Neural Networks

Neural Networks are models that take inspiration from brain's functioning

They aim to replicate the working of a biological neuron, that is brain cells

Neural networks are the backbone of deep learning, and are very useful and complex structures

They are different from other ML models like decision trees, that rely on probability or SVMs that rely on distance.

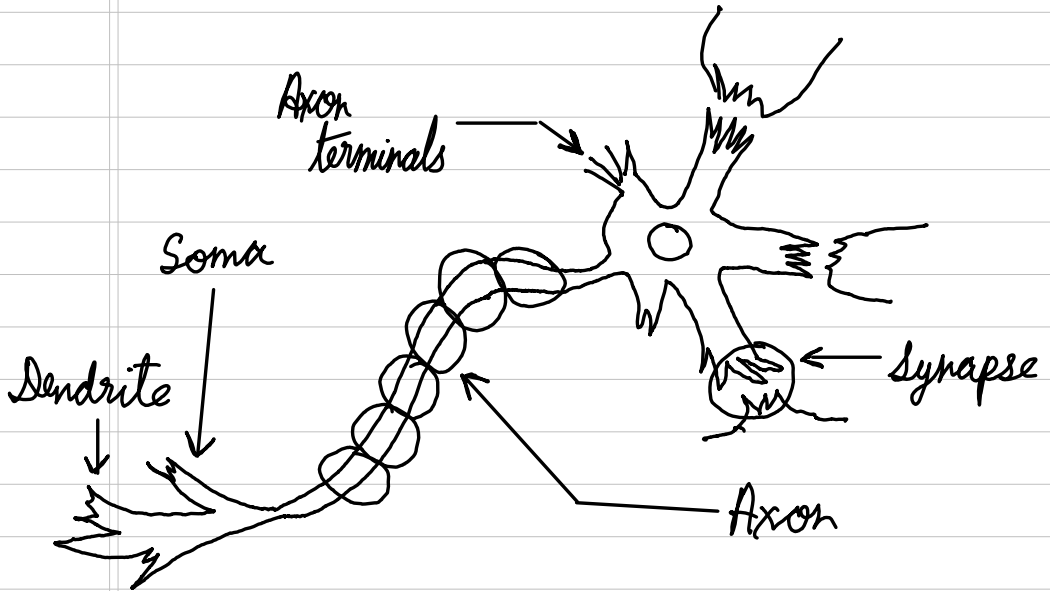They are modelling of our brain, our human intelligence

Applications of Neural Networks

① classification

② Recognition → OCR

③ Prediction eg crop yeild forcasting, stock Market

Neural Networks can learn and solve almost everything

This is because neural networks are universal function approximators

Biological Neurons

Axon
terminals →

Soma

Dendrite →

← Synapse

Axon

Structure of a biological
Neuron

Dendrite : A brush of very thin fibre

Axon : A long cylinderical fibre

Soma : Cell body

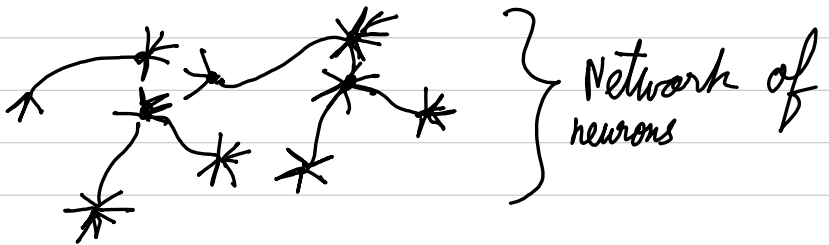Synapse : Junction where axon makes
contact with dendrites of neighboring
dendrites

Biological Networks

Each neuron is $10 \mu m$ long. Human brains have 10^{11} neurons

These neurons operate in parallel and form a network of neurons.

These neurons communicate with each other with the help of electric impulses.

