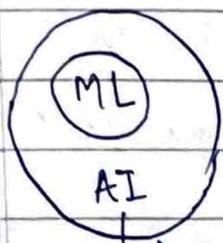


Introduction to Machine Learning (Eric Eaton)



→ ML + DL + NLP

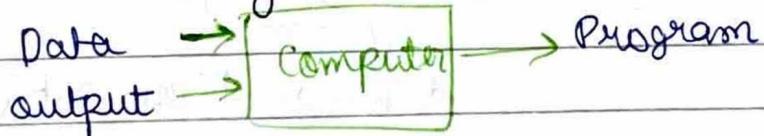
What is Machine Learning?

"learning is any process by which a system improves performance from experience"

Traditional Program



Machine Learning



Types of Learning

- Supervised learning
 - Given: training data + desired outputs (labels)
- Unsupervised learning
 - Given: training data (without desired outputs)
- Semi-supervised learning
 - Given: training data + a few desired outputs
- Reinforcement learning
 - Rewards from sequence of action.

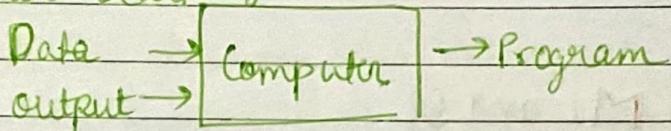
What is Machine learning?

Defined by TOM MITCHELL (1998)

- Machine learning is the study of algorithms that
- improve their performance P
 - at some task T
 - with experience E

A well-defined learning task is given by $\langle P, T, E \rangle$

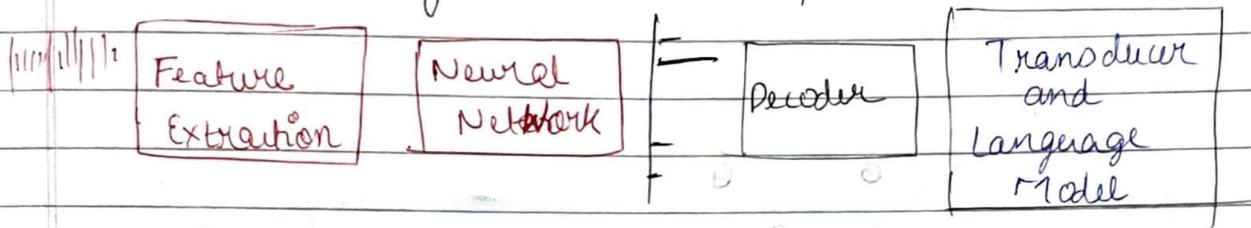
Machine Learning



Example of Task

- Recognizing Patterns
 - facial identities or facial expression
 - Handwritten or spoken words
 - Medical images
- Generating Patterns:
 - Generating images or motion sequences
- Recognizing anomalies
 - unusual credit card transactions
 - unusual patterns of sensor readings in a nuclear power plant
- Predictions:
 - Future stock prices.

Machine Learning in Automatic Speech Recognition

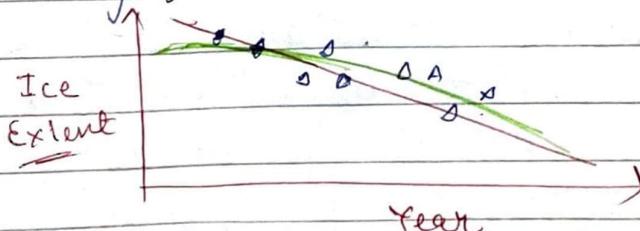


Types of Learning

- Supervised (inductive) learning
 - Given : training data + desired outputs (labels)
 - Training set has inputs and outputs i.e., labeled
- Unsupervised learning
 - Given : training data (without desired outputs)
 - Training set is unlabeled
- Semi-supervised learning
 - Given : training data + a few desired outputs
 - Training set is partially labeled
- Reinforcement learning
 - Rewards from sequence of actions
 - output assessed via rewards and punishment

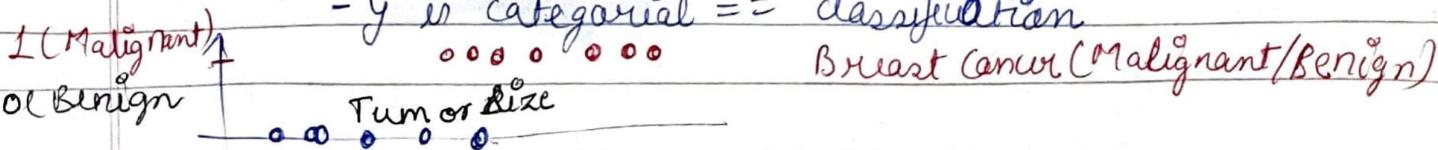
Supervised learning :

