DATA MINING

Introduction-

DATA Mining Concepts-

Data Mining - Data Mining is the process of extracting insights from large datasets using statistical and computational techniques.

- It can involve structured, Semi-structured or unstructured data stored in databases, data warehouses or data lakes.

Data mining involves many algorithms to accomplish different tasks.

* TODAY, DATA is being generated at a rapid phase, everytime we make a click to purchase anything that generates an info of data from the companies to make smart decisions understand customer behaviour and stay competative is called data Mining.

DATA MINING - It is the process of extracting useful insides and knowledge from large datasets.

It involves applying techniques like statistics, ML and database systems to find hidden patterns relationships and trends.

These insides help them to solve business problems in 2 processes. and make future predictions.

COMMON APPLICATIONS OF DATA MINING-

1. Customer Segmentation.
2. Market Basket Analysis.

DOMS

③ Predictive Modeling.

It is widely used across industries like finance, healthcare, retail and telicommunication to make informed decisions.

The core components of this field are ML, Statics, database system, datawaare house, information retrival, highperformance computing, its applications, algorithm, Vizulization, pattern recognization.

Imp

PROCESS OF DATAMINING -

① Data Cleaning And Integration - (Extracts relevant data)

② Data Pre Processing - (Removes, noisy data and missing values)

③ Pattern Recognization & ML - (Classification, Clustring, Regression).

④ Statistical Analysis - (Mean, Mode, Median).

⑤ Evaluation and interpretuation.

⑥ Data Presentation & Visulization.

Q. Discuss Advantages of Datamining.
Q. " Disadvantages of Datamining.
Q. Explain Graph theory.
Q. What are diff. type of Graphs.
Q. What are DFS & BFS, Diff. with example.

Q1Ans→ Advantages of Datamining-

① Marketing/Retailing - Data mining can help marketers in predicting which products their users can be interested in purchasing.

② Banking/Crediting - Data mining can help financial institutions in areas including credit documenting and loan records.

③ Enhance decision making - Data mining focuses more on actionable insights, such as identifying customers segmentation with high potential of sales.

④ Operational Efficiency - In manufacturing industries, where the problem can be analyzed and solutions to improve efficiency can be mined.

⑤ Fraud Detection - Users of invenstments and credit cards employ data mining to analyze account transactions to identify and prevent fraud.

Q2Ans→ Disadvantages of Datamining -

① Privacy Concerns - Data mining involves obtaining and analyzing large ~~volume~~ amount of personal information. Customers often become

Concerned that their details might be used or shared unauthorized.

② Security Risks- Many threats are associated with cyber Security. If not well protected, any financial information can easily be accessed by wrong individuals.

③ Inaccurate results- Data mining gives remarkable information, but this information depends on the quality of the processed data.

④ Complexity & Scalability Issues- This raises complexity and scalability issues as numerous elements complicate and interdepend with variations across software types, size etc.

⑤ Most data mining techniques work well with big data sets but may not be readily available in a small organizations.
Dataset become more populated by noted structures, they become more challenging.

GRAPH THEORY IN DATA MINING-

In data mining, graph theory provides tools to analyze relationships at patterns within data represented as networks.

- How is it used in Data Mining?

⇒ In data mining, graph theory is applied to:

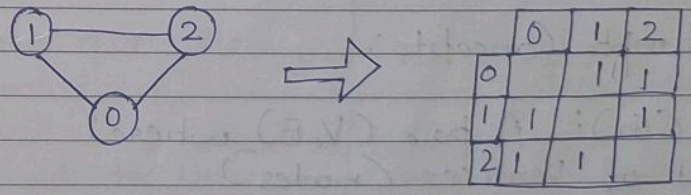
- Network Analysis: Representing and analyzing social networks, web structures, or biological networks.
- Clustering: Grouping similar data points based on their connectivity ~~or~~ within the graph.
- Classification: Categorizing data points based on their relationships to other points in the graph.

Common Graph Representation in Data Mining:-

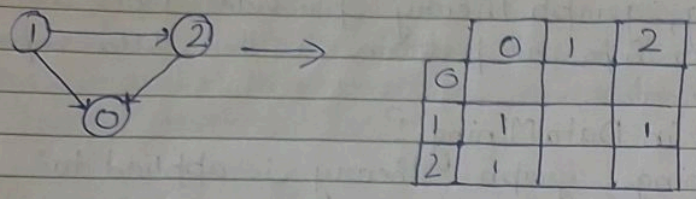
① Adjacency Matrix.
② Adjacency List.

Adjacency Matrix- An adjacency matrix is a way of representing a graph as a matrix of boolean (0's and 1's).

Representation of Undirected Graph to Adjacency Matrix



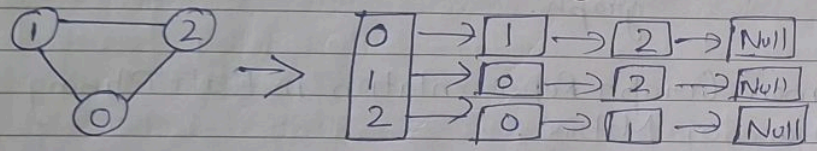
Representation of Directed Graph as Adjacency Matrix:



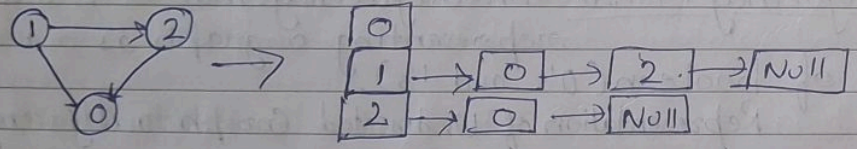
Adjacency List Representation-

An array of list is used to store edges between two vertices is called adjacency list.

