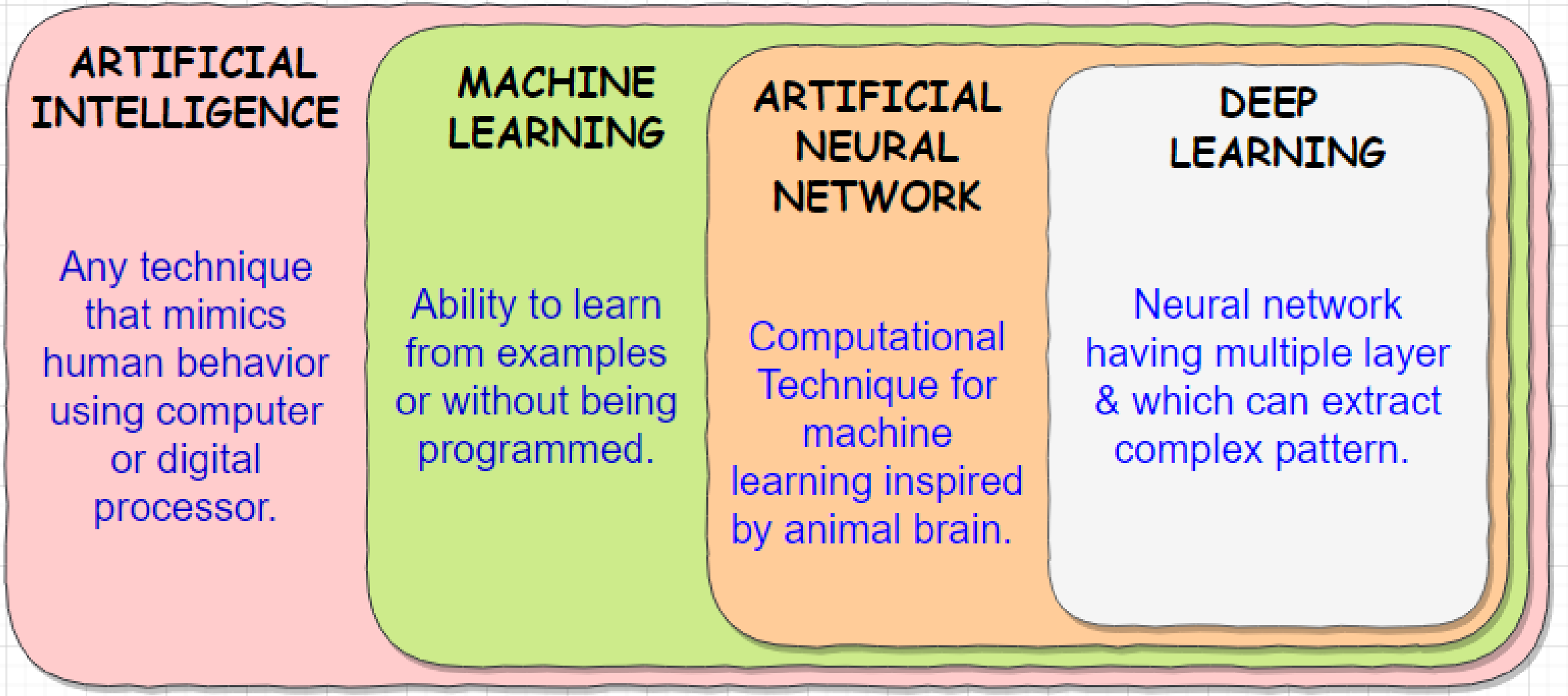
Unit-I:

Introduction of Deep learning, Neural Network, Feed Forward Neural Network, Back Forward Neural Network, the Backpropagation algorithm. Activation Function: Threshold, Sigmoid, Rectifier(ReLU), Hyperbolic Tangent (tanh), Gradient Descent, Stochastic Gradient Descent, Cost Function, Global minima and Local minima.

