CMR INSTITUTE OF TECHNOLOGY

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COURSE: B.Tech / M.Tech / MBA V **SEMESTER**

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Regular / Supply	:
Branch	:
Subject Name	: Artificial Intelligence and Machine Learning
Subject Code	: 22CS/CA/CD/PC52
Name of the Moderator	:
Moderator's Emp. Id & Mobile No	:

(1)

Part A

1. Define Artificial Intelligence.

A. AI refers to the simulation of human intelligence in machines, enabling them to perform tasks that typically require human cognition, such as reasoning, learning, decision making, and problem solving.

2. Examine Heuristic Search Techniques.

A. Heuristic search techniques in AI are strategies used to solve complex problems efficiently by using heuristic, a rule of thumb to guide the search process toward the most promising solutions. Some of the techniques include A* search Algorithm, Greedy Best first search, Hill climbing and etc.

3. Classify characteristics of Uncertainty.

A. * Incomplete Knowledge - Missing data
* Ambiguity - Inputs that support multiple Interpretations.
* Noise - Data corruption due to measurement errors.

* Stochastic Processes - Event with probability outcomes. that can't be predicted.

4. Compare Knowledge and Intelligence

A.

	Knowledge	Intelligence
Definition	Information & facts acquired.	Ability to use Knowledge effectively
focus	what is known	How knowledge is applied
Example	A database of facts	Ability to solve new problems.

5. Summarize the role of expert System.

A. Expert System play the role of simulating the decision-making ability of human experts in specialized domains. It has components such as User Interface, Inference Engine and Knowledge Base. The role of expert systems includes advising, diagnosing, explaining reasoning, predicting outcomes and suggesting alternative solutions within their domain of expertise.

6. Define Machine learning and illustrate its key aspects.

A. Machine learning is a subset of AI where computers learns from data and improve their performance or make decisions without being explicitly programmed.

Key aspects are learning models, Algorithms, Data-driven, continuous improvement and applications.

7. Compare linear and Non-linear Models.

A.

Linear Model	Non-linear Model
Assumes a linear relationship between input features and output	Captures complex non-proportional relationship involving curves or interactions.
Examples: linear regression, SVM.	Examples - Decision trees, nonlinear SVM with kernels.
Limited to linear patterns.	Can model a wide range of complex data patterns.

8. Define logistic Regression.

A. Logistic Regression is a statistical and machine learning technique used primarily for binary classification problems. It predicts probabilities ranging between 0 and 1 to classify inputs into categories, such as yes/no or true/false.

9. Distenguish types of clustering Methods.

A. clustering methods in machine learning differ primarily in how they define & form clusters. Types are partitional, hierarchical clustering, Density-based clustering, Fuzzy clustering.

10. How you judge DIANA is top-down approach.

A. DIANA is a top-down approach starts with all data points grouped into a single cluster and then recursively splits this cluster into smaller clusters. The algorithm selects the most heterogeneous cluster and divides it into two subclusters by splitting off a subset of objects that are most dissimilar from the remaining objects.

11 A. Examine State Space Search by Using BFS.

A. → * Search problem in artificial Intelligence consists of

State Space = Set of all possible states where the start state to goal state.

Start State = The state where the search begins.

Goal State = The state where the search ends.

Transition = An action that changes one state to another.

Action = choices.

Cost = The effort in doing the searching task.

Breadth first Search (BFS)

- It is used to search a graph data structure for a node that meets a set of criteria. It starts at the root of graph and visits all nodes at the current depth level before moving on to the node at the next depth level.
- It uses a queue to keep of nodes to be explored.
- BFS employes a first-In-first-Out (FIFO) queue to ensure nodes are processed

Working / Algorithm.

Step 1 : Initialize

* Start with initial node/state
* Add it to a queue and mark it as visited.

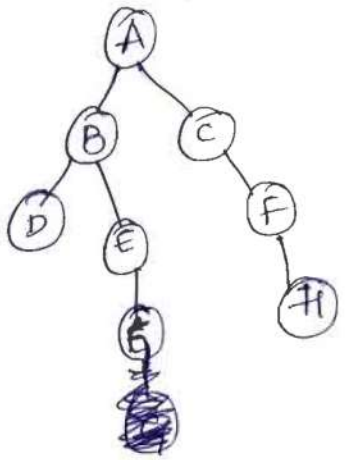
Step 2: Explore

* Dequeue a node from front of the queue
* Process the node
* Enqueue all unvisited neighboring nodes.

