—Best of Luck—

Total No. of Pages :04 Roll No. .....

SIXTH SEMESTER B.Tech. [CSE]

MID SEMESTER EXAMINATION March-2023

CO304 ARTIFICIAL INTELLIGENCE

Time: 1:30 Hours Max. Marks: 25

Note: Answer *ALL* questions.
Assume suitable missing data, if any.
CO# is course outcome(s) related to the question.
L# is the cognitive level required to solve the question.

Total No. of Pages: 2 Roll No.....

VITH SEMESTER B.Tech.(Computer Engineering)

MID SEMESTER EXAMINATION (March, 2020)

CO304 ARTIFICIAL INTELLIGENCE

Paper Code

Time: 1:30 Hours Max. Marks: 25

Note: Answer all questions.
Assume suitable missing data, if any.

Total No. of Pages: 2 Roll No.....

VITH SEMESTER B.Tech.(Software Engineering)

MID SEMESTER EXAMINATION (March, 2018)

CO_304 ARTIFICIAL INTELLIGENC

Paper Code

Time: 1:30 Hours Max. Marks: 25

Note: Answer all questions.
Assume suitable missing data, if any.

Total No. of Pages: 2 Roll No.....

VITH SEMESTER B.Tech.(Computer Engineering)

MID SEMESTER EXAMINATION (March, 2019)

CO304 ARTIFICIAL INTELLIGENCE

Paper Code

Time: 1:30 Hours Max. Marks: 25

Note: Answer all questions.
Assume suitable missing data, if any.

Total Number of Pages 2 Roll No. .....

SEVENTH SEMESTER B.E.(COE)

MID SEMESTER EXAMINATION SEPTEMBER-2010

COE- 405 ARTIFICIAL INTELLIGENCE

Time : 1 Hour 30 Minutes Max. Marks : 20

Note : Answer *ALL* questions.
Assume suitable missing data, if any.

Total No. of Pages:1 Roll No.....12

SIXTH SEMESTER B. Tech.

END SEMESTER EXAMINATION July-2023

CO304 ARTIFICIAL INTELLIGENCE

[illegible]0 Hours Max. Marks: 50

Note: Attempt any five questions. Assume suitable missing data, if any.

Roll No. B.Tech.[CSE]

Total No. of Pages 04 May-2023

SIXTH SEMESTER

END SEMESTER EXAMINATION

CO304 ARTIFICIAL INTELLIGENCE

Time: 3:00 Hours Max. Marks: 40

Note: Answer *ALL* questions.
Assume suitable missing data, if any.
CO# is course outcome(s) related to the question.

Total No. of Pages : 4 Roll No.....

VITH SEMESTER B.TECH: [CSE]

END SEMESTER EXAMINATION (MAY. - 2019)

CO-304ARTIFICIAL INTELLIGENCE

Time: 3:00 Hours Max. Marks: 50

Note: Attempt any five questions.
All diagrams and pseudocode should be neat and clean.

Roll No.....

Total No. of Pages: 3

VIITH SEMESTER B.Tech.(Computer Engineering)

END SEMESTEREXAMINATION (November 18)

CO-401 ARTIFICIAL INTELLIGENCE

Paper Code

Time: 3 Hours Max. Marks: 70

Note: Attempt total 5 questions. Assume missing data if any

Total No. of Pages 2

Roll No.....

VIth SEMESTER

B.Tech.(Computer)

End Semester Examination(supplementary)August 2018

co304

Paper Code

Artificial Intelligence

Title of the subject

Time:3 Hours

Max. Marks: 50

Note: Answer any 5 questions.
Assume suitable missing data, if any.

Total No. of Pages: 2

Roll No.....

VITH SEMESTER

B.Tech.(Computer Engineering)

Supplementary END SEMESTEREXAMINATION

(September 2019)

CO 304

Paper Code

ARTIFICIAL INTELLIGENCE

Time: 3 Hours

Max. Marks: 50

Note: Attempt total 5 questions. Q1 is compulsory

Total No. of Pages: 3

Roll No.....

