

UNIT 1

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Date: _____

* Artificial Intelligence:

It is a branch of computer science by which we can create intelligent machines which can behave like a human, think like human and able to make decisions.

* Goals of AI Scope

- Replicate human intelligence.
- Solve knowledge intensive task.
- An intelligent connection of perception and action.

* Application of AI

- (i) Gaming;
- (ii) Natural language Processing (NLP): Field of AI that deals with enabling Computer to understand, interpret and generate human language.
- (iii) Robotics:
- (iv) Chatbots:
- (v) Machine Learning

* Scope of AI (AI Careers):

- AI Analysts and Developers.
- AI Engineer and Scientist.
- AI Researcher.
- Robotics Specialist.

* Advantages

- It reduces human error.
- It is fast.
- Better handling of information.
- Available 24x7.

Disadvantages

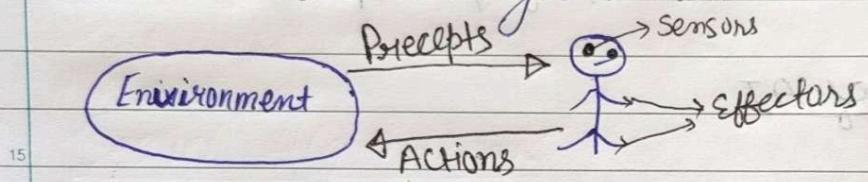
- It is costly to implement.
- It can't duplicate human Creativity.
- It will replace jobs leading to Unemployment.

* Static vs Dynamic :

An environment that keeps constantly changing itself when an agent is up with some action is said to be dynamic environment, else it is called static environment.

* Agents in AI

An agent can be anything that senses the environment through Sensors and act on their environment through actuators.



Intelligent Agents: It is an autonomous entity which act upon an environment using sensors and actuators for achieving goals.

Rational Agent: A rational agent is an agent which has clear preference, models uncertainty and acts in a way to maximize its performance measure with all possible actions.

* Types of Agents in AI based on their degree of perceived Intelligence

- (1) Simple Reflex Agent: Ignore the percept history and act on basis of current percept.
- (2) Model-Based Reflex Agents: Handle partially observable environment.
- (3) Goal-Based: Decision based on how far they are current from the goal.
- (4) Utility-Based: Developed having their end uses as building block.
- (5) Multi-Agent System: Interact with other agents to achieve goal.
- (6) Hierarchical Agent: Organised in hierarchy, with high-level

agents overseeing the behaviour of low-level agent.

* Agent Environment in AI

An environment is everything in the world which surrounds the agent, but it is not part of an agent itself.

* Features of Environment :

- (i) Fully Observable Vs Partially Observable:
- (ii) Deterministic Vs Stochastic : If agent's current state determine completely next state of envirn, called deterministic. In stochastic agent we can't determine next state completely.
- (iii) Episodic Vs Sequential :
- (iv) Static Vs Dynamic :
- (v) Discrete Vs Continuous :
- (vi) Single agent Vs Multi-agent :
- (vii) Known Vs Unknown :
- (viii) Accessible Vs Inaccessible :

* Decision Tree : Decision trees are popular ML techniques used for classification and regression tasks. They represent decision and their possible consequences in a tree-like structure.

* Graph Convolutional Networks (GCN) : GCNs are deep learning models specially designed to work with graph-structured data. They leverage graph structures to perform convolutional operations on nodes, capturing both local and global information.

* State Space Representation :

It is a fundamental concept in AI that involves problems or scenarios in terms of state and transitions between them.

Key components:

1. Initial State: It represents the state from which process begins.
2. Action State: It represents possible moves to change the state.
3. Goal State: The desired state that the system aims to achieve.
4. Transition Model: It defines the rules of functions.
5. Path/Cost Function: It assigns a cost to each path and helps determine the optimal solution.

* Search Algorithm :

Searching is a step by step procedure to solve a search problem in a given search space.