Step 3: Repeat - Continue until the queue is empty.

Step 4: Get the Path - Construct the path from start node to goal node.

Example:



Start node - A

Goal node - G.

Step 1: Begin with [A | | |]

Step 2: Dequeue A and add neighbors of A

Visited_list	Queue
A	[B | C | | | |]

Step 3: Dequeue B and add neighbors of B

Visited_list	Queue
A B	[C | D | E | | |]

Step 4: Dequeue C and add neighbors of C

Visited_list	Queue
A B C	[D | E | F | | |]

Step 5: Dequeue D & it has no neighbors

Visited list	Queue
→ A B C D	[E | F | ·

Step 6: Dequeue E and add neighbors of E

Visited_list

A B C D E

Queue

| F | G | | | |

Step 7: Dequeue F and add neighbors of F

Visited_list

A B C D E F

Queue

| G | H | | | |

Step 8: Dequeue G and goal node is reached

A B C D E F G

11. B. i) Define Means-End Analysis, demonstrate its algorithms.

A. Means-End-Analysis (MEA) is a problem solving technique that works by evaluating difference between the current state and goal state, then systematically reducing the difference through a series of subgoals and actions.

Algorithm

Step 1: Define the Goal and current ~~need~~ node.

Step 2: Compare current state/node and Goal node - Calculate the difference

Step 3: Select an Operator/action - chose an action that can reduce the significant difference between current and goal state/node

Step 4: Attempt to apply action to current to meet the preconditions if not, create new subgoals to satisfy.

Step 5: Recursively apply the same process to these subgoals. breaking down into finer steps.

Step 6: Continue applying actions and subgoals until the goal state is achieved.

Step 7. Throughout, intermediate actions are monitored and adjusted to resolve errors.

ii) Evaluate Means-End Analysis with suitable example.

Example:

Initial state · Goal state Actions

Move

Delete

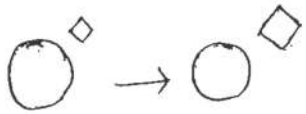
Expand.

Step 1: Compare initial and Goal state. and find the differences.

Step 2: Apply delete action on initial state.

Step 3: Apply move action on current state

Step 4: Apply Expand on current state.



12 A. What is propositional logic ? And Evaluate its important applications and limitations.

A Propositional logic is a powerful and versatile system for reasoning about propositions. Propositional logic including truth tables, rules of inference and proofs. It uses logical connectives such as AND, OR, NOT and IF-THEN to form complex statements from these propositions.

Important Applications of propositional logic.

1. Mathematics - Used to prove theorems, establish logical relationships between concepts and to study the foundations of mathematics

Ex: propositional logic can be used to prove that a certain mathematical statements is always true, are equivalent.

2. Digital Circuit - Used to design and analyze digital circuit, which are the building blocks of modern computer and electronic devices.

- Used to represent and manipulate boolean function, such as AND, OR and NOT.

3. Philosophy :- Used in philosophy to analyze arguments and evaluate their logical validity. To develop theories of knowledge through reasoning about and clarifying concepts such as 'truth', 'belief' and 'knowledge'.

4. Programming :- Used in programming languages to represent and manipulate logical expressions which are used

to control the flow of a program.
Ex: conditional statements. such as if-then and switch-case. etc.

5. Linguistics - to study the structure and meaning of natural language sentences. logical operators such as conjunction, disjunction and negation etc..

6. Artificial Intelligence - To represent and manipulate knowledge in the form of logical statements.
Ex: Propositional logic can be used to represent the knowledge of robot its environment and to reason about its actions.

Limitations.

1. Lack of Expressive - Cannot handle quantifiers or express properties and relationship between objects, limiting its ability to represent complex statements.
2. No handling of Uncertainty - Deals only true or false values and cannot represent probabilities or degree of belief
3. Restricted Reasoning - Struggles with generalizations, exceptions, causality and hypothetical reasoning.
4. Cannot Represent Variables (or) Individual Objects - lacks variables or predicates, so it cannot reason about specific individuals or objects.

12 B. Distinguish between Belief Network and Decision Network with example.

A.

