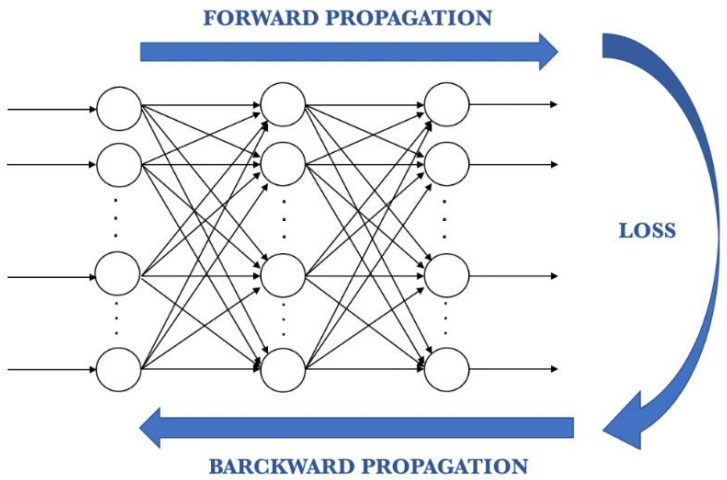


# Neural network learns as humans learn

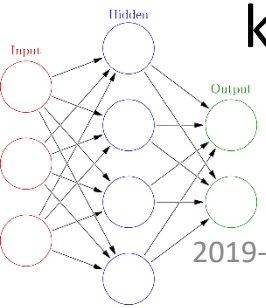
- Learning in a neural network is closely related to how we learn in our regular lives and activities — we perform an action and are either accepted or corrected by a trainer or coach to understand how to get better at a certain task.
- Similarly, neural networks require a trainer in order to describe what should have been produced as a response to the input. Based on the difference between the actual value and the predicted value, an error value also called **Cost Function** is computed and sent back through the system.



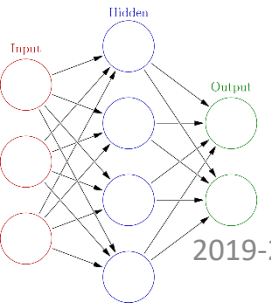
# Examples of Deep Learning at Work

- Automated Driving: Automotive researchers are using deep learning to automatically detect objects such as stop signs and traffic lights. In addition, deep learning is used to detect pedestrians, which helps decrease accidents.
- Aerospace and Defense: Deep learning is used to identify objects from satellites that locate areas of interest, and identify safe or unsafe zones for troops.
- Medical Research: Cancer researchers are using deep learning to automatically detect cancer cells. Teams at UCLA built an advanced microscope that yields a high-dimensional data set used to train a deep learning application to accurately identify cancer cells.
- Industrial Automation: Deep learning is helping to improve worker safety around heavy machinery by automatically detecting when people or objects are within an unsafe distance of machines.
- Electronics: Deep learning is being used in automated hearing and speech translation. For example, home assistance devices that respond to your voice and know your preferences are powered by deep learning applications.



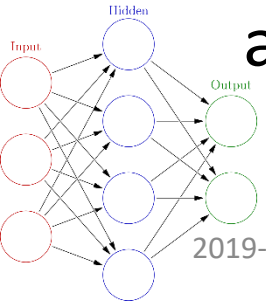
# Deep Neural Networks

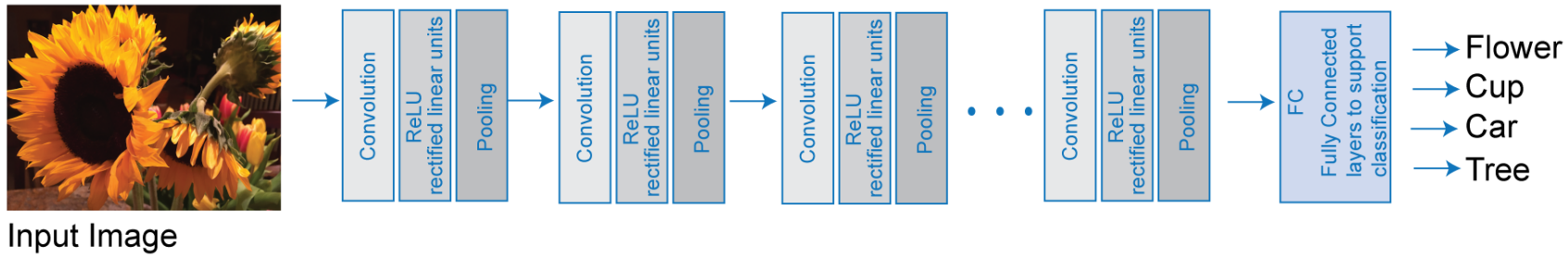
- Most deep learning methods use **neural network** architectures, which is why deep learning models are often referred to as **deep neural networks**.
- The term “deep” usually refers to the number of hidden layers in the neural network. Traditional neural networks only contain 2-3 hidden layers, while deep networks can have as many as 150.
- Deep learning models are trained by using large sets of labeled data and neural network architectures that learn features directly from the data without the need for manual feature extraction.