} Network of neurons

① Dendrite (Input) → Recieves signal from other neurons

② Soma (Processing Unit) → Sums up all input signals. Consists of a threshold value
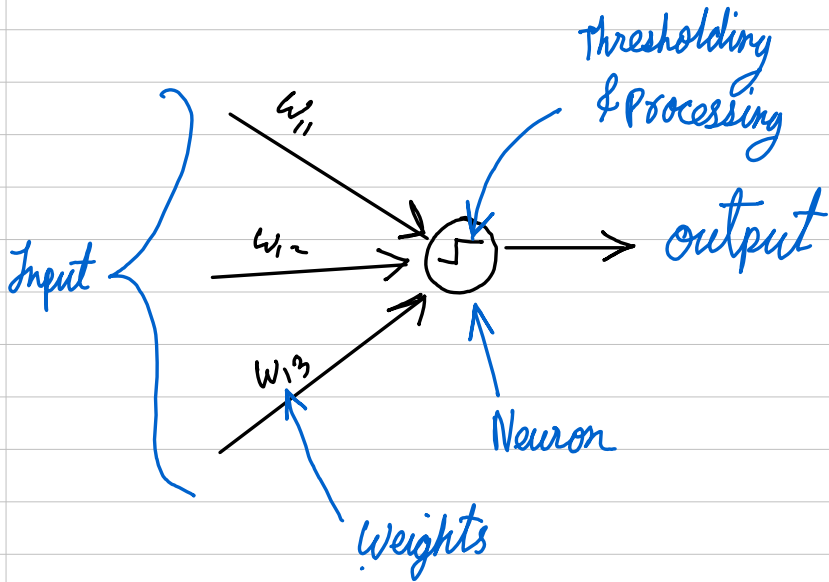
③ Synapse (Weighted Connections) →

Point of communication between neurons. Amount of signal transferred depends upon the strength (synaptic weight) of the connection
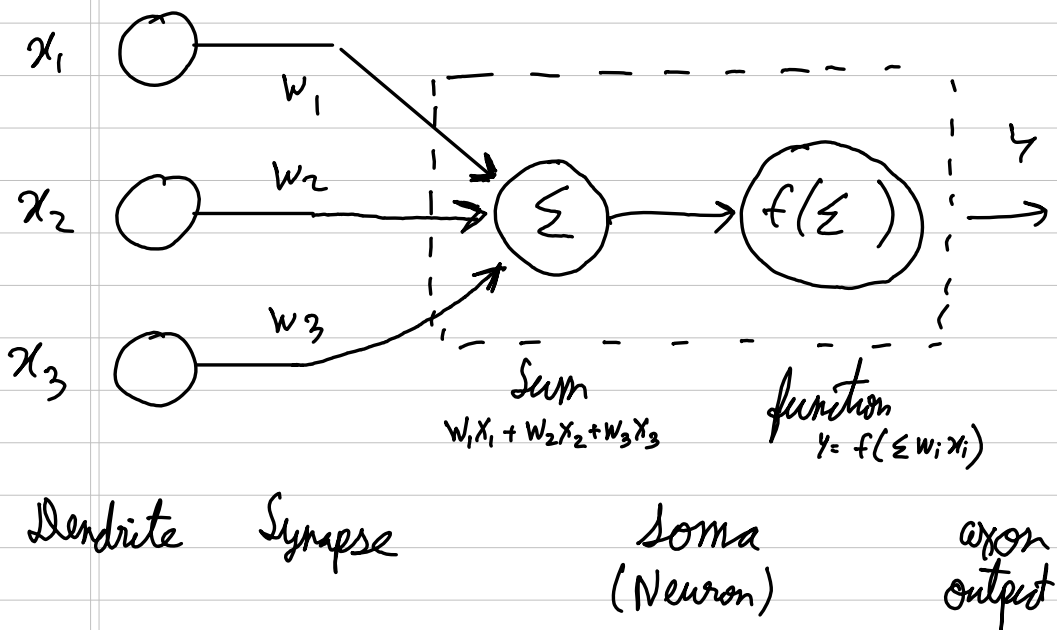
④ Axon terminals (Output) → Transmit signal Neuron fires depending on threshold.