Aspect	Belief Network	Decision Network
Purpose	- Used to represent and reason about uncertain variables probabilistically.	- Used to model decision under uncertainty, incorporating possible actions & its outcomes.
Node Types.	- Contains only chance nodes.	- chance nodes, decision nodes and utility nodes.
Outputs	- Produces updated probability distributions for variables.	- Optimal decision policy maximizing expected utility
Representations	- Does not represent actions	- Explicitly models decision and their consequences.
Utility	- lacks utility	- Includes utility nodes
Type of inference	- Probabilistic inference	- Decision analysis.
structure	- Directed acyclic graph dependencies among random variables.	- Directed acyclic graph including decision and utility nodes, showing dependencies and decision flow.
Complexity	- Conceptually simpler, focusing on knowledge representation.	- More complex, combining knowledge, decisions and preferences.

Applications.	* Diagnostics, * Classification etc..	* Economics, * Robotics.
Example -	Diagnosing a disease based on symptoms and risk factors.	- Deciding treatment options considering diagnosis probability and treatment benefits/costs.

13-A. Define Expert System and explain typical expert System.

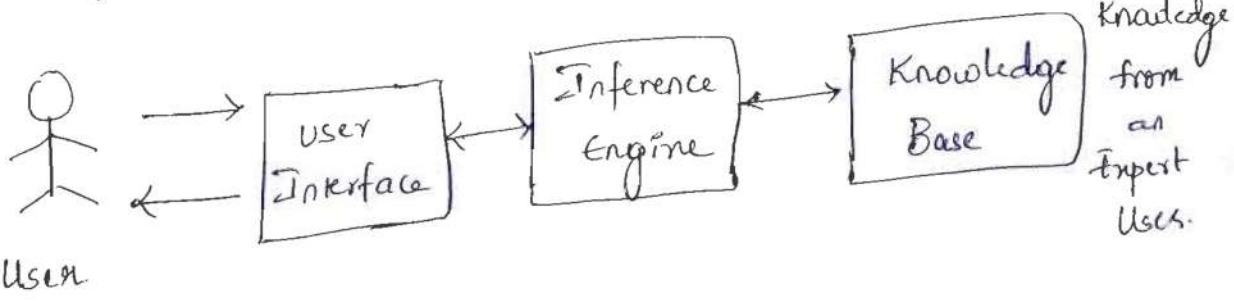
A. An Expert System is a computer-based decision-making System that mimics the logic and expertise of a human specialist in a particular topic. Expert System, developed at Stanford University in the 1970's, assess problems and make recommendations in the same way that a human expert does.

Components

User Interface - code that controls the dialog between User and System.

Inference Engine - The System which derives recommendations from Knowledge base and problem-specific data in working storage.

Knowledge Base - a Set of rules as representation of the expertise. mostly If-THEN rule:



Types

1. Rule-Based-Expert System.
   * Most common type
   * rely on IF-THEN rules.
   * rules are crafted by domain experts and serve as the system's reasoning machanisms.
   * Ex: MYCIN
2. Frame Based Expert System.
   * It organize knowledge using frames.
   * Similar to objects in programming.
   * frames store attributes and values related to specific concepts.
3. Fuzzy logic Systems.
   * Situations involving uncertainty and imprecision
   * Systems don't operate on strict true/false values but allows for degree of truth.
   Ex: household applications like washing Machines and air conditioners.
4. Neural Network-Based Expert Systems.
   * To learn patterns from data and improve decision making.
   * applications - Image recognition & Speech processing.
5. Neuro-fuzzy Expert Systems.
   * More advanced hybrid approach
   * Merge the learning capabilities of Neural Networks

with the uncertainty-handling strengths of fuzzy logic.

Ex: financial forecasting and automated control systems. (7)

13. B. Evaluate different types of machine learning models with examples.

A. Machine learning models can be broadly classified into several types based on how they learn from data and the kind of tasks they are suited for.

1. Supervised learning
   * Learns from labeled data with input-output pairs.
   * Task: Predict output given inputs.
   Examples:
   classification - Logistic Regression, Decision Trees, SVM.
   Regression - Linear, Random forest.