- Regression :-
- Given $(x_1, y_1), (x_2, y_2), \dots, (x_n, y_n)$
 - learn a function $f(x)$ to predict y given x
 - y is a real-valued = regression



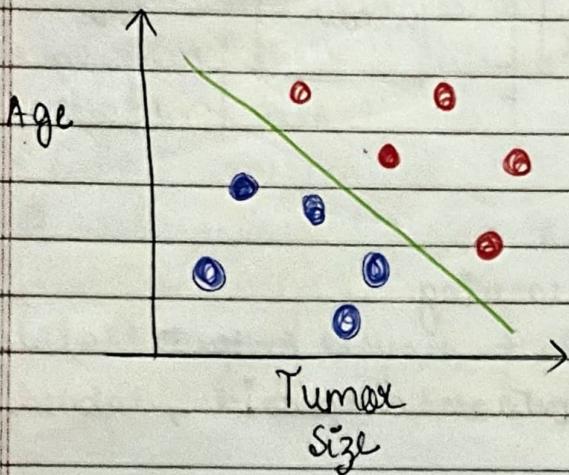
Supervised learning :- Classification

- Given $(x_1, y_1), (x_2, y_2), \dots, (x_n, y_n)$
- learn a function $f(x)$ to predict y given x
- y is categorical = classification



$\textcircled{2} \times$ can be multidimensional

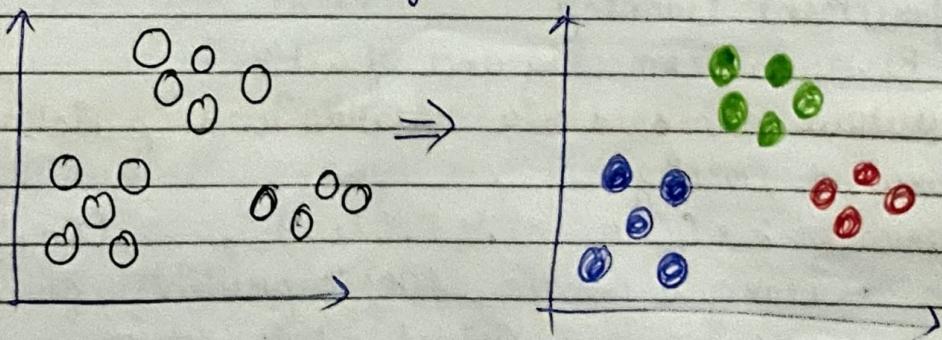
- Each dimension corresponds to an attribute



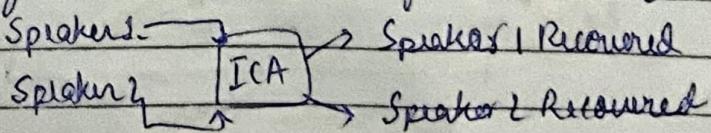
- Clump Thickness
- Uniformity of Cell Size
- Uniformity of Cell Shape

Unsupervised learning

- o Given x_1, x_2, \dots, x_n (without labels)
- o Output hidden structure behind the x 's
 - E.g., clustering

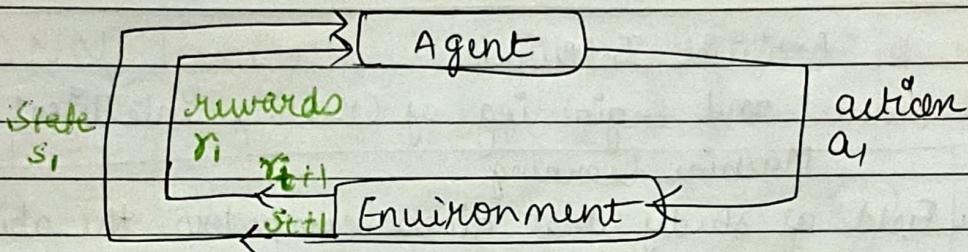


$\textcircled{3} \text{ A} \rightarrow$ Independent component analysis - separate a combined signal into its original sources