*₂₀ Properties of Search Algorithm:

i) Completeness:

ii) Optimality:

iii) Time Complexity:

iv) Space Complexity:

Type_s:

Search Algorithm

Uninformed Search

Breadth First Search

Depth First Search

Simple Hill Climbing

Informed Search

A* algorithm

A* Algorithm

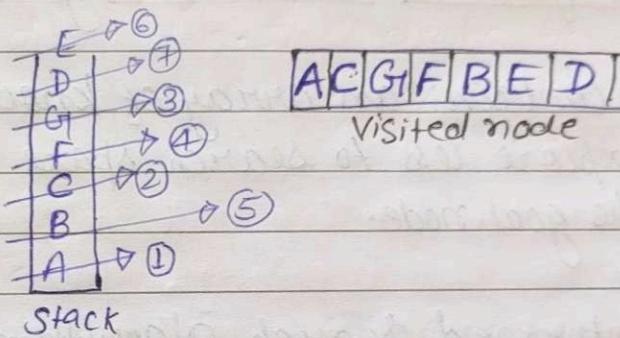
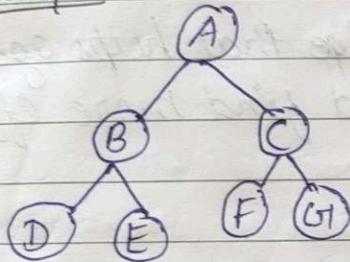
* Uninformed Search

It doesn't contain any domain knowledge such as closeness, the location of the goal.

* Depth First Search (DFS)

- Depth first Search is a recursive tree traversal algorithm.
- DFS uses a Stack structure for implementation.
- This follows LIFO (Last In first Out).

Example:



$$T.C = O(b^d)$$

b = branching factor

$$S.C = O(bm)$$

d = depth

* Advantage

- DFS requires very less memory.
- It takes less time to reach the goal node.

Disadvantage

- No guarantee it will give you solution.

* Breadth First Search

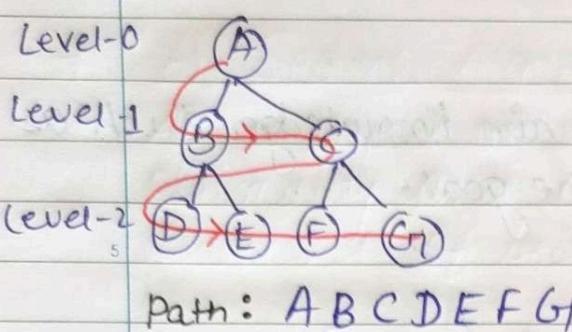
This is level search technique.

It will definitely search the element.

$$T.C = O(b^d)$$

branch factor

Example :



Advantages :

BFS will provide solⁿ if any exists.

Disadvantages :

- It consumes large memory space.
- Its time complexity is more.

* 10. Informed Search Algorithm:

It contains an array of knowledge that helps agents to explore less to search space and find more efficiently the goal node.

Informed search algorithm uses the idea of heuristic.
So, it is also called Heuristic Search.

Heuristic function: It finds most promising path. It takes the current state of the agent as its input and produces the estimation of how close agent is from the goal.

* Heuristic Search Techniques in AI

25 Direct

- BFS
- DFS

Indirect

- Bidirectional Search
- A* Search
- Hill climbing
- Beam Search

* Hill Climbing Algorithm:

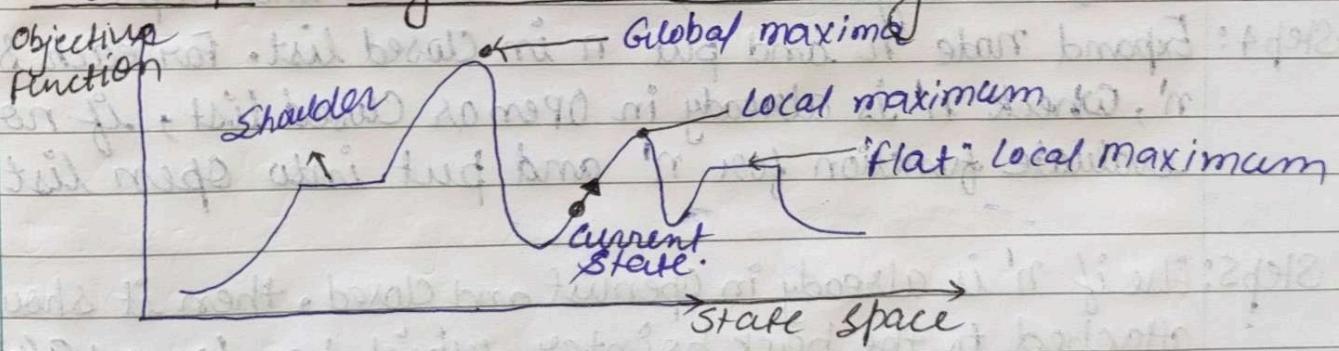
- It is technique for optimizing the mathematical problems.
- It is a local search algorithm that continuously moves in the dirⁿ. of increasing value to find the mountain's peak or the best solution to the problem.