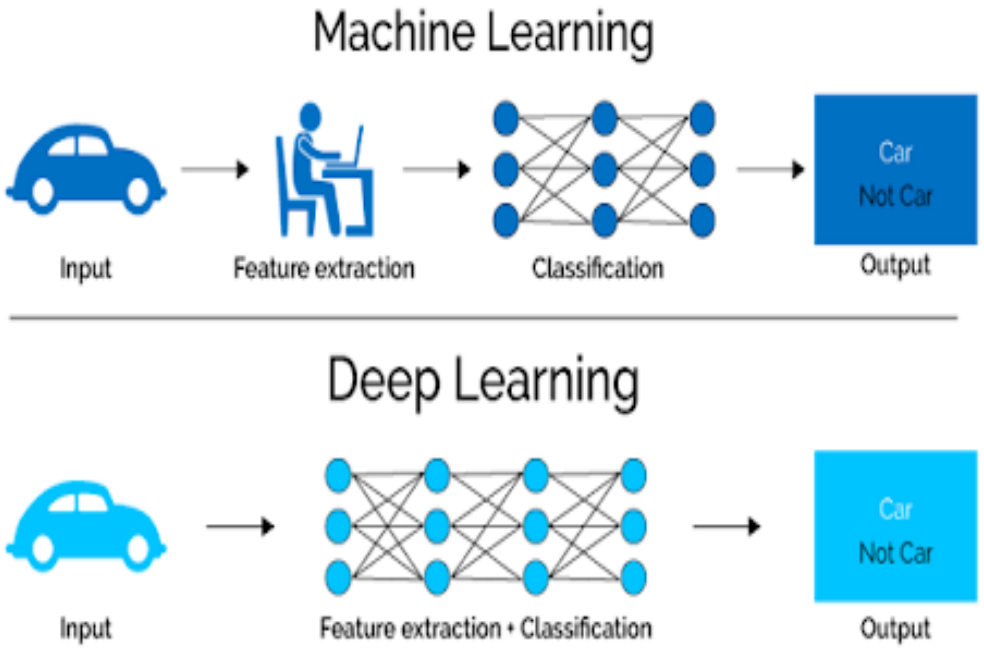

ARTIFICIAL INTELLIGENCE
Any technique that mimics human behavior using computer or digital processor.
MACHINE LEARNING
Ability to learn from examples or without being programmed.
ARTIFICIAL NEURAL NETWORK
Computational Technique for machine learning inspired by animal brain.
DEEP LEARNING
Neural network having multiple layer & which can extract complex pattern.

Introduction of Deep learning

What is deep learning?

Deep learning is a type of machine learning and artificial intelligence (AI) that imitates the way humans gain certain types of knowledge. Deep learning models can be taught to perform classification tasks and recognize patterns in photos, text, audio and other various data. It is also used to automate tasks that would normally need human intelligence, such as describing images or transcribing audio files.

For example, in an image recognition task, the algorithm might learn to associate certain features in an image (such as the shape of an object or the color of an object) with the correct label (such as "dog" or "cat").



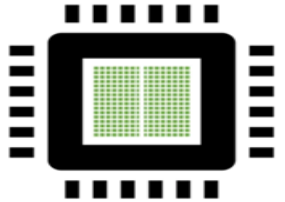
Why deep learning is becoming so popular?

1. Data Growth

2. Hardware advancements
   GPU and TPU

3. Python & Open source Ecosystem

4. Cloud & AI Boom



CPU	GPU
Central Processing Unit	Graphics Processing Unit
4-8 Cores	100s or 1000s of Cores
Low Latency	High Throughput
Good for Serial Processing	Good for Parallel Processing
Quickly Process Tasks That Require Interactivity	Breaks Jobs Into Separate Tasks To Process Simultaneously
Traditional Programming Are Written For CPU Sequential Execution	Requires Additional Software To Convert CPU Functions to GPU Functions for Parallel Execution

CPU
- Small models
- Small datasets
- Useful for design space exploration

GPU
- Medium-to-large models, datasets
- Image, video processing
- Application on CUDA or OpenCL

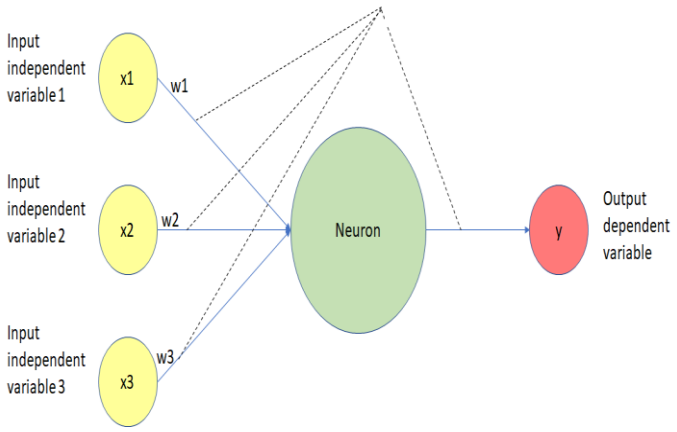
TPU
- Matrix computations
- Dense vector processing
- No custom TensorFlow operations

FPGA
- Large datasets, models
- Compute intensive applications
- High performance, high perf./cost ratio

What is Neurons

Neurons are the building blocks of the nervous system. They receive and transmit signals to different parts of the body.