VITH SEMESTER

B.Tech.(Computer Engineering)

END SEMESTEREXAMINATION

(May 2018)

CO 304

Paper Code

ARTIFICIAL INTELLIGENCE

Time: 3 Hours

Max. Marks: 50

Note: Attempt total 5 questions. Q1 is compulsory

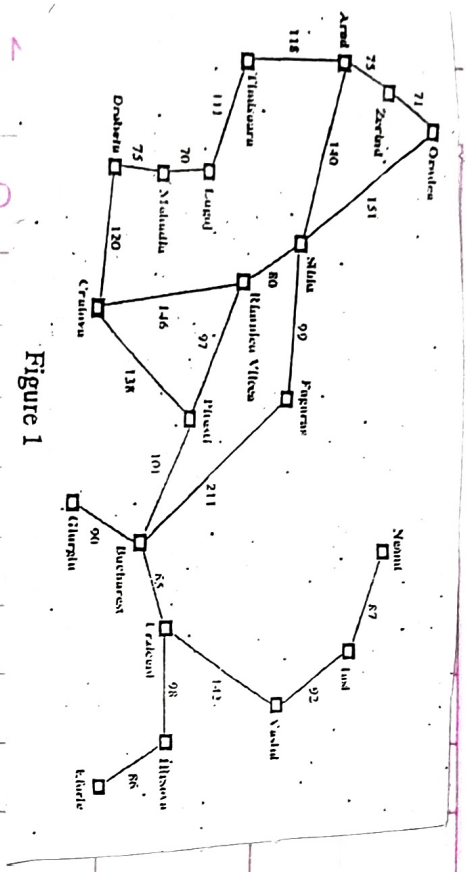

Figure 1

UNIT-1

Page No.
Date

INTRODUCTION

(c) What are the applications of Artificial Intelligence? 2023SE [2]

The applications of AI are:

MUNDANE TASKS

- Perception
  - → Computer vision
  - → Speech recognition
- Natural Language (NLP)
  - → Understanding
  - → Generation
  - → Translation
- Common Sense Reasoning
- Robot control

FORMAL TASKS

- Games
  - → Chess
  - → Backgammon
  - → Checkers - Go
- Mathematics
  - → Geometry
  - → Logic
  - → Integral calculus
  - → Proving properties of programs
- Search and control strategies

EXPERT TASKS

- Engineering
  - → Design
  - → Fault Finding
  - → Manufacturing planning
- Scientific / Medical / Financial analysis

(b) Define components of AI program. 2023SE

1.) LEARNING: Learning involves the capability of the system to acquire knowledge and improve its performance over time, akin to human learning processes.

2.) REASONING: Reasoning grants the system the ability to analyze info., draw conclusions and make decisions based on logical thinking.

3.) PROBLEM-SOLVING: AI program with this excel at defining problems, exploring various solutions, and implementing effective strategies to achive desired outcome.

4.) PERCEPTION: This component refers to the systems ability to interpret sensory input such as vision, sounds, smell, touch enabling it to understand and interact with environment.

5.) LANGUAGE-UNDERSTANDING: The computer uses software to interpret text, translate to computer language and produce an output in language that humans can understand.

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Q1 (a) Mention the categorization of intelligent systems. 2023SE [2]

Based on the functionality of AI based systems, they can be categorised into the following:

1. REACTIVE MACHINES AI: Operates based on present data, performing pre-defined tasks without forming future inferences.

2. LIMITED MEMORY AI: Utilizes past data stored in a temporary memory to make informed decisions
Eg.) Self driving car.

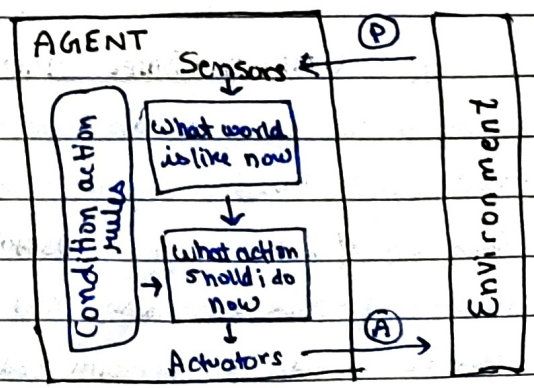
3. THEORY OF MIND AI: Advanced AI focussing on emotional intelligence, currently under rigrous research for better understanding human beliefs and thoughts.