Undirected Graph to Adjacency List



Directed Graph to Adjacency list



Basic Graph Concepts:

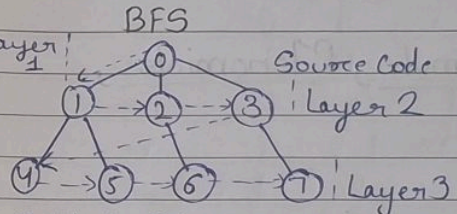
- Graph (G): A pair (V, E) where:
- V = Set of Vertices (nodes)
- E = Set of edges (Connections between nodes)

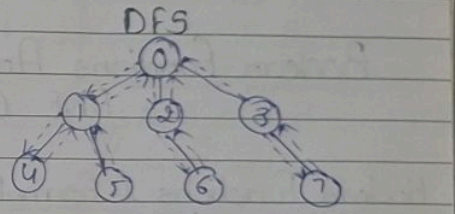
Types of Graphs:

- Undirected Vs Directed (Digraph).
- Weighted vs Unweighted.
- Cyclic Vs Acyclic.
- Sparse vs Dense.

DFS And BFS-

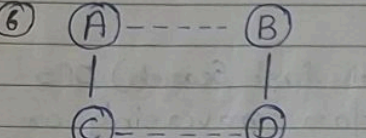
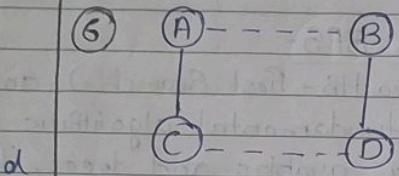
BFS (Breadth-first Search) and (Depth First Search) DFS are two fundamental algorithms used for traversing or searching graphs and trees. This article covers the basic difference between breadth-Fist Serch and Depth-first Search.





Difference between DFS & BFS

BFS	DFS
① BFS stands for Breadth First Search.	① DFS stands for Depth First Search.
② BFS uses queue data structure.	② DFS uses stack data structure.
③ BFS builds the tree level by level.	③ DFS builds the tree sub-tree by sub-tree.

BFS	DFS
④ It works on the concept of FIFO	④ It works on the concept of LIFO.
⑤ BFS is more suitable for searching vertices closer to the given source.	⑤ DFS is more suitable when there are solutions away from source.
⑥  Order of traversal would be A, B, C, D.	⑥  Order of traversal would be A, B, D, C

Boolean Functions And Formule, Monomials, DNF CNF

Boolean Functions & Formulae –

→ It takes inputs from boolean variable.

Boolean function is a set of rules used to simplify a given logical expression without changing its function-ality.

Truth Table formation –

- Table that comprise all the possible outcomes of a Boolean function used in Boolean algebra
- Establish a relation between various variable that contributes to the Bodean function.
- 1 = True Value
  0 = False Value

A∧B – AND
A∨B – OR

Truth Table for 2 variables –

A	B	A∨B	A∧B	~A	~B
0	0	0	0	1	1
0	1	1	0	1	0
1	0	1	0	0	1
1	1	1	1	0	0

Methods of Solving Boolean function :–

① K-Map

- Sum Of Product (SOP):–

eg:-

	A	B	C	Y
m_0	0	0	0	1
m_1	0	0	1	0
m_2	0	1	0	1
m_3	0	1	1	1
m_4	1	0	0	0
m_5	1	0	1	0
m_6	1	1	0	1
m_7	1	1	1	1

$SOP = \sum(m_0, m_2, m_3, m_6, m_7)$
$= A'B'C' + A'BC' + A'BC + ABC' + ABC$
$= A'B'C' + BC'(A+A') + BC(A+A')$
$= A'B'C' + BC' + BC$
$= A'B'C' + B(C'+C)$
$= A'B'C' + B$

- Product of Sum (POS):–

② NAND Gates–

A	B	A∧B	~A∧B
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0

$F(A, B, C) = ABC + A'B + B'C' + A'C'$

AND	∧	True if both inputs are true
OR	∨	True if at least one input is true
NOT	¬	flips 0 to 1 & 1 to 0
XOR	⊕	True if input are diff

MONOMIALS-

In data mining, monomials are used as building blocks for more complex expressions.

- Monomial is a single term consisting of a coefficient and one or more variables raised to non-negative integer powers.
  e.g:- $3x$, 7, $2xy^2$, $4a^3b$
- They are the simplest type of polynomials.

How are monomials used in Data mining?

1. Feature Selection:
   Monomials can be used to represent potential features in a dataset. e.g:-
   Dataset:- Customer behavior
   Monomial:- Age * Purchase_frequency.

2. Pattern Discovery:
   Monomials can be used to discover interesting patterns in data. e.g:-
   Dataset:- Sales dataset
   Monomial:- Might be represented ~~by~~ a like
   product_A * product_B.