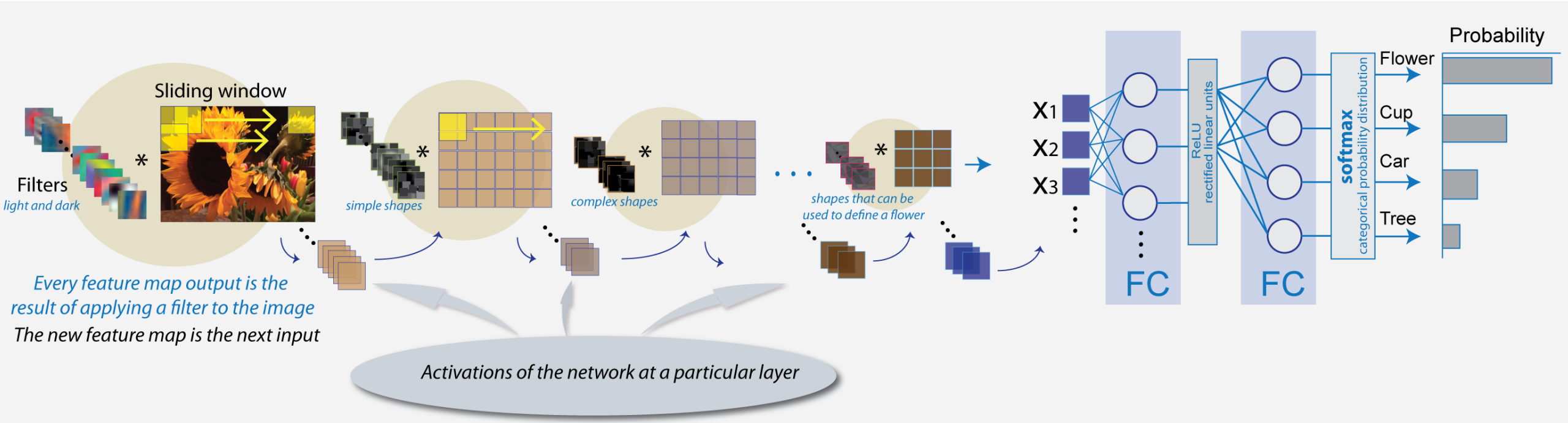


# Convolutional Neural Networks

- One of the most popular types of deep neural networks is known as convolutional neural networks **(CNN** or **ConvNet)**. A CNN convolves learned features with input data, and uses 2D convolutional layers, making this architecture well suited to processing 2D data, such as images.
- CNNs eliminate the need for manual feature extraction, so you do not need to identify features used to classify images.
- The CNN works by extracting features directly from images. The relevant features are not pretrained; they are learned while the network trains on a collection of images.
- This automated feature extraction makes deep learning models highly accurate for computer vision tasks such as object classification.

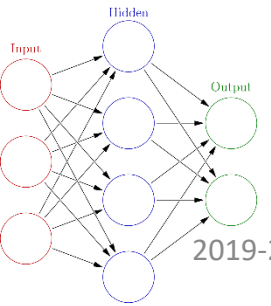



Input Image
Convolution
ReLU rectified linear units
Pooling
Convolution
ReLU rectified linear units
Pooling
Convolution
ReLU rectified linear units
Pooling
Convolution
ReLU rectified linear units
Pooling
FC
Fully Connected layers to support classification
Flower
Cup
Car
Tree


Sliding window
Filters
light and dark
simple shapes
complex shapes
shapes that can be used to define a flower
Every feature map output is the result of applying a filter to the image
The new feature map is the next input
Activations of the network at a particular layer
X1
X2
X3
FC
ReLU rectified linear units
FC
softmax
categorical probability distribution
Probability
Flower
Cup
Car
Tree

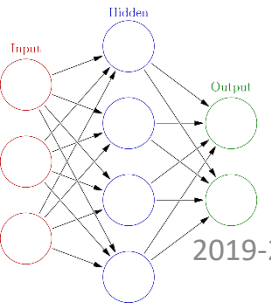
# Convolutional Neural Networks

- CNNs learn to detect different features of an image using tens or hundreds of hidden layers.
- Every hidden layer increases the complexity of the learned image features.
- For example, the first hidden layer could learn how to detect edges, and the last learns how to detect more complex shapes specifically catered to the shape of the object we are trying to recognize.



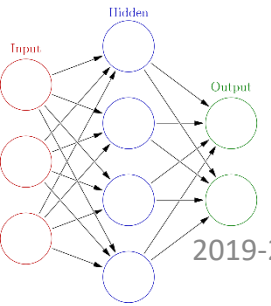
# How to Create and Train Deep Learning Models

- The three most common ways people use deep learning to perform object classification are:
  - Training from Scratch
    - To train a deep network from scratch, you gather a very large labeled data set and design a network architecture that will learn the features and model.
    - good for new applications, or applications that will have a large number of output categories.
    - Takes lot of time - days or weeks to train
  - Transfer Learning
  - Feature Extraction



# How to Create and Train Deep Learning Models

- The three most common ways people use deep learning to perform object classification are:
  - Training from Scratch
  - Transfer Learning
    - a process involves fine-tuning a pretrained model.
    - start with an existing network, such as AlexNet or GoogLeNet, and feed in new data containing previously unknown classes
    - After making some tweaks to the network, you can now perform a new task, such as categorizing only dogs or cats instead of 1000 different objects.
    - Has advantage of needing much less data (processing thousands of images, rather than millions), so computation time drops to minutes or hours.
  - Feature Extraction



# How to Create and Train Deep Learning Models

- The three most common ways people use deep learning to perform object classification are:
  - Training from Scratch
  - Transfer Learning
  - Feature Extraction
    - slightly less common, more specialized approach to deep learning is to use the network as a feature extractor.
    - Since all the layers are tasked with learning certain features from images, we can pull these features out of the network at any time during the training process.
    - These features can then be used as input to a machine learning model such as support vector machines (SVM).