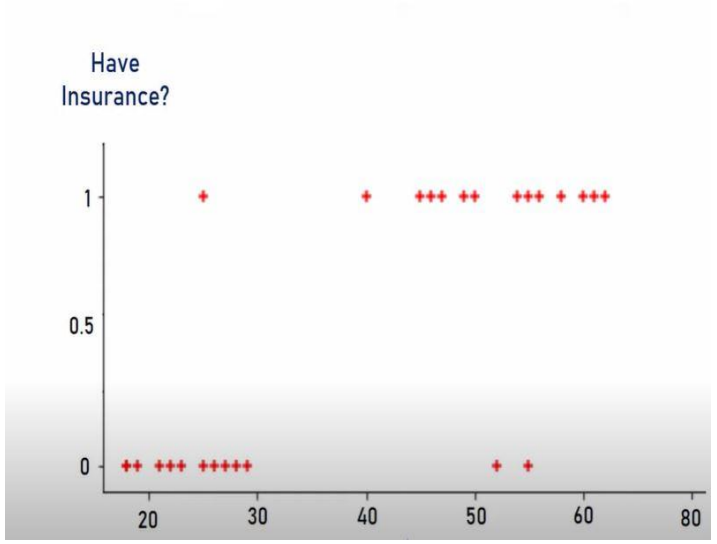
Neurons in deep learning models are nodes through which data and computations flow. Neurons work like this: They receive one or more input signals. These input signals can come from either the raw data set or from neurons positioned at a previous layer of the neural net.