Algorithm :

$$(m) + (n)B = (r)$$

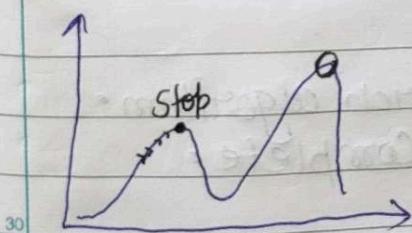
- Step1: Evaluate initial state. if goal state, then return Success & STOP.
- Step2: Loop until solution is found.
- Step3: Select and apply an operator to the current state.
- if it is goal state, return success & quit.
 else if, if it is better than current state, then assign it new state.
 else if, if not better than current state, then return to Step2.
- Step4: Check new State.
- Step5: Exit.

* State Space diagram of Hill climbing :-

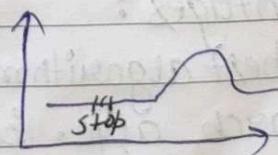


* Problems in Hill Climbing :

(1) Local Maximum



(2) Plateau/Flat maximum



(3) Ridge

* A* Search Algorithm :-

A^* is based on using heuristic method to achieve optimality and completeness and it is a variant of best-first algorithm.

$$f(n) = g(n) + h(n)$$

Estimated cost
of cheapest
solution

↓
Cost to reach
node 'n' from
start state

→ Heuristic
value of node n.

* Algorithm :

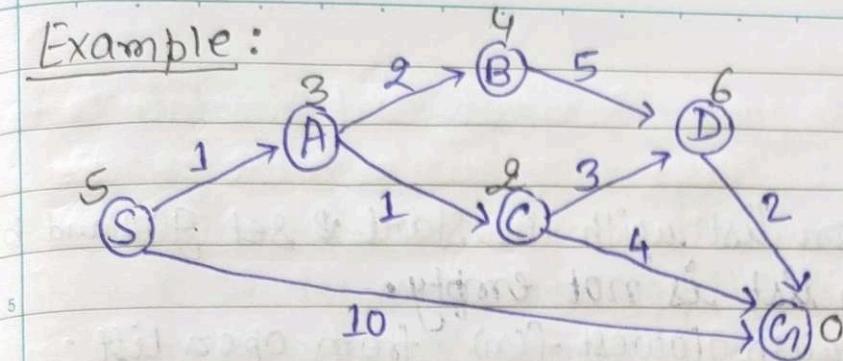
- Step 1: Place the starting node in the Open list.
- Step 2: If open list is empty, then return failure and Stop.
- Step 3: Select node [openlist] which has smallest $f(n)$,
If node is goal node, return success and Stop.
- Step 4: Expand node n and put n in Closed list. For each successor n' , check n' is already in Open or Closed list, if not then evaluate function for n' and put into Open list.
- Step 5: Else if n' is already in Open list and closed, then it should attached to the back pointer, which has lowest $g(n')$ value.
- Step 6: Return Step 2.

* Advantages :

- A^* is best algorithm than other search algorithm.
- A^* Search algo. is optimal and complete.

* Disadvantages :

- It doesn't always produce shortest path.
- The main drawback of A^* is memory requirement.

Example :

1. $\{S \rightarrow A \Rightarrow 1+3=4, S \rightarrow G \Rightarrow 10+0=10\}$ Select $S \rightarrow A$ hold $S \rightarrow G = 10$ Comparing previous hold also.
2. $\{A \rightarrow B \Rightarrow 1+2+4=7, A \rightarrow C \Rightarrow 1+1+2=4, S \rightarrow G = 10\}$ Select $S \rightarrow A \rightarrow C$
3. $\{C \rightarrow D \Rightarrow 1+1+3+6=11, C \rightarrow G = 1+1+4+0=6, S \rightarrow G = 10, A \rightarrow B = 7\}$ Select $C \rightarrow G$

\therefore final path = $S \rightarrow A \rightarrow C \rightarrow G$
 cost = 6

* AO* Search algorithm:

⇒ The AO* algorithm extends A* by allowing the heuristic function to change dynamically during the search process.