Reinforcement Learning

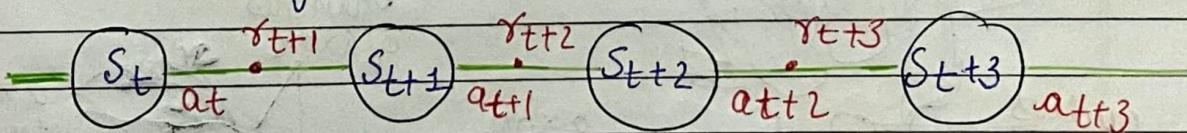
- Given a sequence of states and actions with (delayed) rewards, output a policy
 - Policy is a mapping from states \rightarrow actions that tells you what to do in a given state
- Example - Robot in a maze
 - Agent - Environment Interface



Agent and environment interact at discrete timesteps

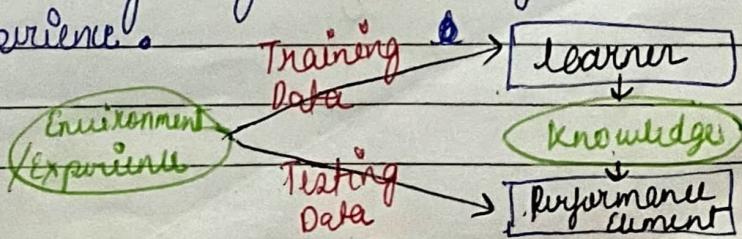
$$t = 0, 1, 2, \dots$$

Agent observes state at step t : $s_t \in S$
 produces action at step t : $a_t \in A(s_t)$
 gets resulting rewards: $r_{t+1} \in \mathbb{R}$
 and resulting next state: s_{t+1}



→ Designing a learning system

- choose the training experience
- choose exactly what is to be learned
 - i.e. the target function
- choose how to represent the target function
- choose a learning algorithm to infer the target function from the experience



Every ML algorithm has three components

- Representation
- Optimization
- Evaluation

Deep Neural Networks

$$y = f(x)$$

Artificial Intelligence

- The Science and Engineering of Creating Intelligent Machines

Machine Learning

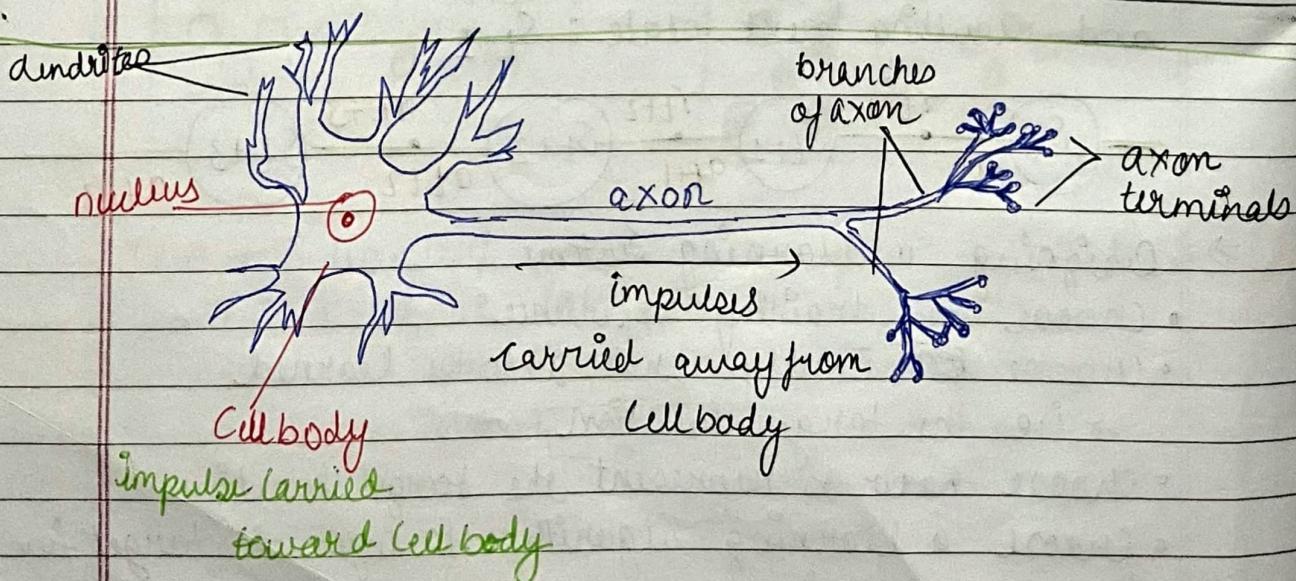
The Field of study that gives computers the ability to learn without being explicitly programmed

Brain-Inspired

An algorithm that takes its basic functionality from our understanding of how the brain operates