2. Unsupervised learning
   * learns from unlabeled data and identifies patterns.
   * Task: clusters & group data.
   Examples:
   clustering - K-Means, DBSCAN
   Dimensionality reduction - PCA

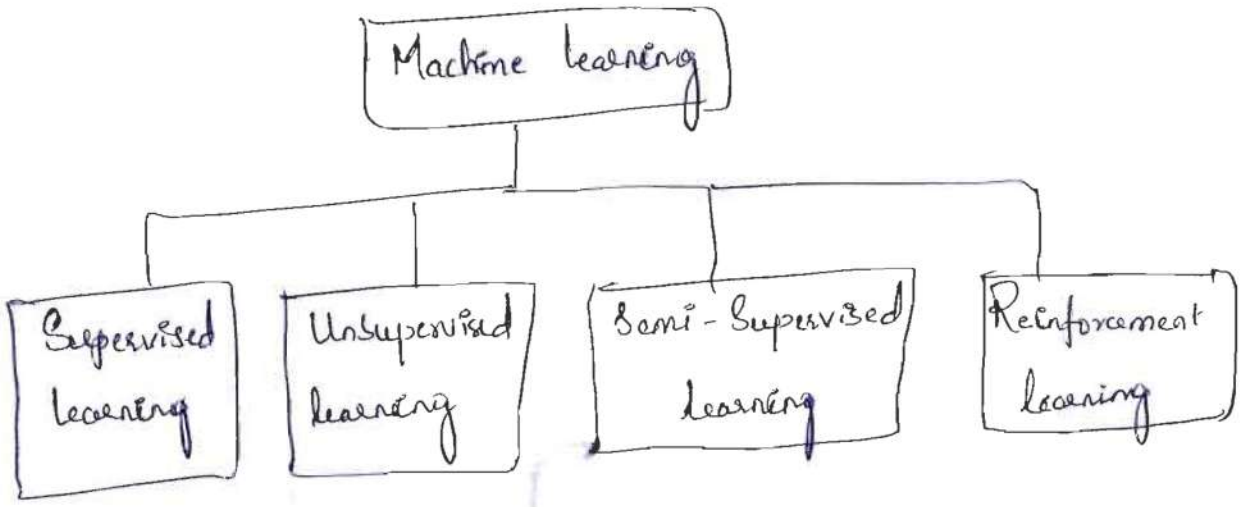
3. Reinforcement learning
   * Learns by interacting with an environment to maximize cumulative reward.
   * Task: Learn optimal actions through trial & error.
   Examples:
   Q-learning, Deep Q Network.

4. Semi-Supervised learning.

* Uses a small amount of labeled data along with large unlabeled data

* Task - Improve learning where labeling is costly.

Example - Using both labeled and unlabeled medical images to improve diagnosis accuracy.



(14) (A) Linear regression and Explain its types

Linear Regression is a statistical method used to find the relationship between two or more variable it helps us predict the value of one variable called dependent variable based on other variables called independent variables

Ex:- if you know how many hours a student studies you can predict their marks

This relationship can be shown by a straight line

$$y = mx + c$$

y = marks (dependent variable)

x = study hours (Independent variables)

m = Slope (how much marks change per hour).

c = intercept (value of marks when x = 0)

Types of linear Regression

① Simple Linear Regression

* uses one independent variable to predict one dependent variable

Eg: Predicting weight based on hight

$$y = b_0 + b_1 x$$

② Multiple linear Regression

* uses two or more independent variables to predict one dependent variable

Eg:- predicting house price based on size + location + number of rooms

③ Polynomial Regression

• When the relationship is not a straight line but curved, we use polynomial regression

eg: Relationship between speed and fuel consumption

$y = b_0 + b_1 x + b_2 x^2 + b_3 x^3 + \cdots$

④ Ridge Regression

• used when multiple variables are highly correlated
• Helps prevent overfitting (model becoming too accurate for training data but bad for new data)

⑤ Lasso Regression

Also prevents overfitting but additionally can remove unimportant variable automatically

⑥ Elastic Net Regression:-

combination of Ridge + Lasso
useful when the dataset has many variables

(14) ⑬ Evaluate linear regression assumptions with examples.

① Linearity

The Relationship between independent variable(s) and dependent variable must be linear (a straight line)

Ex:
* As Temperature increases, ice-cream sales increase in a straight-line pattern
* If the relation is curved (like speed vs fuel efficiency) linear regression will not work properly.

② Independence of Errors:

The errors (residuals) must be independent of each other. In simple words. one observation should not influence the error of another

③ Homoscedasticity (Constant Variance of Errors)

The errors shd have equal variance at all levels of the independent variable.