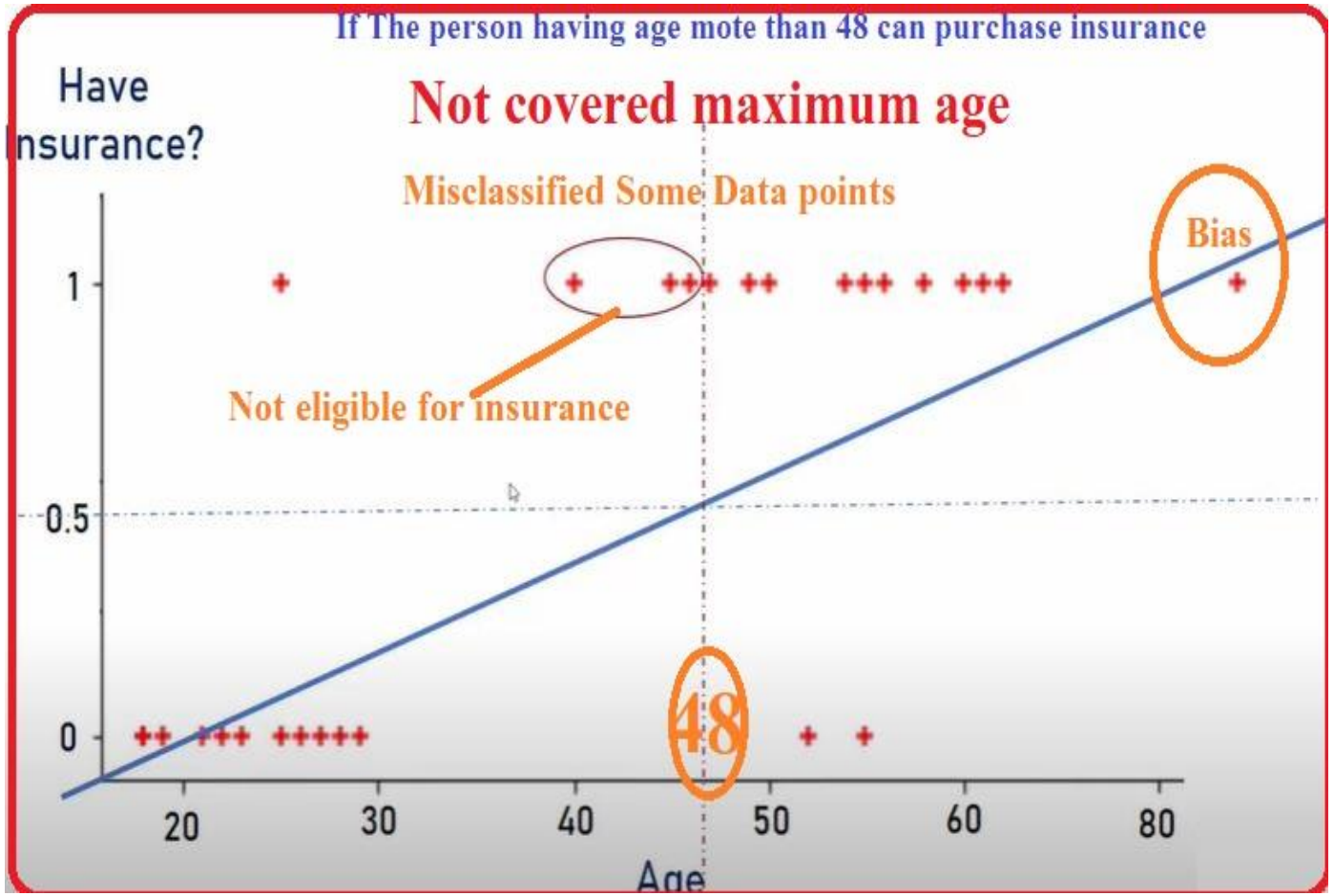


age	have_insurance
22	0
25	0
47	1
52	0
46	1
56	1
55	0
60	1
62	1
61	1
18	0
28	0
27	0
29	0
49	1

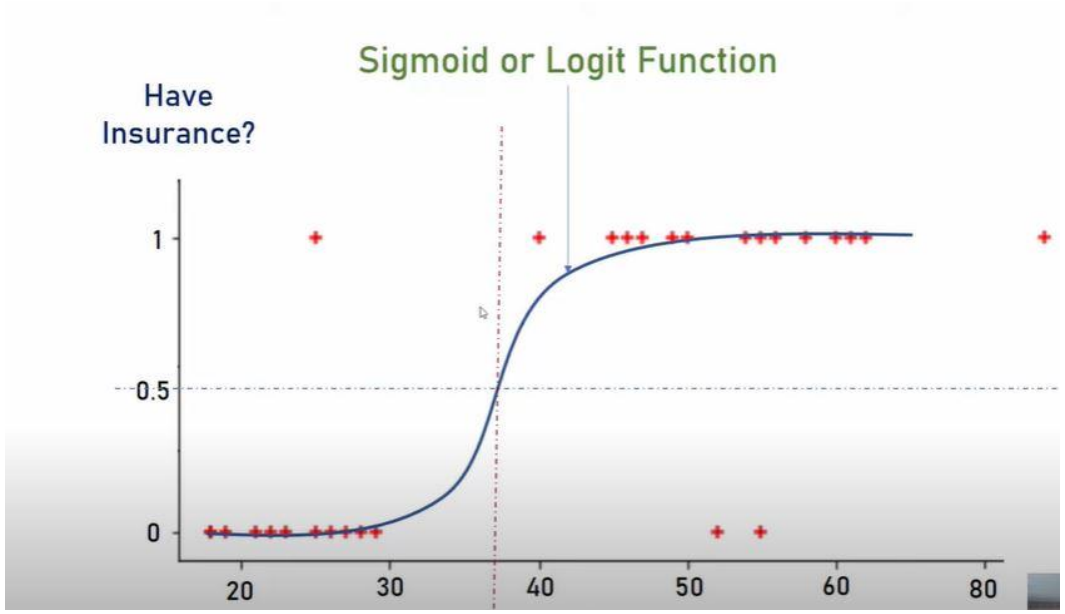
Binary Classification

Given an age of a person, come up with a **function** that can predict if person will buy insurance or not




If The person having age mote than 48 can purchase insurance
Have Insurance?
Not covered maximum age
Misclassified Some Data points
Bias
Not eligible for insurance
1
0.5
0
48
20
30
40
50
60
80
Age