4. SELF-AWARE AI: Speculative and futuristic type of AI with its own consciousness, which is now a distant possibility.

Q2 (a) Explain in detail, the structure of different intelligent agents. 2023SE [8]

An intelligent agent is an autonomous entity which act upon an environment using sensors and actuators for achieving goals. These are:

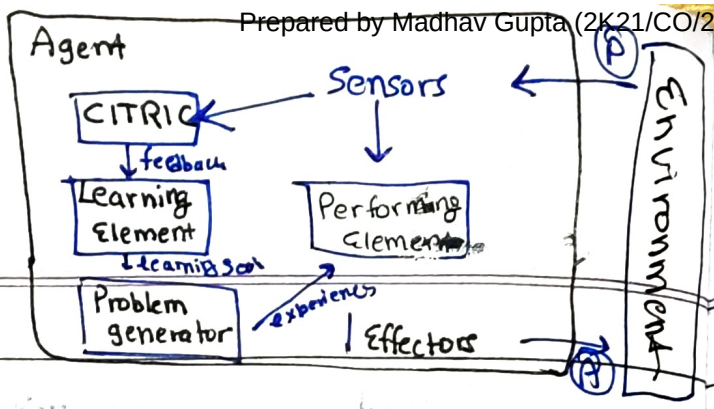
1. SIMPLE REFLEX AGENTS:
works only on current situation / perception and ignores the history of prev. state.
↳ Condition - Action Rule.



Limitations
i.) very limited knowledge
ii) no knowledge about non perceptual parts of state
iii) can go in ∞ loop.

5. **LEARNING AGENTS :**

Can learn from its past knowledge Starts to ACT with basic knowledge and then able to act by adapting learning.



2. **MODEL - BASED REFLEX AGENT :**

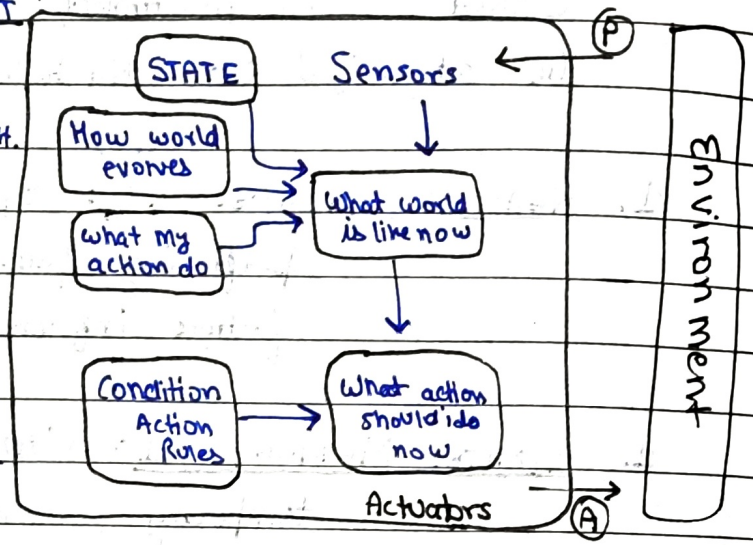
→ It works by finding the rule whose condition matches current sit.

→ Can work in partially observable env. and track situation.

→ Agent keeps track of internal state which is adjusted by each percept and that depends on percept history.

It uses info :

① How world is evolving? | ② How agent's action affect the world?