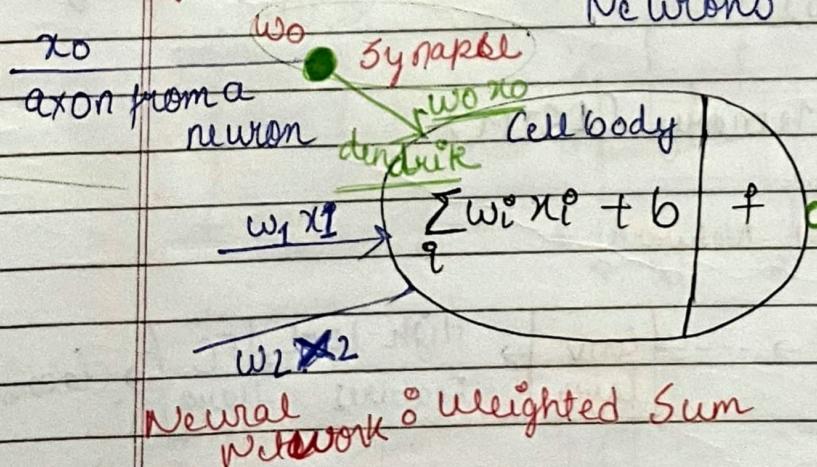
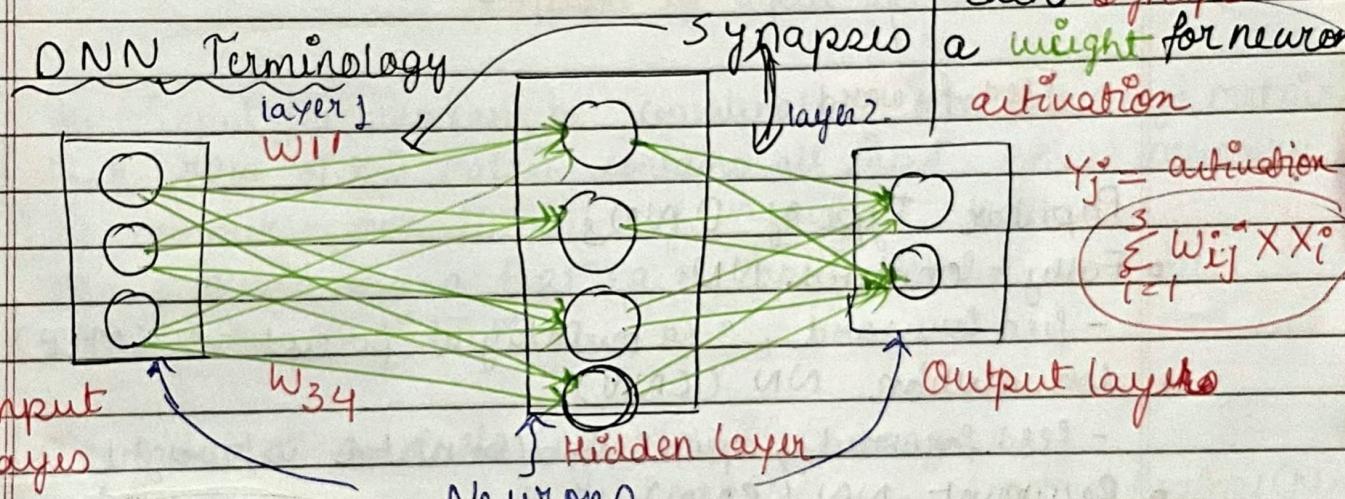
spiking