Artificial Neural Networks

ANN is a (vague) simulation of neural networks

Thresholding & Processing

Input

output

Neuron

weights

Biological	Artificial
Cell	Neuron
Dendrites	Weights
Soma	Net Input
Axon	Output

x_1

W_1

x_2

W_2

x_3

W_3

Σ

$f(\Sigma)$

y

Sum
$W_1 x_1 + W_2 x_2 + W_3 x_3$

function
$y = f(\Sigma W_i x_i)$

Dendrite   Synapse   Soma   axon
                                   (Neuron)   output

A neural network consists of a laarge number of neurons

These neurons are interconnected with each other
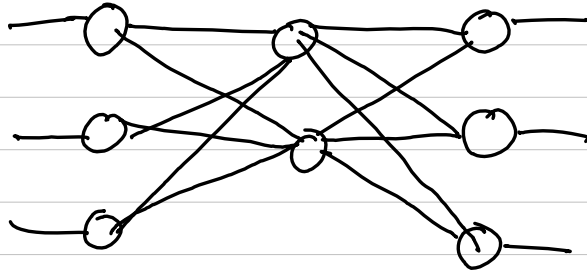
Activation of a neuron is the input to the next neuron

A Neural Network has parameters like weights that need to be decided when model is trained

Hyperparameters include →

① Learning rate

② Learning rules (eg activation functions)

③ Number of layers ⎫
                                    ⎬ Network
④ Arrangement of Neurons ⎭ architecture
   & Connection pattern

single layer feed forward network
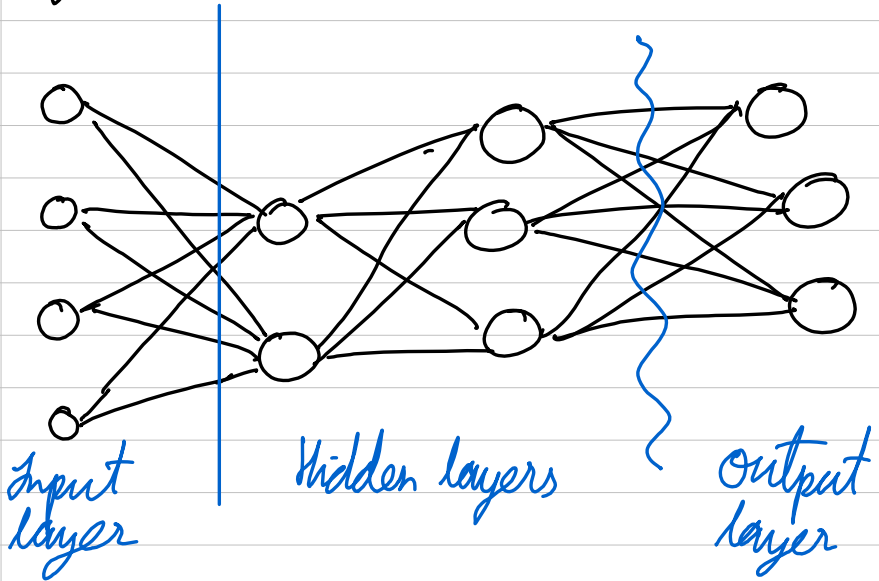
Simplest form of neural network
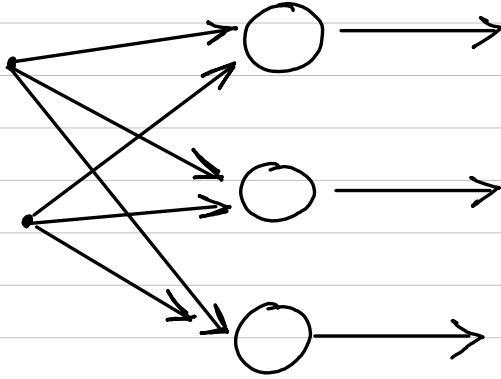
outputs are $f(\leq w_i x_i)$

where w_i are determined (learnt)
by the network

Very simple model useful only for
small classification and function approximation
tasks