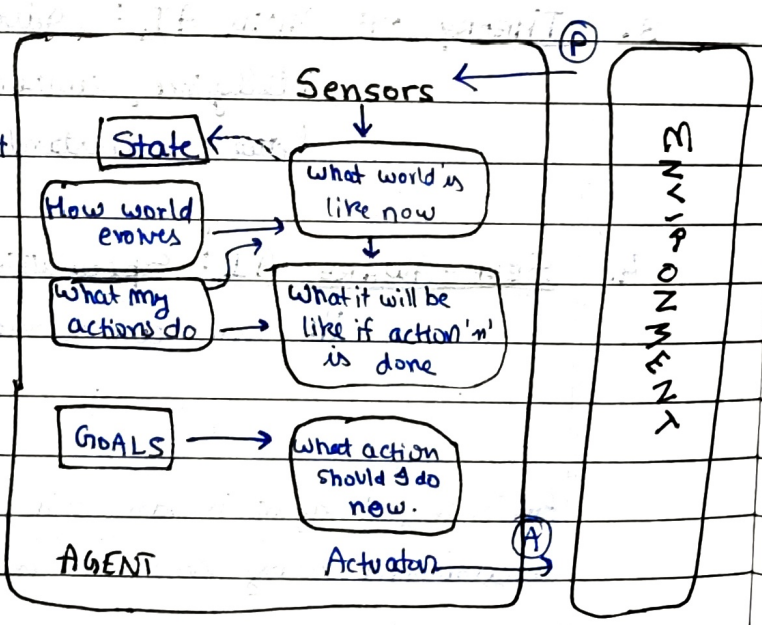
3. **GOAL-BASED AGENTS :**

↳ Focuses only on reaching the goal set

↳ Agent takes decision based on how far it is currently from the goal state

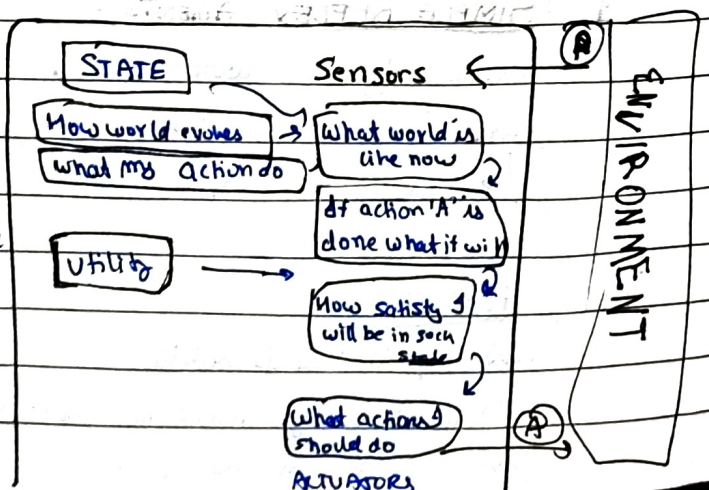
↳ Every decision is taken to minimize dist to goal state.

↳ More Flexible agent.



4. **UTILITY - BASED AGENTS :**

Agents are more concerned about the utility for each node. Act based not only on goals but also the best way of achieving goal. Useful when there are multible possible alternatives and agent has to choose in order to perform best action.



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[b] Differentiate between forward reasoning and backward reasoning. 2

2010M

The difference between the problem solving methods are :-

	FORWARD REASONING	BACKWARD REASONING
1.	It is a data driven task	It is a goal driven task.
2.	It begins with new data	It begins with uncertain conclusions
3.	The objective is to find a conclusion that would follow.	The objective is to find the facts that support the conclusions.
4.	It is an opportunistic type approach	It is a conservative type approach.
5.	It tests all rules and can produce an infinite no. of conclusions	It tests some rules and produce a finite no. of conclusions.
Eg)	Suitable for answering problems such as planning, control monitoring etc.	Suitable for problems like diagnosis.

1. Answer *any TWO* of the followings

2023E

[a] Assume that you are hired by a company to evaluate the potential for using artificial intelligence (AI) techniques (not robots) to improve efficiency and reduce costs. You are given a list of tasks and are asked to identify which of the tasks can be replaced by an AI agent. The major tasks involved in the manufacturing process are: Assembly line tasks, Quality control inspections, Inventory management, Predictive maintenance, and Logistics

(i) Identify which of the tasks can be automated using AI techniques.