⇒ The AO* method divides any given difficult problem into a smaller group of problems that are then resolved using the AND-OR graph.

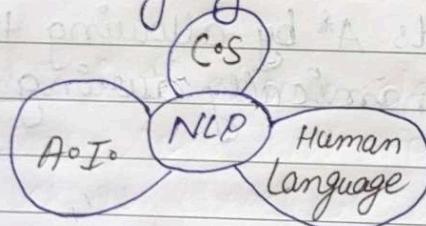
⇒ The adaptive nature of the algo allows it to refine the search and potentially find better solution compared to traditional A*

Algorithm :

- Step 1: Initialize the Open list with the start & set $g(n)$ and $h(n)$.
- Step 2: While the open list is not empty.
 - (a) Select the state with lowest $f(n)$ from open list.
 - (b) If the state is goal state, terminate and return solution.
 - (c) Expand the selected state by generating its successors.
 - (d) For each successor, calculate g -value and update h -value.
 - (e) If successor's state has a lower f -value than its previous occurrence, update its f -value and add to open list.

* Natural Language Processing (NLP) :

It is a part of C.S., Human language & AI. It is the technology that is used by machines to understand, analyse, manipulate and interpret human's language.



* Component of NLP :

1. **Natural Language Understanding (NLU):** It helps the machine to understand and analyse human language by extracting the metadata such as concepts, entities, etc.
2. **Natural Language Generation (NLG):** NLG acts as a translator that converts the computerized data into natural language & representation. It involves

Text planning, Sentence planning and Text Realization.

* NLU

- 5 NLU is the process of reading and interpreting language.

It produces non-linguistic output from natural language input.

NLG

- NLG is the process of writing or generating language.

It produces constructing natural language outputs from non-linguistic inputs.

* Phases of NLP:

1. Lexical Analysis: This phase scans the source code as a stream of characters and convert into meaningful words, etc.
2. Syntactic Analysis (Parsing): Checks grammar, word arrangement.
3. Semantic Analysis: Focuses on literal meaning of words.
4. Discourse Integration: Meaning of sentences that follow it.
5. Pragmatic Analysis: It helps to discover the intended effect by applying set of rules/regularn.

* Application of NLP:

- Question Answering.
- Spam Detection.
- 30 • Sentiment Analysis.
- Machine Translation.
- Spelling Correction.
- Chatbot.
- Information Extraction
- NLU

* Difficulties in NLP :

NLP is difficult because Ambiguity and Uncertainty exists:-

- (1) Lexical Ambiguity :- Presence of two or more possible meanings of the sentence within single word.
- (2) Syntactic Ambiguity :- A sentence can be parsed in different ways.
- (3) Referential Ambiguity :- Referring to something using pronouns.
e.g. Dashrath went to Bansal. He said "I am tired".
→ exactly who is tired?

* Advantage Of NLP

- It is very time efficient. → NLP may not show context.
- It helps user to ask questions → NLP is unpredictable.
about any subject & get response. → It require more key strokes.
- It helps Computer to communicate
with human in their language

Disadvantage

* NLP APIs : It allows developers to integrate human-to-machine communication and complete several useful tasks such as Speech recognition, chatbots, Spelling correction,

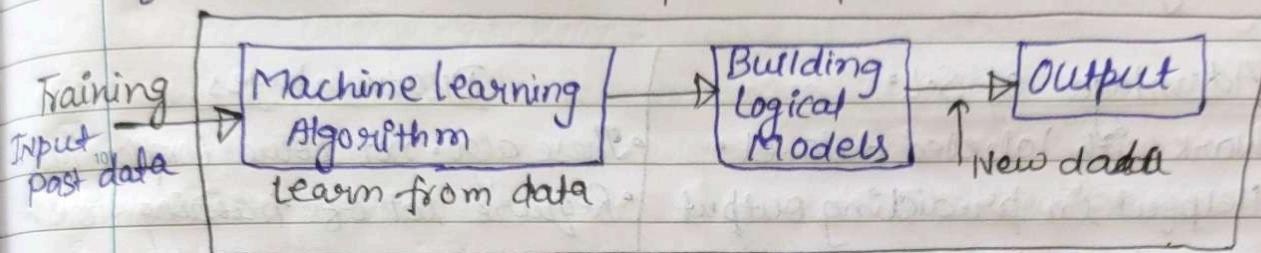
25 List of NLP APIs →

- IBM Watson API
- chatbot API
- Speech to text API.
- Cloud NLP API.