3. Building Models:
   Monomials can be combined to create more complex models, such as polynomials.

DNF (Disjunctive Normal forms)-

A formula which is equivalent to a given formula and which consists of a sum of elementary products is called a DNF of given formula.
e.g:- $(P \wedge \sim Q) \vee (Q \wedge R) \vee (\sim P \wedge Q \wedge \sim R)$

CNF (Conjunctive Normal form)-

A formula which is equivalent to a given formula and which consists of a product of elementary sums is called a conjunctive normal form of given formula.
e.g:- $(P \sim \vee Q) \wedge (Q \vee R) \wedge (\sim P \vee Q \vee \sim R)$.

Data Mining Techniques-

- Data Mining is the process of discovering useful patterns and insights from large amount of data.
- Data mining is often a synonym for Knowledge Discovery from DATA (KDD).

Inventor - Gregory Piatetsky - Shapiro (1989)
- It is widely used in bussiness areas.

Steps in KDD-

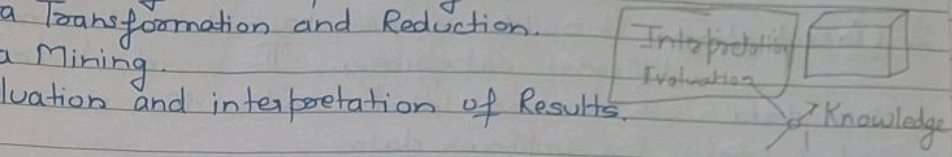
- Data Selection- Identify and Select relevant data from various sources.
- Data Preprocessing- Clean and transform the data to address errors and inconsistencies, making it suitable for analysis.
- Data Transformation- Convert the cleaned data into a form that is suitable for data mining algorithms.
- Data Mining- Apply data mining techniques to identify patterns and relationships in data.
- Pattern Evaluation- Evaluate the identified patterns to determine their usefulness in making predictions.
- Knowledge Representation- Present the pattern in a way that is understandable and useful for decision - making.
- Knowledge Refinement- Refine the knowledge obtained to improve accuracy.

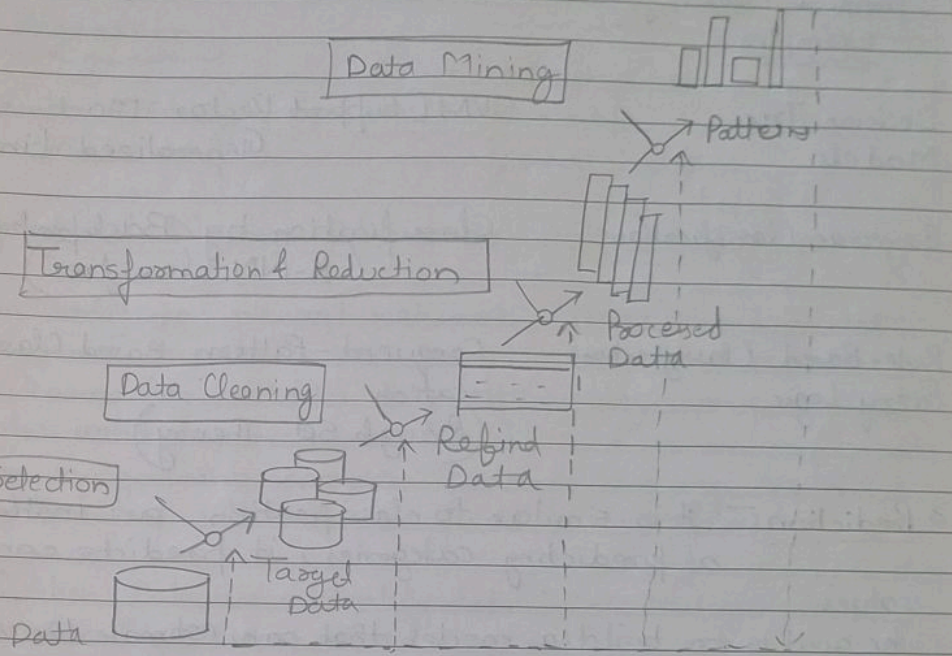
KDD is widely used in the fields of ML, Statics, AI etc.

DOMS

Steps in KDD-

- Data Selection.
- Data Cleaning and Preprocessing.
- Data Transformation and Reduction.
- Data Mining.
- Evaluation and interpretation of Results.





Data Mining Techniques-

① Association- Association analysis looks for patterns where certain items or conditions tend to appear together in a dataset.
- Commonly used in Market Basket Analysis to see which products are often bought together

DOMS

One method, called association classification, generates rules from the data and uses them to build a model.

2. Classification - It builds models to sort data into different categories. The model is trained on data with known labels and is then used to predict labels for unknown data.

Examples:-

Decision Tree Models

SVM (Support Vector Machine)

Generalized Linear

Bayesian Classification

Classification by Backpropagation (K-NN classifier)

Rule-Based Classification

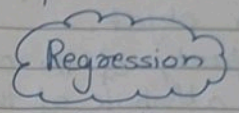
Fuzzy Logic

Frequent-Pattern Based Classification (Rough Set Theory)

3. Prediction - It is similar to classification, but instead of predicting categories, it predicts continuous values.
The goal is to build a model that can estimate the value of a specific attribute for new data.

4. Clustering - Clustering groups similar data points together without using predefined categories. It helps discover hidden patterns in the data by organizing objects into clusters where items in each cluster are more similar to each other than to those in other clusters.