(ii) Evaluate the benefits and limitations of using AI to perform the identified tasks. [Maximum two sentences for each task]

[2+2] [CO1]

i)

ENVIRONMENT

PROBLEM SOLVING

(ii) Explain the concepts of state space, production rules and control strategy. 2018E

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(b) Define state space and give the state space for water jug problem. Define the production rules and work out the production rule for this problem. 2018E

(5,5)

A state space is a set of all possible states that a system can exhibit. It provides a structural representation of the different configurations or situations that can occur within a given problem domain.

Water Jug Problem :

You are given two jugs, a 4-gallon one and a 3-gallon one. Neither has any measuring markers on it. There is a pump that can be used to fill the jugs with water. How can you get exactly 2 gallons of water into the 4-gallon jug.

STATE SPACE: It can be described as a tuple (x,y) where x represents the amount of water in 4-gallon jug and y represents the amount of water in 3-gallon jug. such that $0 \leq x \leq 4$ and $0 \leq y \leq 3$.

Q1. Answer to the point for any five from following:

(i) Define the production system using water jug problem. 2018S

Production system helps in structuring AI program in a way that facilitates describing and performing the search process. It consists of production rules which are (condition, action) pairs which mean, "If condition then action".

Sr	Current State	Next State	Descriptions.
1.	(x,y) if $x<4$	$(4, y)$	Fill the 4 gallon jug
2.	(x,y) if $y<3$	$(x,3)$	Fill the 3 gallon jug
3.	(x,y) if $x>0$	$(x-d,y)$	Pour some water out of 4 gallon jug.
4.	(x,y) if $y>0$	$(x,y-d)$	Pour some water out of 3 gallon jug.

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5.	(x,y) if $y>0$	$(0,y)$	Empty the 4 gallon jug
6.	(x,y) if $x>0$	$(x,0)$	Empty the 3 gallon jug
7.	(x,y) if $x+y>=4$ and $y>0$	$(4, y-(4-x))$	Pour water from the 3 gallon jug into the 4 gallon jug until 4 gallon jug is full.
8.	(x,y) if $x+y>=3$ and $x>0$	$(x-(3-y), 3)$	Pour water from the 4 gallon jug into the 3 gallon jug until 3 gallon jug is full.
9	(x,y) if $x+y<=4$ and $x>0$	$(x+y, 0)$	Pour all the water from the 3 gallon jug into the 4 gallon jug
10.	(x,y) if $x+y<=3$ and $y>0$	$(0, x+y)$	Pour all the water from the 4 gallon jug into the 3 gallon jug.
11.	$(0,2)$	$(2,0)$	Pour the 2 gallons from 3 gallon jug into the 4 gallon jug.
12.	$(2,y)$	$(0,y)$	Empty the 2 gallons in the 4 gallon jug

1[a] Define production system. What are the requirements of a good control strategy? 2010 M 3

A good control strategy:

1. Causes motion. i.e. in water jug problem, blindly following rules without progress won't lead to a sol^n. essentially.

2. Should be systematic: i.e taking random actions, although causes motion, might be ineffient, revisiting states and using unnessary steps in the process.

1[a] Consider 3-puzzle problem, it consists of a 2×2 board with three numbered tiles and a blank space. A tile adjacent to the blank space can slide into the space. The object is to reach a specified goal state(s). The initial state S goal states G_1 and G_2 are shown in Fig. 1. Give the problem formulation for the above problem. Illustrate the state space with the help of a diagram, along with applicable actions. Also, give a possible sequence of actions to achieve goals G_1 and G_2, if there are any.