IF we Want to cover maximum age group Then We will use Sigmoid Function



$$sigmoid(z) = \frac{1}{1 + e^{-z}}$$

e = Euler's number ~ 2.71828

$sigmoid(200) = \frac{1}{1+2.71^{-200}}$ = almost close to 1

$sigmoid(-200) = \frac{1}{1+2.71^{200}}$ = almost close to 0

Sigmoid function converts input into range 0 to 1

Step 1

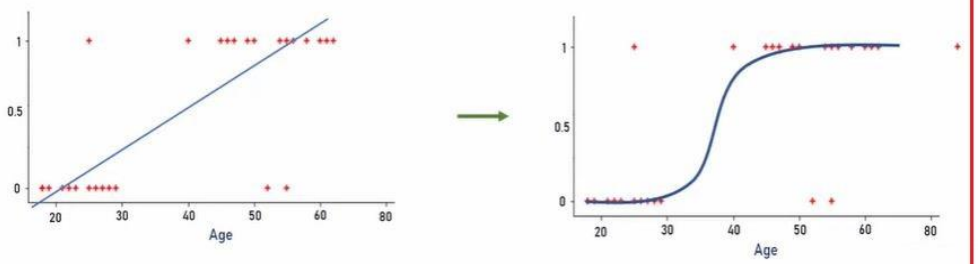
$$y = m * x + b$$

Age

Step 2

$$z = \frac{1}{1 + e^{-y}}$$

If person will buy insurance



$$y = 0.042 * x - 1.53$$

Age

NEURONS FOR SINGLE VARIABLES

value < 0.5 = person will not buy insurance

value >= 0.5 = person **will** buy insurance

Age = 35 → $y = 0.042 * x - 1.53$ → $z = \frac{1}{1 + e^{-y}}$ → 0.48

$$y = 0.042 * x - 1.53$$

Age

$$y = 0.042 * x1 + 0.008 * x2 + 0.2 * x3 - 1.53$$

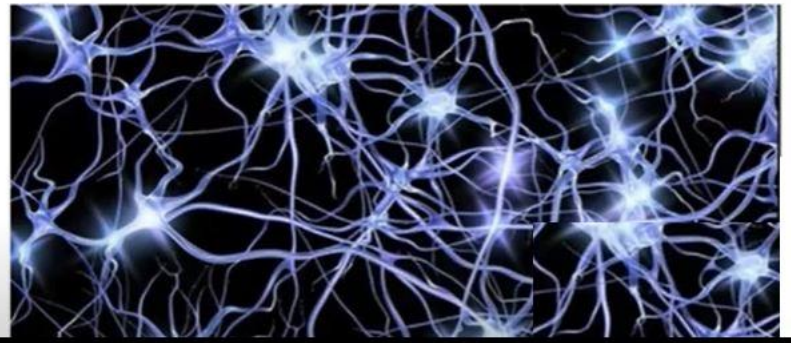
Age Income Education

$$y = w1 * x1 + w2 * x2 + w3 * x3 + b$$

$$y = \sum_{i=0}^{n} w^i x^i + b$$

Neural Network

- A neural network is a very powerful machine learning mechanism which basically mimics how a human brain learns.

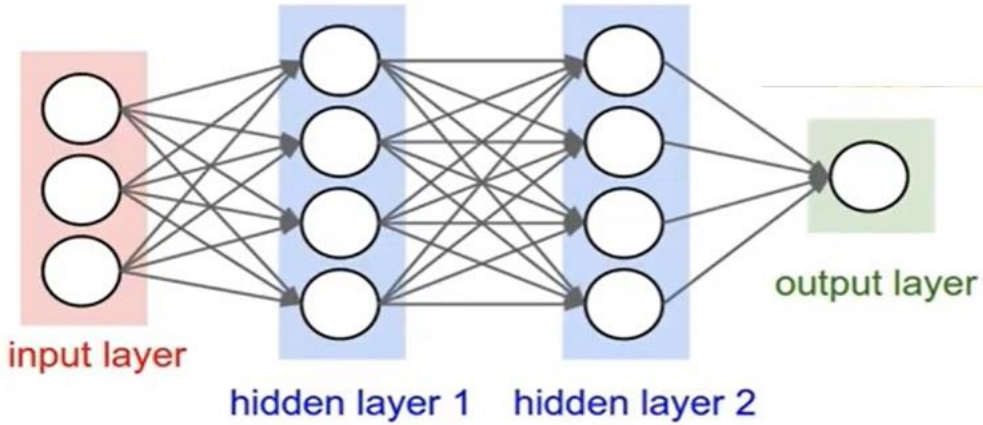


Activation Function ?

- Activation function are an extremely important feature of the artificial neuron network. They basically decide whether a neuron should be activated or not.
- It limit the output signal to a finite value.
- Logit = (Input * Weight) + Bias
- Bias is the information which can impact output without being dependent on the any feature.

- Bias is the information which can impact output without being dependent on the any feature.
- It does the non-linear transformation to the input to the input making it capable to learn and perform more complex relationship.

Neural Network



Without an activation function, the neural network is just a linear regression model.

Lets say we have five layers but no activation function. We multiple the input data by weight matrix of first, add bias and send next and again do same, and so on. We could easily combine all layer into one.

NO curve in linear regression, so can not solve complex pattern.

In second picture, we can not draw straight line slope. Hence non-linearity or curve required to solve complex problems.

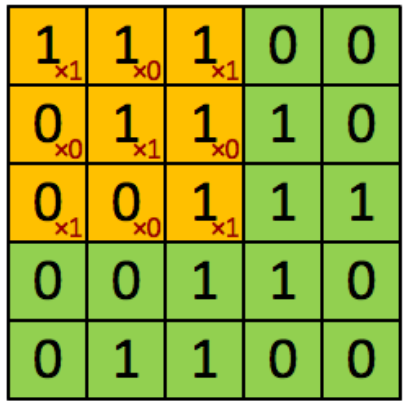
- We can represent any kind of function with neural network. Hence neural network consider as UNIVERSAL FUNCTION APPROXIMATORS, means they can compute any function or any process.
- The main purpose of activation function is to introduce non-linearity in the network so it would be capable of learning more complex pattern.