Multilayer Feed Forward Network

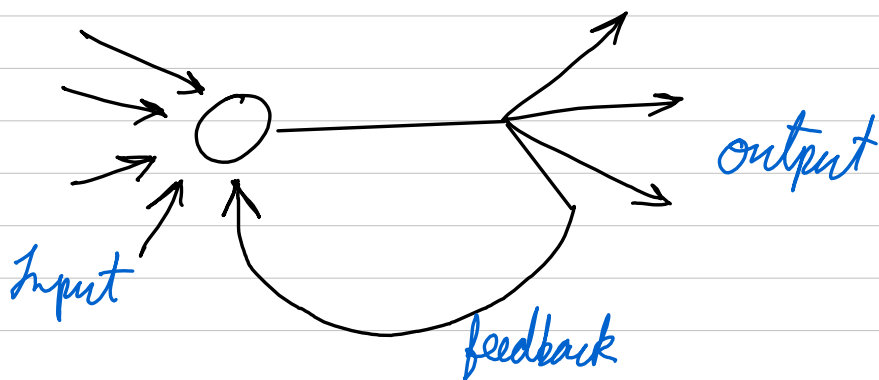Formed by interconnection of several layers
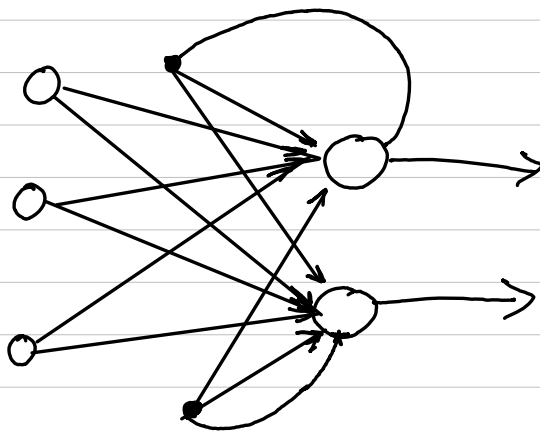
Multiple layers are present in the network

More hidden layers, more complexity of the model

Feed Back Networks

A feedback is given to the network
That is, the output of the neurons
is fed as input to the model.

Input

output

feedback

Single layer Recurrent layer
Output is fed back into entire layer

If output is directed back to same
layer, then it is lateral feedback

Recurrent Networks

Recurrent networks are networks with feedback
networks in closed loop

Recurrance

Input
layer

Hidden
layers
with
Recurrance

output
layer

Multilayer
Recurrent
layer
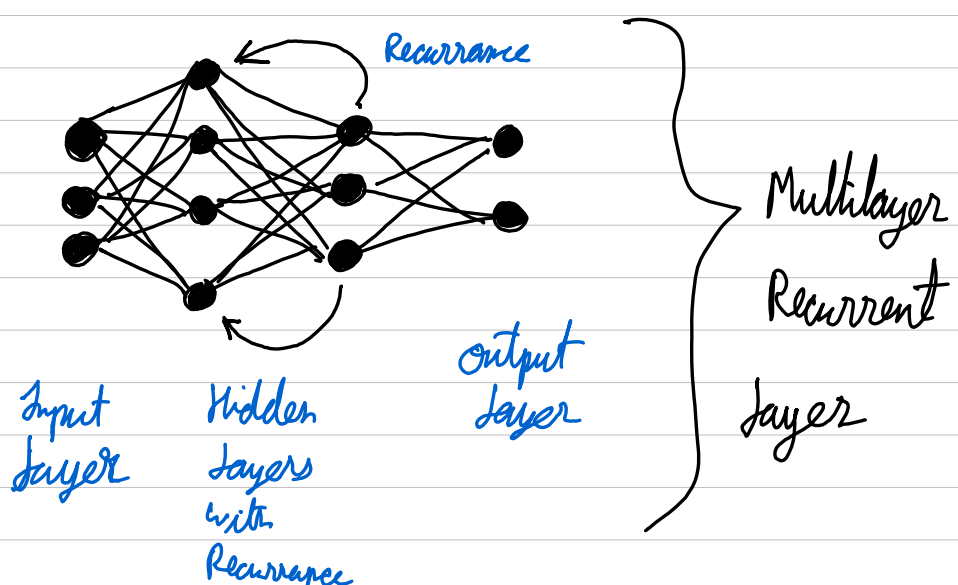
RNNs maintain an internal state memory
helping them to recognize patterns