Eg: suppose you predict salary based on experience

For low experience: prediction error is small

For high experience: prediction error becomes very large

This means variance is not constant → heteroscedasticity

④ Normality of Errors:-

Residuals (errors) should be normally distributed

Eg:- if you predict student marks using study hours

- Most Errors should be small
- Very large positive / negative errors should be rare

⑤ NO Multicollinearity (For Multiple linear Regression)

Independent variable should not be highly correlated with each other

Eg you want to predict house price using

- size of house
- Number of bedrooms

⑥ NO Auto correlation

Residuals should not be correlated with each other

Eg: while predicting stock prices, today's error is often related to yesterdays this creates patterns in residuals, violating auto correlation assumption.

(14) (B) Difference Between Decision Tree & Random forest

Decision Tree	Random Forest
① A model that splits data into branches based on conditions	① A collection of many decision trees working together
② Builds one tree	② Builds many trees and combines results
③ usually lower accuracy	③ Higher accuracy because it averages many trees
④ very prone to overfitting	④ Reduces overfitting because multiple trees vote/average
⑤ small change in data → big change in tree	⑤ very stable, small data change don't affect much
⑥ Fast to train	⑥ slower because many trees are built
⑦ Easy to understand and visualize	⑦ Hard to visualize because it has many trees.
⑧ splits data using features until a decision is reached	⑧ Creates many trees using random samples + random.
⑨ when simplicity and explainability are important	⑨ when accuracy and robustness are more important.

(14) (B) what is meant by K-Nearest Neighbors algorithm demonstrate its metrics

(A) It is a supervised machine learning algorithm used for classification and regressions

It works based on a simple idea.

① KNN looks at the K nearest (closest) data points in the training set.

② It checks their labels.

the final output is based on majority vote

HOW KNN WORKS

Imagine you want to predict whether a fruit is an apple or ~~organ~~ orange based on

* weight
* color

A new fruit appears → KNN checks the K-closest fruits in the datasets

* If most neighbors are apples → predicts apple
  If most neighbors are oranges → predicts orange

Distance Metrics used in KNN

To find the nearest neighbors, KNN uses distance formulas called metrics

Euclidean Distance

This is the straight-line distance between two points

$$d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$$

Eg) point A = (2,3)
" B = (5,7)

$d = \sqrt{(5-2)^2 + (7-3)^2} = \sqrt{9+16} = 5$

use when
- Data is continuous
- standard geometric distance is needed

② Manhattan Distance (City Block Distance)

Moves only in horizontal + vertical directions

$d = |x_1 - x_2| + |y_1 - y_2|$

$d = |2-5| + |3-7| = 3+4 = 7$

use when
- Data has sharp edges
- Movement is grid-like

③ Minkowski Distance

A generalization of both euclidean and Manhattan

$d = (|x_1 - x_2|^p + |y_1 - y_2|^p)^{1/p}$

- if $p=1 \rightarrow$ manhattan
  $p=2 \rightarrow$ euclidean

④ Hamming Distance:

counts how many positions are different
used for categorical or binary variable

Example:
string A: "10111**0**"
B: "10101**0**"

Difference: 1 (fourth position) → Hamming distance = 1

Use when

- Data is text/string
- Binary feature

15.A Explain self-organizing map and how do SOM works compose one example

(A) A Self-Organizing Map (SOM) is an unsupervised machine learning algorithms used mainly for clustering, visualization, Dimensionality reduction

SOM converts high. dimensional data (like 10 features) into a 2D map (grid) while keeping similar items close together

HOW SOM WORKS (step-by-step)

SOM contains a grid of neurons, each neuron has a weight vector (like a small memory). when data is given, SOM organizes itself in four steps

Step 1:- Initialize neurons

All neurons in the grid are given random weight initially.

Step 2: Take an input data point

choose one sample from the dataset

Ex: A fruit with 2 features

① weight = 0.8, sweetness = 0.3

Step 3:- Find the Best Matching unit (BMU)

this is usually done using Euclidean Distance

the neuron with the smallest distance is called BMU

Step 4 update the BMU and its neighbors

The BMU and near by nurons adjust their weight to become more like the input

$$W_{new} = W_{old} + \alpha (input - W_{old})$$

α : learning rate

Near by neurons are updated more than far ones

over time the update becomes smaller

Repeat for all data

After many iterations, neuron arrange themselves

Such that

Similar data → close in map

Dissimilar data → far apart

Example:

Input data (2 features

Fruit	weight	sweetness
Apple	0.8	0.9
lemon	0.2	0.3

SOM Grid

two neurons N_1 & N_2

① Find BMU

For apple (0.8, 0.9)

N_1 is closer → becomes BMU

so N_1 moves closer to apple

For lemon (0.2, 0.3)

N_2 is closer → becomes BMU

So N_2 moves closer to lemon

Result

N_1 represent Apple-like fruits

N_2 represent Lemon-like fruits

(15)(B) Explain Expectation Maximization algorithm and construct EM algorithm flow chart.