5. Regression - It is used to predict continuous values, like prices or temp, based on past data.



Linear Regression

Looks for a straight like relationship

Multiple linear regression

Which uses more variables to make predictions.

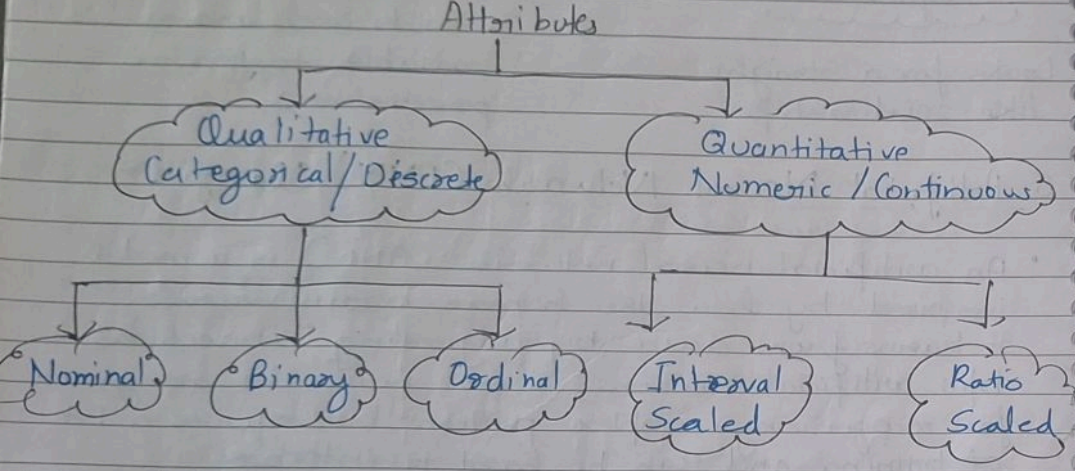
6. Artificial Neural Networks (ANN) Classifier

- An artificial neural network (ANN) is a model inspired by how the human brain works. It learns from data by adjusting connections b/w artificial neurons. Neural networks are great for recognizing complex patterns but require a lot of training and can be hard to interpret.

7. Outlier Detection - Identify data points that are very diff. from rest of the data.
8. Genetic Algorithm - It is inspired by natural selection. They solve problems by evolving solutions over several generation. Each of Solution is like a "Species" and the fittest solutions are kept and improved over time, simulating "Survival of the fitting" to find the best solution to a problem.

ATTRIBUTES- The attribute can be defined as a field for storing the data that represents the characteristics of a data object.
The attribute is the property of the object.
e.g:- hair colour is the attribute of the lady.

Types of Attributes-



Nominal Attributes-

- The values of a nominal attribute are symbols or names of things.
each value represents some kind of category, code, or state.
- The value of nominal attributes do not have any meaningful order.
- It makes no sense to find the mean (average) value or median (middle) value for such an attribute.

- However, we can find the attribute most commonly occurring value (mode).

Binary Attributes-

- A binary attribute is a special nominal attribute with only two states: 0 or 1.

Ordinal Attributes- It is an attribute with possible values that have a meaningful order or ranking among them, but the magnitude b/w successive values is not known.

- This attribute has three possible values: small, medium and large.
- The central tendency of an ordinal attribute have mode & median not mean.

Interval - Scaled Attributes - These are measured on a scale of equal-size units. Value has order, can be +ve, 0, -ve.
e.g:- Temperature attribute, Calendar dates.

- The central tendency of an interval attribute can be represented by its mode, median & its mean data.

Ratio Attribute - It is a numeric attribut with an inherent zero point.
e.g. Number_of_words in a doc. object.

Properties of Attribute Values -
① Distinctness. - equal to & not equal to
② Order & - less than & Greater than
③ Addition - +, -
④ Multiplication - *, */

Q Diff. Nominal, Ordinal, Interval-Scaled & Ratio Attrib-ute types.

Data mining Concepts, Inputs, Instance, Attribute & Output.

INSTANCE - The input to the ML scheme is a set of instances.
These instances are the things that are to be classified, associated or clustered.
- We generally use more specific term, instances to refer to the data.

Each data set is represented as a matrix of instances Vs attributes. which in the database terms is a single relation or a flat file.

Representing Data & Output Knowledge -

Concepts - • Classification.
• Association.
• Clustering.
• Prediction.

Instance - That is taken as the tuple or the relation
- These are the things to be classified, associ-ated or clustered.
- These are the individual or the independent examples of the concept to be learned.
- These are determined by set of attributes.
- Input to the learning scheme is the set of instances represented as a single relation or a table.
- Independent Assumption - There are no relationships b/w the attributes.
- +ve / -ve eg. for a Concept -
- Closed World Assumption (CWA)
- -ve = All not +ve.
- We use the relation Ist order predicate logic.

Attributes -

Output Knowledge Representation -

① Association Rules -
② Decision Tree.
③ Classification Rules.
④ Prediction Schemes — • KNN, Bezian, Neural Network, Regression
⑤ Clustering — Type of grouping :-
~~Partition~~ ~~Hierarchical~~
• Partition
• Hierarchical

Type of description
- Statistical
- Structural.

Visulization Techniques -

BASIC STATISTICAL DESCRIPTION OF DATA :-

It is used to identify properties of data and highlight which data values are to be treated as noise.
For this purpose we use mean, median & mode.

Mean - $\frac{\text{Sum of all Values}}{\text{No. of Values}}$.