[1+2+2] [CO1, CO2] [L3]

2023 M

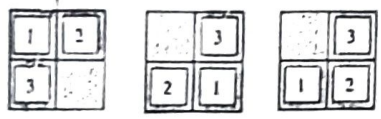


Fig.1: (a) S, (b) G_1, (c) G_2

PROBLEM FORMULATION

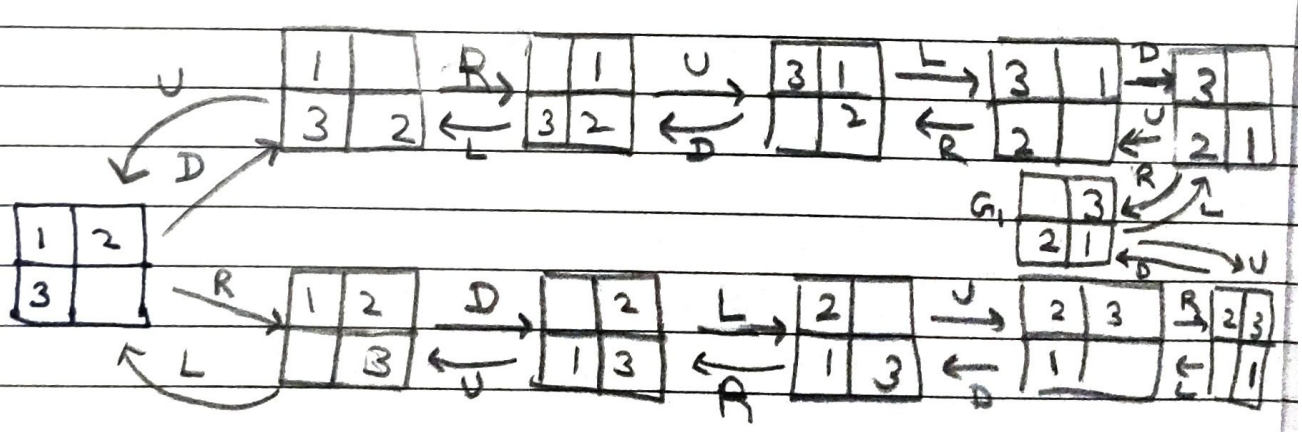
Initial State (S): A 2x2 board with three numbered tiles and a blank space arranged in a certain order

Actions (A): Slide a tile adjacent to the blank space into the space. [L R U D]

Transition model: defines the result of an action, i.e. the new state after performing a valid action.

Goal Test: Check if the current state matches either of the specified goal states G_1 or G_2

Cost Function: Let it be uniform cost.



Path to G_1: ① DRULDR
② RDLURD

Path to G_2: Unreachable.

[b] Consider a vacuum-clear World shown in Fig. 2. This World has just three locations: rooms A, B and C. The vacuum agent perceives which room it is in and whether there is dirt. It can move left, move right, suck up the dirt, or do nothing. One straightforward agent function is the following: if the current room is dirty, then suck; otherwise, move to the other room. Find the number of states in the state space and write a pseudo code for the reflex agent program.

[1+2] [CO2] [L3]

2023M

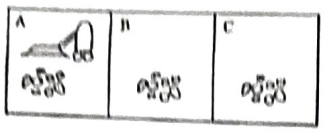


Fig. 2

There are 3 rooms and each room can be dirty or clean

∴ #dirt configs = $2^3 = 8$ possible

∵ Vacuum location = 3 per case

∴ # states = $8 \times 3 = 24$

PSEUDO CODE

```
function REFLEX-VACUUM-AGENT ([location, status]) → action
        if status == Dirty :
                return "Suck"
        if location == A :
                return "Right"
        elif location == B :
                return "Right"
        elif location == C :
                return "Left"
        else
                return "nothing"
```

Q2. Analyze the project characteristics of 8 puzzle problem. 2020M [2]

The 8-puzzle is a square tray in which are placed, eight square tiles. The remaining ninth tile is uncovered. Each tile has a number on it. A tile that is adjacent to the blank space can be slid into that place. A game consists of a starting position and a specified goal position. The goal is to transform the starting position into goal position by moving the tiles around

Start

2	8	3
1	6	4
7		5

Goal

1	2	3
8		4
7	6	5

R.T.O.

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Date

1.) Is the problem decomposable ?
No, one game have single solution.

2.) Can the steps be ignored or undone ?
Yes, we can undo the present move.