Convolution, Padding, Stride, and Pooling in CNN

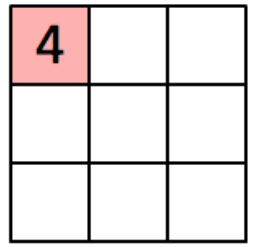
Convolution operation

The convolution is a mathematical operation used to extract features from an image. The convolution is defined by an image kernel. The image kernel is nothing more than a small matrix. Most of the time, a 3x3 kernel matrix is very common.

In the below fig, the green matrix is the original image and the yellow moving matrix is called kernel, which is used to learn the different features of the original image. The kernel first moves horizontally, then shift down and again moves horizontally. The sum of the dot product of the image pixel value and kernel pixel value gives the output matrix. Initially, the kernel value initializes randomly, and its a learning parameter.



Image

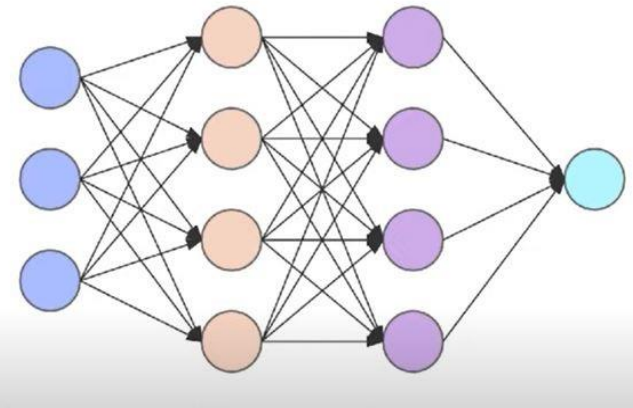


Convolved Feature

There are some standard filters like **Sobel filter,** contains the value 1, 2, 1, 0, 0, 0, -1, -2, -1, the advantage of this is it puts a little bit more weight to the central row, the central pixel, and this makes it maybe a little bit more robust. Another filter used by computer vision researcher is instead of a 1, 2, 1, it is 3, 10, 3 and then -3, -10, -3, called a **Scharr filter**. And this has yet other slightly different properties and this can be used for vertical edge detection. If it is flipped by 90 degrees, the same will act like horizontal edge detection.

Difference Between CNN,RNN and ANN

1. Artificial Neural Network (or ANN)



Feed-Forward Neural network

(forward direction)

Advantages of ANN

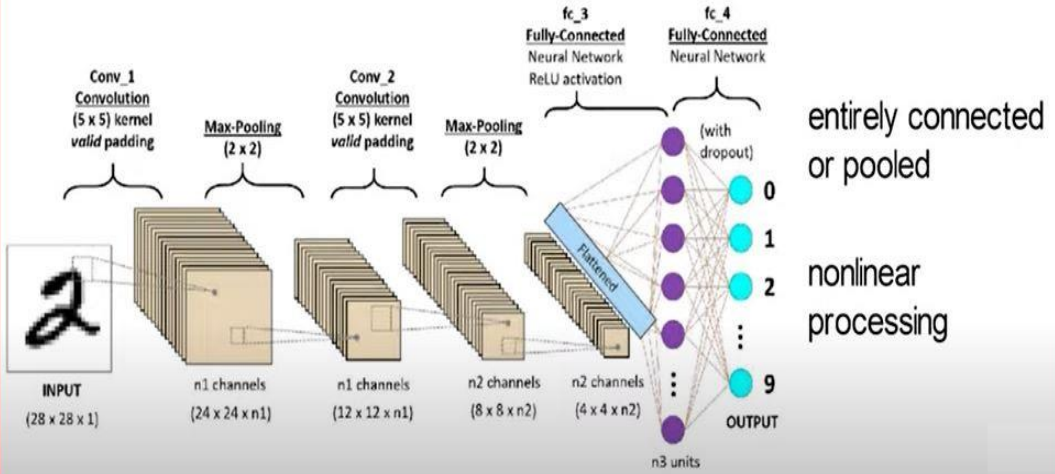
Advantages

- they store information on the entire network
- they have the ability to work with incomplete knowledge
- they offer fault tolerance and have distributed memory
- they offer us the ability to work with incomplete knowledge