Neural Network



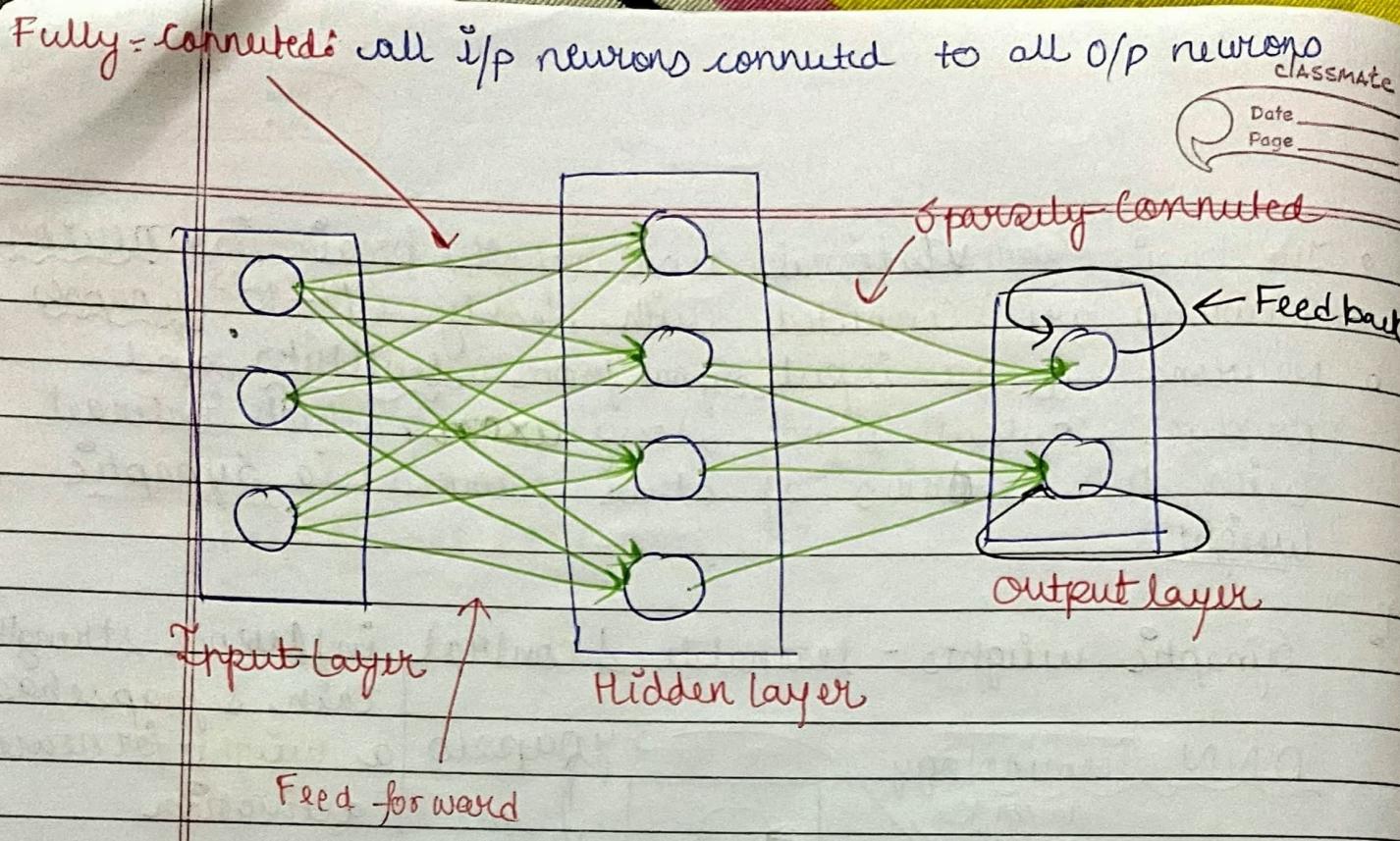
- The basic computational unit of the brain is a neuron
- Neurons are connected with nearly $10^4 - 10^{15}$ Synapses
- Neurons receive input signal from dendrites and produce output signal along axon, which interact with the dendrites of other neurons via Synaptic weight

Imp. Synaptic weights - learnable & control influence strength
Each synapse has a weight for neuron activation



Spiking Architecture or Brain Inspired

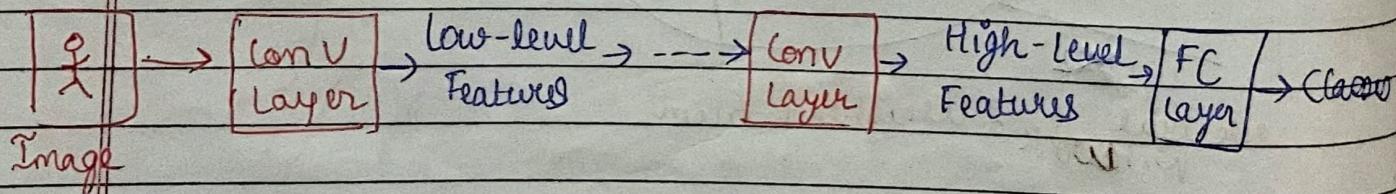
Integrated and fire: Once a neuron reaches a certain potential, it spikes and resets its potential



Popular Type of DNNs

- Fully-connected NN
 - feed forward, a.k.a multilayer perceptron (MLP)
- Convolution NN (CNN)
 - feed forward, sparsely-connected w/ weight sharing
- Recurrent NN (RNN)
 - feedback
- Long Short-Term Memory (LSTM)
 - feedback + storage

Deep Convolution Neural Network



- The features are the elements of your input vectors
- The number of features is equal to number of nodes in the input layer of the network

why convolution? How the shape of fn is change with respect to other function
 ↳ feature Related Matrix Multiplication