3.) Is the universe predictable ?
Yes, since it requires only one agent and we can predict the position of blocks in next move.

4.) Is a good solution absolute or relative ?
It is absolute as we dont have to bother about other sol^n

5.) Is the solution a state or a path ?
The solution is a path to reach the goal state.

6.) What is the role of knowledge ?
Lots of knowledge helps to constrain the search for a solution.

7.) Does the task require human-interaction ?
No, additional human ~~interaction~~ assistance is not needed.

b. Give any five project characteristics to analyze a problem domain 2019S

(iii) List five project characteristics to analyze a problem domain 2018E (4,5,5)

1.) Is the problem decomposible into a set of (nearly) independent smaller or easier subproblems.

2.) Can solution steps be ignored or atleast undone if they prove unwise ?

3.) Is the problem's universe predictable?

(d) Mention characteristics of a problem. 2023 SE

6.) Is a large amount of knowledge absolutely necessary to solve the problem, or is knowledge important only to constrain the search?

7.) Can a computer that is simply given the program return the solution, or will the soln of the problem require interaction with the person?

4.) Is a good solution to the problem obvious without comparison to all other possible solutions.

5.) Is the desired solution a state of the world or a path to the state

(ii) Analyze the problem characteristics of Travelling sales man problem. 2018M

A salesman has a list of cities, each of which he must visit exactly once. There are direct roads between each pair of cities on the list. Find the route the salesman should follow for the shortest possible round trip that both starts and finishes at any one of the cities.

Is the problem decomposable?
No

Can solution steps be ignored or undone?
Yes, we can explore other path if one isn't optimal.

Is the good solution absolute or relative?
Relative, as we need to find the best path.

Is the soln a path or state?
Its the path to travel in all cities optimally in a round trip.

What is the role of knowledge?
Specialized algorithms and heuristics play a vital role and a large amount of general knowledge isn't need.

Does the task require human interaction?
NO.

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Q1(a) Explain different project characteristics and analyze the problem characteristics for robot moving a desk from one room to another? 2019E [5]

The characteristics are mentioned beforehand.

1. Decomposable: Its partially decomposable as it can be broken into subtasks like lifting, navigating, placing down.

2. Reversibility: Some steps like path planning can be reversed.

3. Predictability: The robot's movements and basic physics are predictable while external and human obstacles introduce unpredictability

4. Good Solution: No, its relative since various factors are to be considered.

5. Path to final state

6. Knowledge requirement: Knowledge is helpful i.e. about the environment, capabilities to avoid collision. But it can be done with limited knowledge too.

7. Human Intervention: likely needed incase of unforeseen events, safety.

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(e) Write about the analysis of search methods 2023ES [2] [CO1]

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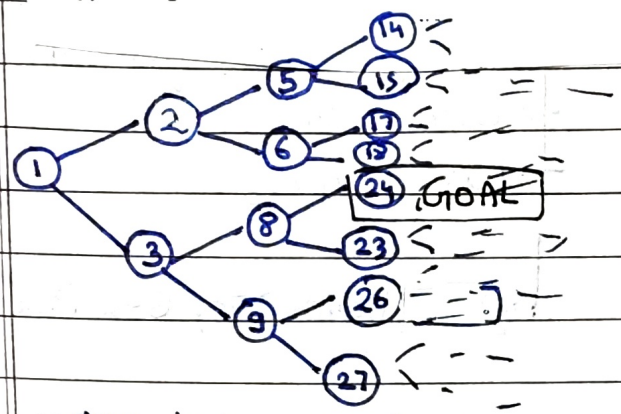
Date

Q2. Consider a state space where start space is number 1 and successor for state numbered n is 3n and 3n-1. Draw the search tree. List the order in which nodes will be visited using following search techniques if goal node is numbered as 24 2018M

(i) Depth first search, (ii) Iterative deepening search. [2]

Search Tree



Using lexicographical order

i.) DFS : 1 → 2 → 5 → 14 → 41 → 122 → - - - - - -

ii.) Iterative deepening search

d = 0 : 1

d = 1 : 1 → 2 → 3

d = 2 : 1 → 2 → 5 → 6 → 3 → 8 → 9

d = 3 : 1 → 2 → 5 → 14 → 15 → 6 → 17 → 18 → 3 → 8 → 23 → $\boxed{24}$ Goal

(iii) Define the term admissibility of a search procedure. Which search procedure is admissible? 2019M

A search procedure is admissible if it always find an optimal solution if one exists. In this the heuristic function never underestimates the cost of reaching the goal i.e.