Weighted Mean - $\frac{\sum w_i x_i}{\sum w_i}$

Median - It is used to find the centre of the data
If dataset is odd
Median is the middle value. $= n/2$
If dataset is even
Median is the average of central value.
$\frac{n + n/2}{2}$

• Mode - Max. occuring value.
- It is used to find the values that occurs most frequently.
Datasets with 1, 2, or 3 more are called unimodel, bimodel & tri-model.
- If all the values repeat only ones then there is no mode.

For the numerical attributes, we take Mean, Mode, Median
For nominal attributes, we use mode.
For Ordinal attributes, we use Mode / Median.

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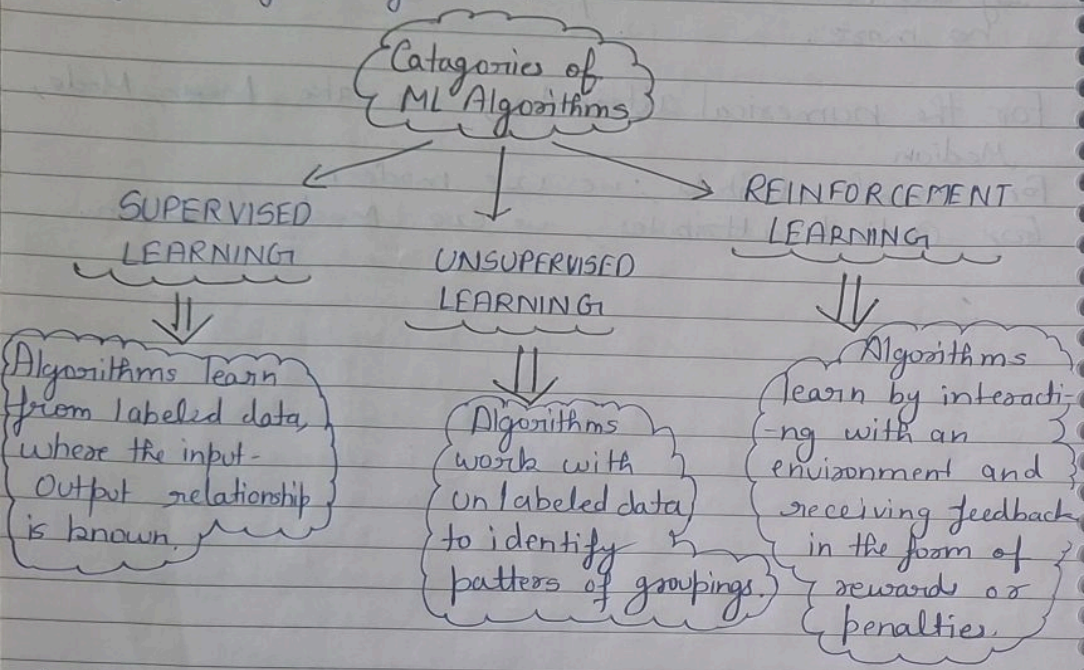
MACHINE LEARNING ALGORITHM-

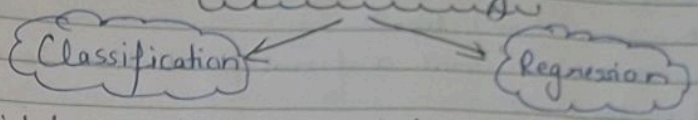
Machine learning algorithms are essentially set of instructi-ons that allow computers to learn from data, make predictions, and improve their performance over time without being explicitly programmed.



SUPERVISED LEARNING ALGORITHMS-

- These algos are trained on datasets where each example is paired with a target or response variable, known as the label.
- The goals → ① To learn a mapping function from input data to the corresponding output labels.
  ② Enabling the model to make accurate prediction on unseen data.

Catagories of Supervised Learning



Most widely used Supervised learning algorithms are:-

① **Linear Regression** - It is used to predict a continuous value by finding the best-fit straight line between input and output
- Minimizes the difference between actual values and predic-ted values using a method called 'least Squares" to best fit the data.
- Predicting a person's weight based on their height OR Predicting house prices based on size.

② **Logistic Regression** - It predicts probabilities and assigns data points to binary classes (e.g- Spam or not spam)
- It uses a logistic function (S-shaped curve) to model the relationship between input features and class probabilities.
- Used for classification tasks (binary or multi-class).

e.g- Predicting whether a customer will buy a product online or diagnosing if a person has a disease.

Note:- Despite its name, logistic regression is used for classification tasks, not regression.

③ **Decision Trees** - It splits data into branches based on feature values, creating a tree-like structure.

- Each decision node represents a feature; leaf nodes provide the final prediction.
- The process continues until a final prediction is made at the leaf nodes.
- Works for both classification & regression tasks.

4. Support Vector Machines (SVM) - It finds the best boundary that separa-ates data points into different classes.
- Uses support vectors to define the hyperplane.
- Can handle linear and non-linear problems using Kernel functions: → It is a method used to take data as input and transform it into the required form of processing data.
- focuses on maximizing the margin between classes, making it robust for high-dimensional data or complex patterns.

Margin signifies the distance b/w the decision boundary and the closest data points from each class.