Helpful for NLP, speech recognition & time
series prediction

Supervised Learning in ANN

Input → [ANN] ⟶ output Predicted

↑ update parameters

↓

Error signal Generator ← Actual value
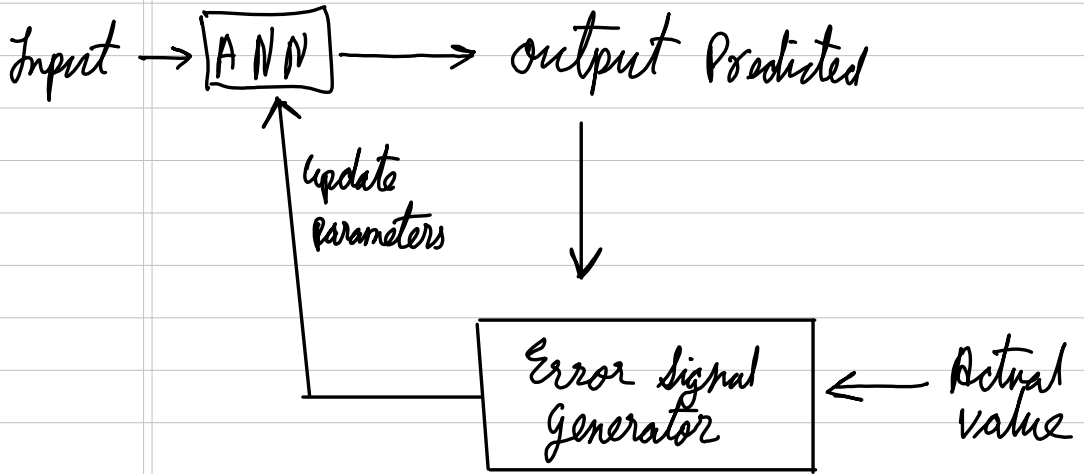
The actual value & the predicted values are matched and the error value is calculated

Depending on error value, the parameters (weights) are updated

This is much like linear regression where we use gradient descent to update values of m & c

Unsupervised Neural Networks

The expected output is not known hence no explicit error function present

ANN will try to find some kind of pattern using input data set without any external aids

Known as self organizing networks

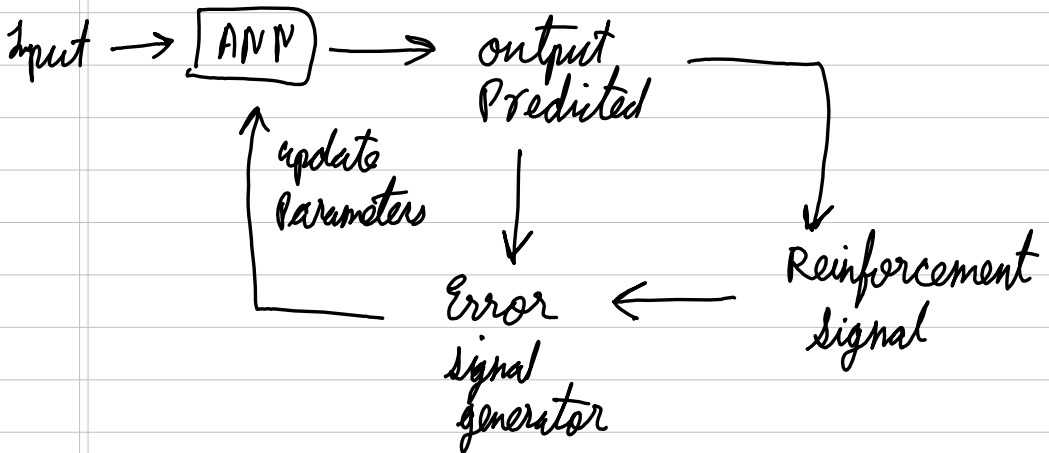Network recieves input patterns and organizes to form clusters

Example → GAN (Generative Adverserial Networks)

Reinforcement learning

Exact information about the output
is not known.

Only critic information is known

Example network might be told that
only 50% of the information is correct

Input → [ANN] → output
                 Predicted

↑ update
parameters

Error ← Reinforcement
signal   signal
generator

* Advantages →

Complex Pattern Recognition

Non linearity

Feature learning

* Disadvantages →

Complexity

Black box Nature ∴ less interpretability

Overfitting

Data dependance → Requires large datasets