Machine Learning

Machine learning is said as a subset of AI that is mainly considered with the development of algorithm which allows a computer to learn from the data and past experience on their own.

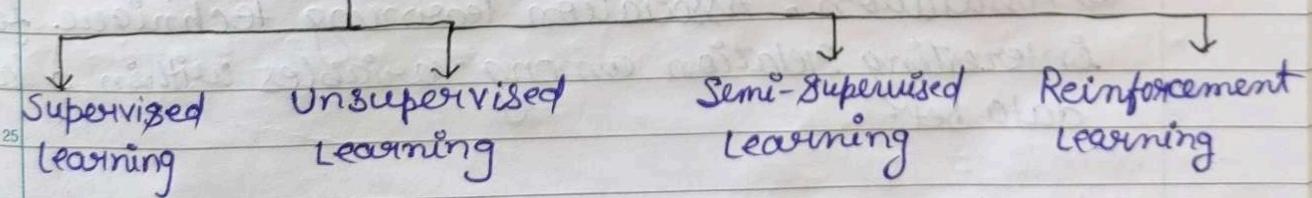


* Need of ML:

- Solving Complex problem, which are difficult for human.
- Easily identifies trends and patterns.
- Automation (NO human intervention needed).
- Handling multi-dimensional and multi-variety data.

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ML Types



①

- Supervised Machine Learning: It is a type of ML in which machine are trained using well "labelled" training data and on basis of that, machine predicts output. The labelled data means input data is tagged with correct output.

(a) Classification: They are used to solve the classification problems in which the output variable is categorical, such as, Yes or No, Male or Female, etc.

Eg. Random Forest Algo., Decision Tree Algo., Svm algo.

(b) Regression:

* <u>Advantage of S.L.</u>	<u>Disadvantages</u>
• Work with labelled dataset.	• These algo. not solve complex task.
• Helpful in predicting output on basis of prior experience.	• Require lot of training time.

2.) Unsupervised Machine Learning: It is a learning method in which a machine learns without any supervision.

(a) Clustering: The clustering technique is used when we want to find the inherent group from data.
Eg. K-means Clustering Algo, Mean-shift Algo., etc.

(b) Association: Association learning technique finds interesting relation among variables within a large data set.

* <u>Advantage of US-Learning</u>	<u>Disadvantage</u>
• Can be used for Complex task.	• Output can be less accurate.
• They are preferable as unlabeled dataset is easier as compared to labeled for various tasks.	• Working with USL is more difficult.

(3) Semi Supervised Learning: It lies b/w Supervised and Unsupervised machine learning. It is simple and easy, highly efficient.

(4) Reinforcement learning: It is a feedback-based learning method, in which a learning agent gets a reward for each right action and penalty for wrong action.

- (a) Positive Reinforcement learning.
- (b) Negative Reinforcement learning.

* Advantages

- Help in solving complex real-world problems.
- Helps in achieving long term results.

Disadvantages

- RL is not preferable for simple problems.
- Requires huge data and computations.

* Applications of ML:

- Image Recognition.
- Speech Recognition.
- Traffic Prediction
- Product Recommendation
- Self-driving car.
- Robotics.

* Limitations of ML:

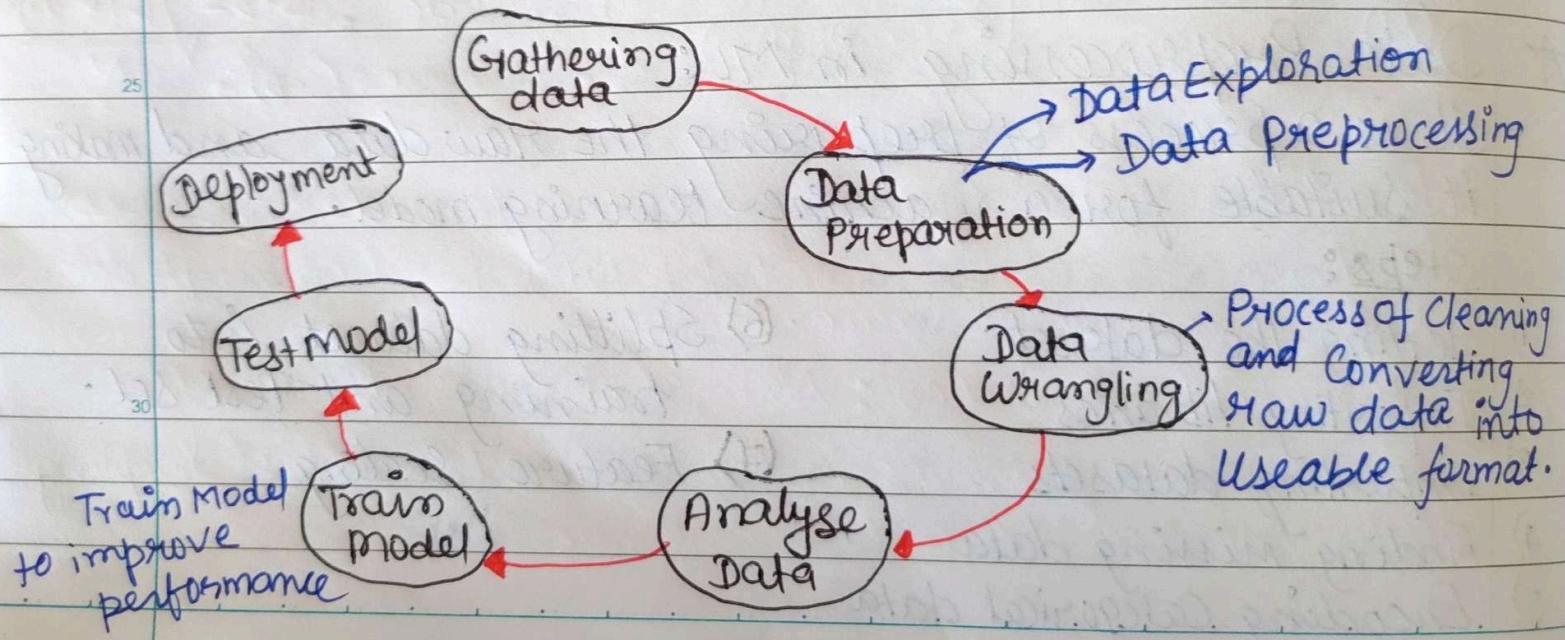
i) Time and resource.

ii) Interpretation of result.

iii) Data Acquisition:- Require massive data to train.

iv) High error-susceptibility.

★ M.L. Life Cycle: It involves Seven Major Steps.



* Regression : Regression is a supervised learning technique used for predicting continuous or real-valued output based on input feature. It's aims to establish a relationship between the Independent Variable (Input) and dependent Variable (Output) by using regression model to the training data.

* Types of Regression :-

- 1. Linear Regression :- It assume linear relationship b/w I^oD^o and D^o.
- 2. Polynomial , , :
- 3. Logistic , , : It's classification algo, used for binary classificⁿ problem.
- 4. Lasso , , :
- 5. Ridge , , : It is used to address Overfitting in linear reg.
- 6. SVM : Support Vector Machine (Accuracy & error).
- 7. Decision Tree Regression :
- 8. Random Forest , , : (SVM + Decision Tree Regression)
- 9. Gradient Boosting , , : Builds model in sequential manner.

Independent data
↑

* Regression Evaluation Metrics :

- MSE (Mean Squared Error) : $\frac{1}{N} \sum (\text{Actual output} - \text{Predicted output})^2$
- RMSE = $\sqrt{\text{MSE}}$
- MAE (Mean Absolute Error) = $\frac{1}{N} \sum (\text{Actual output} - \text{Predicted output})$
- R-Squared $\Rightarrow 1 - \frac{SS_R}{SS_m}$ SS_R = square sum error of regression line
 SS_m = mean line

* Probability in ML:

Probability is the measure of the likelihood of an event occurring, ranging from 0 (impossible) to 1 (certain).

Probabilistic models are widely used in ML for making predictions and estimating uncertainties.

Bayes' Theorem: It relates conditional probabilities, allowing for calculation of posterior probabilities based on prior knowledge and new evidence. $P(A|B) = \frac{P(B|A) \cdot P(A)}{P(B)}$

Probability Distribution: It describes the probabilities of different outcomes for a random variable.