(A) The Expectation-Maximization (EM) algorithm is an iterative method used to find the maximum likelihood estimates when data has missing value or hidden (latent) variables

It is widely used in clustering, Gaussian mixture Models, Missing data problems hidden, markov models

(*) E-step (Expectation step)

Estimate the missing data or latent variables,
compute the expected value of log-likelihood
use current parameter values

* M-step (Maximization step)

update parameters to maximize the expected log-likelihood
these new parameters are used again in the next-E-step

Simple example of EM.

we have two types of coins (A and B) but we dont know

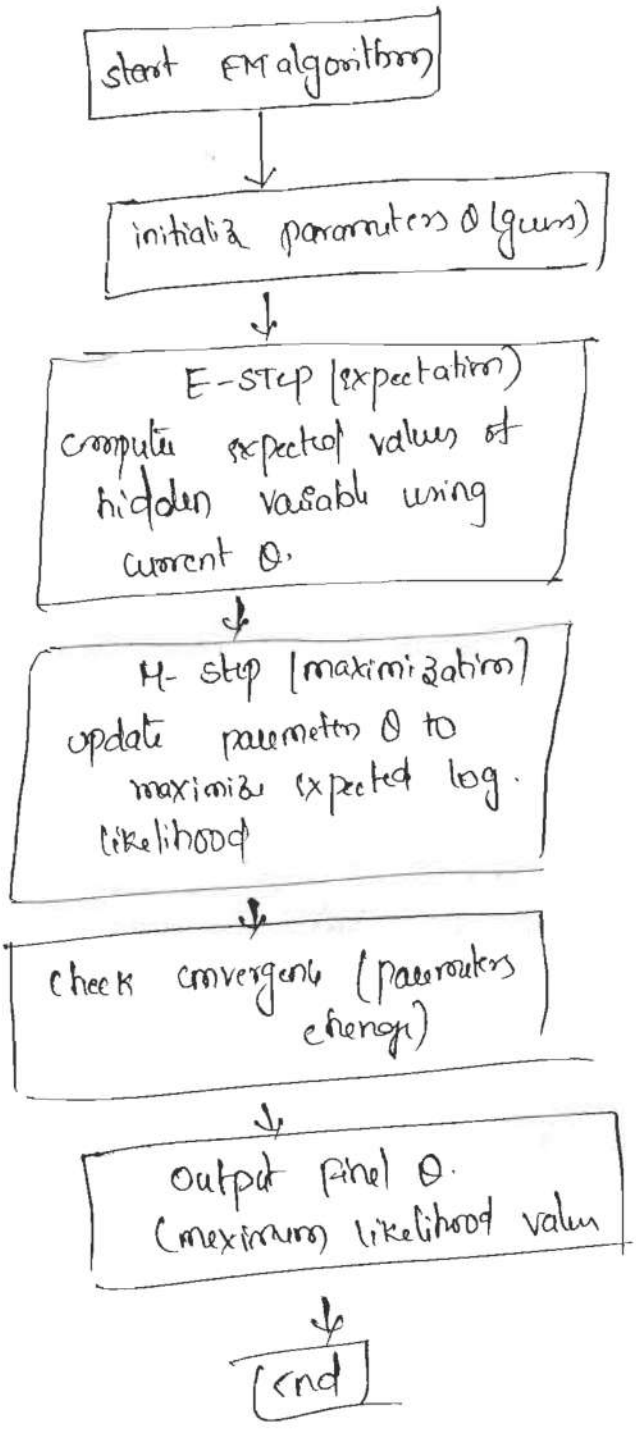
which coin produced which sequence
the probability of heads for each coin

EM Procen

E-step :- Based on current guesses, calculate the probability that each sequence came from coin A or B

M-step using these probabilities re-estimate

Flow chart


start EM algorithm
initialize parameters θ (guess)
E-step (expectation)
compute expected values of hidden variable using current θ.
M-step (maximization)
update parameter θ to maximize expected log. likelihood
check convergence (parameters change)
Output final θ.
(maximum) likelihood value
End