5. K-Nearest Neighbors (K-NN)-

KNN is a simple algorithm that predicts the output for a new data point based on the similarity (distance) to its nearest neighbors in the training dataset, used for both classification and regression tasks.
- Calculates distance between point with existing data points in training dataset using distance metric. e.g:- Euclidean, Manhattan etc.
- Identify K nearest neighbors to new data point based on the calculated distance.

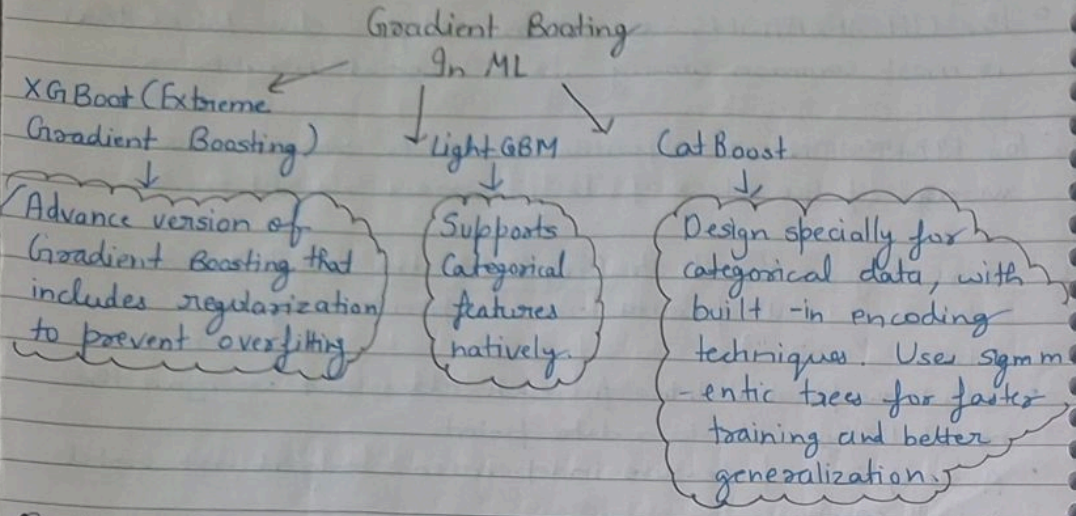
- For CLASSIFICATION, algorithm assigns class label that is most common among its K nearest neighbors.
- For REGRESSION, the algorithm predicts the value as the average of the values of its K nearest neighbors.

6. Naive Bayes- Based on Baye's theorem and assumes all features are independent of each other (hence "naive")
- Calculates probabilities for each class and assigns the most likely class to a data point.
- Assumption of feature independence might not hold in all cases
- Works well for high-dimensional data.
- Commonly used in text classification tasks like spam filtering: Naive Bayes.

7. Random Forest - It is an ensemble method that combines multiple decision trees.
- Uses random sampling and feature selection for diversity among trees.
- Final prediction is based on majority voting (classification), averaging (regression).

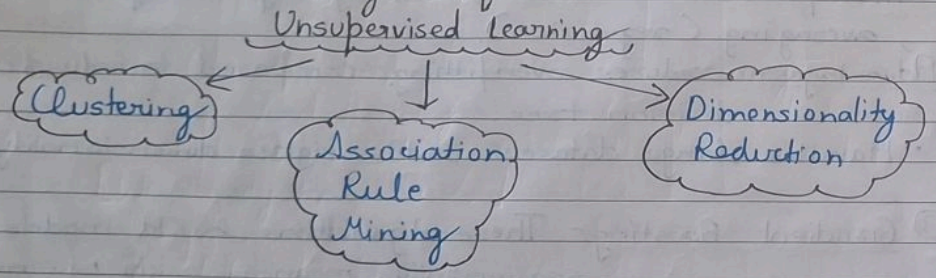
Advantages- reduces overfitting compared to individual decision tree.
- Handles large datasets with higher dimensionality.

8. Gradient Boosting- These algorithms build models sequentially, meaning each new model corrects errors made by previous ones. Combine weak learners to create a strong predictive model.

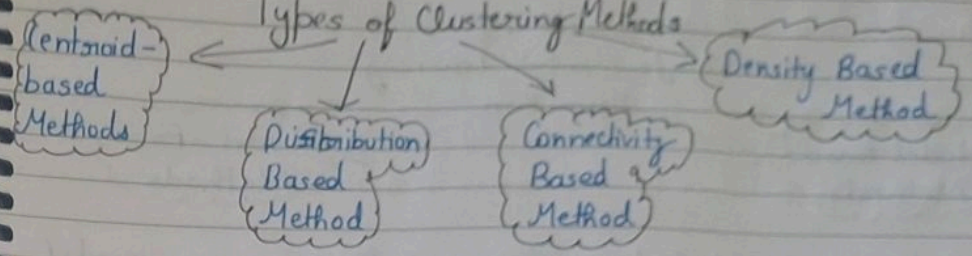


8. Neural Networks- These are considered part of supervised machine learning algo, as they require labeled data to train and learn the relationship between input and desired output.

UNSUPERVISED LEARNING-
It works with unlabeled data to discover hidden patterns or structures without predefined outputs.



Clustering - It groups data points into clusters based on their similarities or differences. The goal is to identify natural groupings in the data.