Joint Probability $P(A \cap B)$, Conditional Prob. ($P(A|B) = P(A \cap B)/P(B)$)

* Statistics and Linear algebra for ML:

Statistics involves collecting, analyzing, interpreting, presenting and organizing data.

- Descriptive statistics techniques summarize and describe the main characteristics of a dataset.

Mean, Median ($\text{odd} \Rightarrow (\frac{n+1}{2})^{\text{th}} \text{ term}$
 $\text{even} \Rightarrow ((\frac{n}{2})+1)^{\text{th}}$) , Mode , $S.D = \sqrt{\frac{\sum(x-\bar{x})^2}{N}}$

- Inferential statistics techniques allow to make inferences and draw conclusions about population based on sample data.
 Hypothesis Testing, p-value.

Probability Distribution: Normal, binomial, poisson, etc.

Sampling and Estimation: Random and Stratified Sampling.

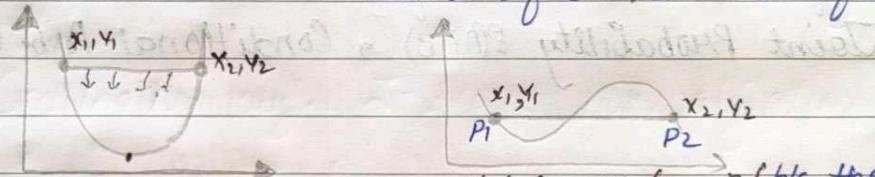
Statistical Tests: t-test, chi-square test.

* Linear Algebra in ML

- Vector and Matrices data structure used to represent and manipulate data in ML.
- Linear Equation and Systems are used to express relationship between variable in ML models.
- Eigenvector and Eigenvalue, Matrix Operation, Matrix decomposition.

* Optimization: The process of optimization aims to lower the risk of error and improve the accuracy of the model.

* Convex Optimization refers to optimization of convex function which involves finding the global minimum or maximum of a convex function.



Convex sets: Sets that satisfy the condition that line connecting any two point lies entirely within set.

Convex function: function " "

Global Maxima/minima:

* Data Visualization:

Data visualization is the graphical representation of data to uncover pattern, trends and relationship among raw data. It helps in understanding complex datasets.

Techniques: Scatter plot, line graph, bar chart, histogram,

* Hypothesis :

ML professionals and data scientist make an initial assumption for the solution of the problem. This assumption is known as Hypothesis.

Null Hypothesis:

- It suggest that there is no relationship b/w two variable.
- It is denoted by H_0 .
- $H_0 \rightarrow T_1 \neq T_2$
 $M_1 = M_2$
- P+testing

Alternative Hypothesis

- Opposite to H_0 .
- It is denoted by H_A .
- $H_A \rightarrow T_1 \neq T_2$
 $M_1 \neq M_2$

* Probability Distribution

- Gaussian (Normal) distribution: It is characterized by its Mean and Standard deviation.
- Skewness measure the asymmetry of a distribution, kurtosis measure the degree of peakness or flatness of dist.
- Categorical distribution represent discrete variable with a limited set of possible values or categories.
- Continuous distribution represent variable with any value ^{within} a range.
- Skewed distribution have non-symmetric shape.

* Data Preprocessing in ML:

It is a process of preparing the raw data and making it suitable for a machine learning model.

Steps:

- 1) Getting the dataset
- 2) Importing libraries
- 3) Importing datasets
- 4) Finding missing data
- 5) Encoding categorical data
- 6) Splitting dataset into training and test set.
- 7) Feature Scaling.

★ Normalization

$$X_n = \frac{X - \text{Min}(X)}{\text{Max}(X) - \text{Min}(X)}$$

- This technique uses minimum and max value for scaling of model.

- It is helpful when features are of diff. scales.

- range $\rightarrow [0, 1]$ or $[-1, 1]$

- Also called Scaling Normaliz.

- Useful when feature distribution is Unknown.

Standardization

$$x = \frac{x - \text{mean}(x)}{\sigma} \rightarrow S.D. \cdot \sigma x$$

- This technique uses mean and S.D. for scaling of model.

- Helpful when Mean is 0 and S.D. (σ) is set to 1.

- Not specific range

Z-score normalization

- Useful when feature distribution is normal.

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