Disadvantages

- they have huge hardware dependency
- they sometimes have unexplained behavior which can leave us tormeneted with results
- there is no specific rule for determining the structure of artificial neural networks and appropriate network structure is achieved through experience and trial and error

2. Convolutional Neural Network (or CNN)



entirely connected or pooled

nonlinear processing

Advantages of CNN

Advantages

- they offer very high accuracy in image recognition problems
- they are capable of automatically detecting important features without any human supervision
- weight sharing

Disadvantages

- CNNs do not encode the position and orientation of object
- they lack the ability to be spatially invariant to the input data
- a lot of training data is required in order for it to work efficiently

ANN	CNN	RNN
Tabular or Text Data	Image Data	Sequence data
No Parameter Sharing	Yes	Yes
Operate on Fixed Length input	Operate on Fixed Length input	Don't
No Recurrent Connections	No Recurrent Connections	They are Possible
No Spatial Relationships	They are Possible	No Spatial Relationships
ANN is considered to be less powerful than CNN, RNN	CNN is considered to be more powerful than others	RNN includes less feature compatibility when compared to CNN
Having fault tolerance, Ability to work with incomplete knowledge	High accuracy in image recognition problems, & weight sharing	Remembers each and every information, & offers time series prediction

Backpropagation in Neural Networks

- What is Backpropagation?
- What is Backpropagation in a Neural network?
- How does Backpropagation work?
- Benefits of Backpropagation
- Applications of Backpropagation

Which among the following is not a layer of a neural network?