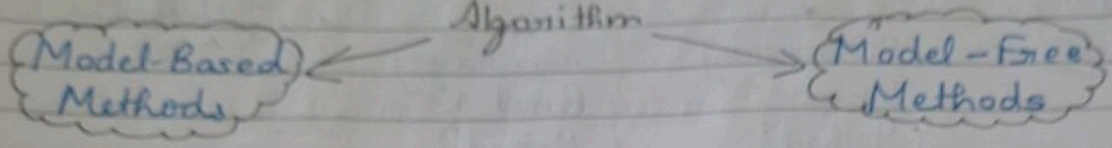


Dimensionality Reduction-
It is used to simplify datasets by reducing the number of features while retaining the most important information.
- Principal component Analysis (PCA).
- t-distributed Stochastic Neighbor Embedding (t-SNE).
- Non-Negative Matrix Factorization (NMF).
- Independent Component Analysis (ICA).
- Locally Linear Embedding (LLE).
- Latent Semantic Analysis (LSA).
- Autoencoders.

Association Rule - Find Patterns between items in large datasets, typically in MARKET BASKET ANALYSIS.
- Apriori Algorithm.
- FP-Growth (Frequent Pattern-Growth).
- ECLAT (Equivalence Class Clustering and bottom-up Lattice Traversal).

REINFORCEMENT LERNING ALGORITHMS: Reinforcement learning involves training agents to make a sequence of decisions by rewarding them for good actions and penalizing them for bad ones.

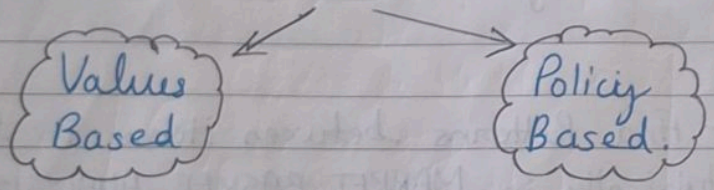
Categories of Reinforcement Learning Algorithm



1. Model-Based Methods - These methods use a model of the environment to predict outcomes and help the agent plan actions by simulating potential results.

2. Model-Free Methods - These methods do not build or rely on an explicit model of the environment.

Types of Model-Free Methods



Difference between :-

CLASSIFICATION Vs CLUSTERING

Feature	Classification	Clustering
Type	Supervised learning.	Unsupervised learning.
label	Data is labeled. [We already know classes]	Data is unlabeled.
Goal	Assign new data to predefined classes.	Discover hidden patterns or natural groupings
Output	Know categories (Spam & not spam)	UnKnown Natural grps

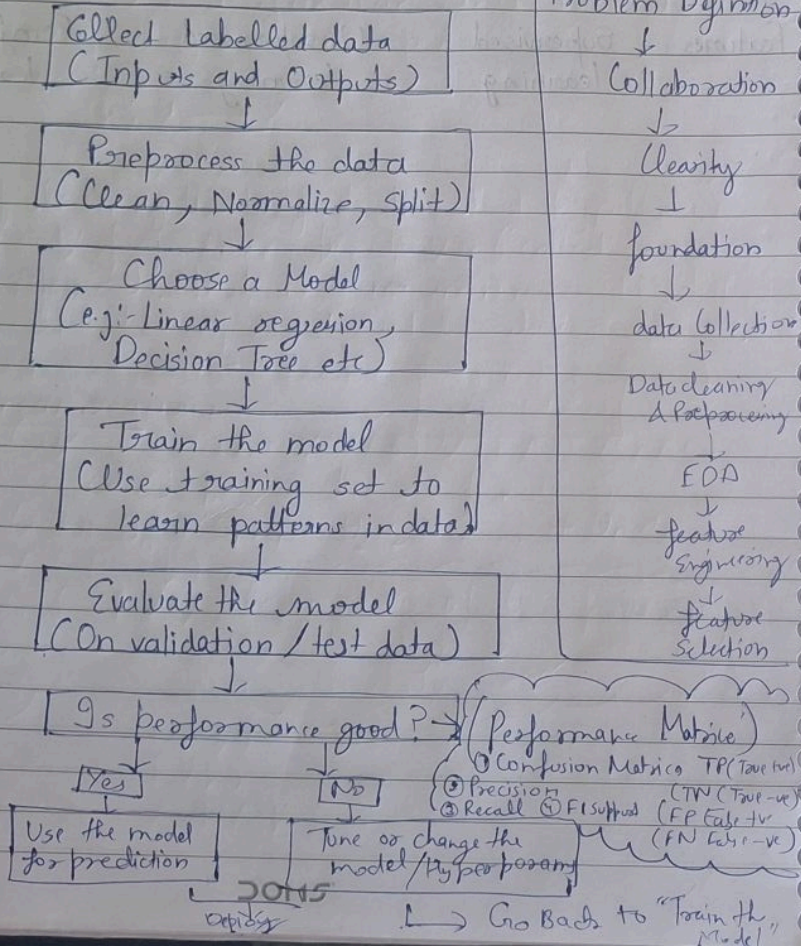
Algorithms	Logistic Regression, Decision Tree, SVM, Naive Bayes	K-Means, DBSCAN, Hierarchical Clustering, GMM.
Complexity	Less Complex with labeled data.	More complex due to a lack of labels and group definitions.
e.g.:-	Email spam detection, disease diagnosis	Customer segmentation, anomaly detection.

Boolean functions & formula.
Supervised learning framework.
Explain the concept of hypothesis in machine learning.

Q2 Ans - Supervised learning framework -

Supervised learning framework is a type of machine learning where a model is trained on a labeled dataset.

Flowchart



Problem Definition
↓
Collaboration
↓
Clearity
↓
foundation
↓
data Collection
↓
Data cleaning & Preprocessing
↓
EDA
↓
feature Engineering
↓
feature Selection

EDA - Exploratory Data Analysis

CSV files - Excel sheet form
ARFF - Attribute relation format

Key Components of framework.

① Input → • Represented as vectors (e.g.:- Numerical, categorical, text, images)
• Denoted as X.

② Output Labels (Targets) → • Desired outcomes for each input.
• Denoted as Y.

③ Model → • A function that maps inputs (X) to output (Y) : —

$$\hat{Y} = f(x)$$

④ Loss function → • Measures the difference b/w the predicted output ($\hat{Y}$) and the true output (Y).
• Guides the learning process.

⑤ Training Process - • Model learns by minimizing the loss function using optimization algo like gradient descent.

⑥ Evaluation - Performation is evaluated using metrics on a validation / test set.

⑦ Deploy.

Advantages - ① Clear feedback via labels.
② Easier to evaluate performance.
③ Widely used and well understood.

Disadvantages - ① Requires large, accurately labeled datasets.
② Doesn't perform well if the labels are missing.

DOMS

Hypothesis In Machine learning – (guess)

A Hypothesis is basically a model or function that the learning algo uses to approximate the true relationship between inputs and outputs in your data.

Specifically –

1. In supervised learning, you have some input data X and corresponding output labels Y.
2. The hypothesis h is a function that tries to predict the output given an input: $h: X \rightarrow \hat{Y}$
3. The goal of learning is to find the best hypothesis h from a set of possible functions (called the hypothesis space) that minimizes the difference between predicted outputs $\hat{Y}$ and the true outputs Y.

Eg: In linear regression:– $\boxed{Y = ax + b}$

The hypothesis could be a linear function:

$$h_\theta(x) = \theta_0 + \theta_1 x_1 + \theta_2 x_2 + \ldots + \theta_n x_n$$

- θ parameters are learned during training
- Diff. values of θ represent diff. hypothesis about the data.

Hypothesis space – The set of all possible hypotheses (functions) that the algorithm can choose from.

CNF and DNF Conversion :–

CNF (Conjunctive Normal form)
DNF (Disjunctive Normal form)

(P, Q) → atoms

(∧, ∨) — ∧: Conjunction, ∨: Disjunction

Conjunctive NF → ( ) ∧ ( ) ∧ ( )

↓

Only and operator in b/w diff. Value.

Disjuctive NF → ( ) ∨ ( ) ∨ ( )

↓

Only or operator is there.

CNF – A compound statement is in CNF if it is obtained by operating (∧)(And) among variables connected by ORs (∨). eg:– $(P \vee Q) \wedge (Q \vee R)$

DNF – A compound statement is in DNF if it is obtained by operating (∨)(OR) among variables connected by ANDs (∧)

eg:– $(P \wedge Q) \vee (\neg q \wedge \neg r)$

Steps for Conversion in CNF-

Step1- Remove all implication & by implications with the formula $A \to B$, $A \leftrightarrow B$

$A \to B \equiv \neg A \vee B$

$A \leftrightarrow B \equiv (A \to B) \wedge (B \to A)$

$A \leftrightarrow B \equiv (A \wedge B) \vee (\neg A \wedge \neg B)$

Step2- Remove all negations inside.

$\neg \neg A \equiv A$

$\neg (A \vee B) \equiv \neg A \wedge \neg B$

$\neg (A \wedge B) \equiv \neg A \vee \neg B$

Step3 - Move all conjunctions outside the disjunction

Distributive law $\begin{cases} (m \wedge p) \vee r \equiv (m \vee r) \wedge (p \vee r) \\ m \vee (p \wedge r) \equiv (m \vee p) \wedge (m \vee r) \end{cases}$

Extended distributive law- (Double distributive law)

$(a \vee b) \wedge (a \vee c) \equiv (a \wedge a) \vee (a \wedge b) \vee (b \wedge a) \vee (b \wedge c)$

Q1. Convert to CNF

$P \wedge (P \to q)$

$\equiv P \wedge (\neg P \vee q)$

find

Q2. ~~Convert~~ the DNF of

$P \wedge (P \to q)$

$\equiv P \wedge (\neg P \vee q)$

$(P \wedge \neg P) \vee (P \wedge q)$ Ans

Q. find the CNF of

$\neg (P \vee Q) \leftrightarrow (P \wedge Q)$

$= (\neg (P \vee Q) \to (P \wedge Q)) \wedge ((P \wedge Q) \to \neg (P \vee Q))$

$= ((P \vee Q) \vee (P \wedge Q)) \wedge (\neg (P \wedge Q) \vee \neg (P \vee Q))$

$= (P \vee Q) \vee (P \wedge Q) \wedge ((\neg P \vee \neg Q) \vee (\neg P \wedge \neg Q))$

$= (P \vee Q \vee P) \wedge (P \vee Q \vee Q) \wedge (\neg P \vee \neg P \vee \neg Q) \wedge (\neg P \vee \neg Q \vee \neg Q)$ Ans

Convert of DNF → $\neg (P \vee Q) \leftrightarrow (P \wedge Q)$

Convert of DNF → $(Q \vee (P \wedge R)) \wedge \neg ((P \vee R) \wedge Q))$