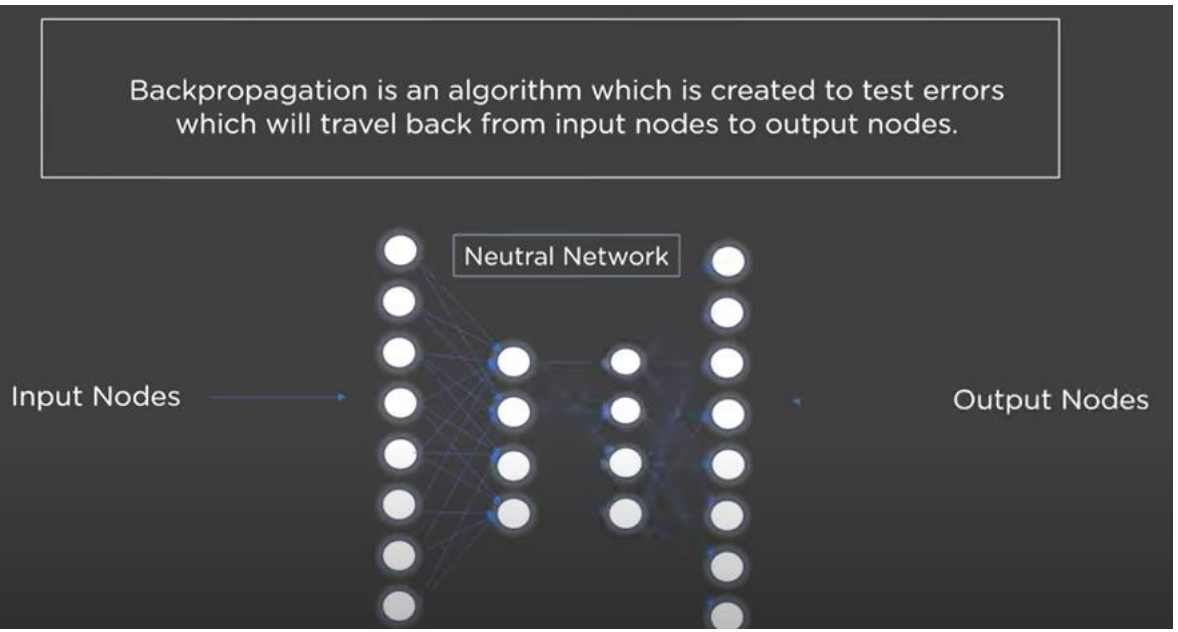
A. Input Layer

B. Output Layer

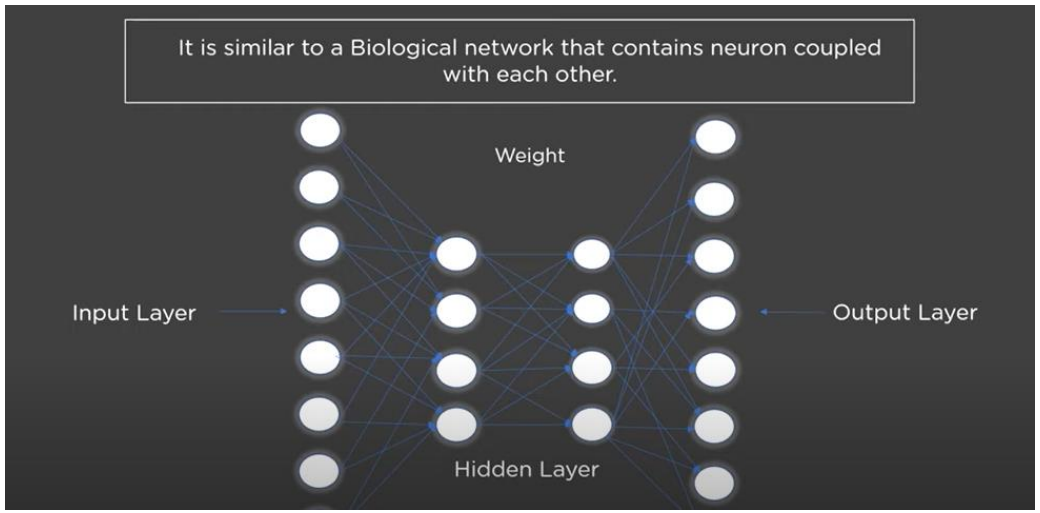
C. Propagation Layer

D. Hidden Layer

Backpropagation is an algorithm which is created to test errors which will travel back from input nodes to output nodes.




What is Backpropagation
in neural network?


It is similar to a Biological network that contains neuron coupled with each other.
Weight
Input Layer
Output Layer
Hidden Layer


How does
Backpropagation work?

Agriculture

1.Optimize yield production by using data from sensors and satellites taking into account temperature, humidity, etc.

Aerospace & Defence

2.Identify objects from images acquired via satellites
3.Use surveillance cameras to detect suspicious events or gather intelligence

Automotive

4.Develop autonomous things including vehicles. There are numerous deep learning models used in such devices including those for detecting traffic signs & lights, other vehicles, pedestrians, etc.

Financial services

5.Trading: Estimate future stock market prices
6.Fraud detection: Detect fraudulent activities with higher accuracy and fewer false positives
7.Evaluate a client's creditworthiness by analyzing information from multiple sources and responding to loan applications faster

Healthcare

11. Diagnose diseases leveraging medical imaging solutions, for example recognition of potential cancerous lesions on radiology images
12. Personalize medical treatments
13. Determine patients most at risk in the healthcare system

Insurance

14. Automate claims and damage analysis from reports or images
15. Image-based risk prediction for home insurance
16. Pricing risk

Manufacturing

Manufacturing companies including discrete manufacturing like automotive or other industrial companies (e.g. oil&gas) rely on deep learning algorithms:

17. Provide advanced analytics tools for processing big data about manufacturing

18. Generate automated alerts about the issues of production lines (e.g. on quality assurance or safety) using sensor data to notify relevant teams on time

19. Support predictive maintenance systems by analyzing images and other sensor data

20. Empower industrial robots with sensors and computer vision skills

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20.Empower industrial robots with sensors and computer vision skills

17.Monitor working environment around heavy machineries automatically to ensure people and items are at a safe distance

Pharmaceuticals & Medical Products

22.Drug discovery: Prediction of drug effects, monitoring the use of drug and identifying its side effects
23.Enable precision medicine which includes remedies based on genetic, environmental or lifestyle factors (also called personalised medicine)
Public sector
24.Make predictions about population health risks
25.Facial recognition for security checks

Retail & E-commerce

26.Offer new shopping experiences such as “Just Walk Out” stores, and checkout-less shopping. For more, feel free to read our article on cashierless stores.
27.Other shopping experiences powered by deep learning include voice-enabled shopping and in-store robots.
28.Image search: Scanning the image of the product to find the product on the store or suggest similar alternatives
29.Forecasting product demand more accurately according to buying habits analysis and future trend predictions
30.Deliver effective inventory management to prevent of out-of-stock and oversupply

Analytics

33.Most deep learning applications empower analytics solutions. Therefore analytics departments rely on deep learning in numerous cases

Customer success

34.Chatbots offering immediate and personalized customer service
35.Monitor customers' responses, reviews and social media activity to identify what they say about the brand

36.Churn prevention: Examine data in customer feedback forms/texts, identify potential churners and communicate with the customer without losing time

Cybersecurity

35.Intrusion detection/prevention systems (IDS / IPS): Investigate user activities and network traffic to prevent malicious activities and reduce false alerts

Operations

36.Automatically extract data from documents using deep learning models

Sales & Marketing

•Create personalised advertisements according to browsing data
•Identify potential clients that are most likely to buy the solution
•Logo and counterfeit item detection in social media for brand protection