" h(n) is always less than or equal to actual cost of lowest path from node 'n' to goal "

Thus, it underestimates :

It ensures that it never ~~[illegible]~~ overlooks the optimal sol^n and does not return solutions with cost higher than optimal

Eg) A* search algorithm.

UNIT - 2

HEURISTIC SEARCH TECHNIQUES

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Q1. (a) What are the advantages and disadvantages of intelligent search over non intelligent search? Give an example of intelligent and non intelligent program for Tic Tac Toe problem. 2018S

Uninformed Search	Informed Search
→ Search without information.	→ Search with information
→ No knowledge	→ Use knowledge to find steps to soln
→ Time consuming	→ Quick Soln
→ More Complexity (Time / Space)	→ Less Complexity (T/S)
Eg) DFS, BFS, etc.	Eg) A*, Heuristic DFS, Best First Search

Q1. Answer following to the point.

a. Give an example of intelligent and Non intelligent program for Tic Tac Toe Problem. 2019S

TIC TAC TOE
(Not implemented)

Intelligent programs
→ Minimax Algo
→ " " with α-β pruning

Non - Intelligent program
→ Simple rule based prog.
→ Random Move Algo.

2 What do you mean by a heuristic function? Explain with an example. 2
2010M

Heuristic functions are mechanisms used to estimate the cost from a given state to the goal. Informed Search algorithms utilize these functions to prioritize paths which are likely to lead to optimal answer efficiently.

Eg)

2	3	1
7	8	
6	4	5

Start

	3	2
8	1	6
7	4	5

Goal

In 8-puzzle problem,
h(n) = no of misplaced tiles
h(n) = 7

1. Write down two intelligent programs for the TIC-TAC-TOE problem.

1.) Heuristic Approach

This approach uses a set of heuristic values to determine the next best move. The board is represented as a 9-element vector where each element can be 2(blank), 3 (X), 5(O). The program defines several functions to evaluate the board state and make the next move based on heuristic values.

Represent board as a 9-element vector

```
function MAKE2():
    if central square is blank :
        return 5
    else return any other square
function POSWIN (player):
    if player cant win on next move:
        Return 0
    else
        Return square no. for winning move.
function GO( player_number)
    make a move in the square specified by square_number.
function PLAY():
    turn=1
    while game is not over :
        if turn == 1 : GO(1)
        else if turn == 2 :
            if central square is blank: GO( 5)
            else : GO ( 1)
        else if turn == 3:
            if top-right square is blank: GO(9)
            else : GO (3)
        else if turn >= 4 :
            winning_move = POSWIN('X')
            if winning_move != 0 :
                GO (winning_move)
            :More rules
        turn++
    end.
```

Date / /
Page No.

2.) Minimax - Algorithm

This approach recursively determines the optimal move by considering all possible future game states. This assigns a score to each game state based on outcome and chooses that move which maximizes the player's score and

Represent the board as a 9-element vector.

```
function IsTerminal (board):
    Check if the game has ended (win, lose, draw)
    return true / false.
function UTILITY (board):
    Evaluate the utility (score) of the board
    return a score
function RESULT (board, move, player)
    return the new board state after making the move
function MiniMax (board, player):
    if IS_TERMINAL (board):
        return UTILITY (board)
    if player == 'X':
        value = -∞
        for each available move:
            new_board = RESULT(board, move, player)
            value = max(value, minimax(newboard, 'O'))
        return value
    else
        value = ∞
        for each available move:
            new_board = RESULT (board, move, player)
            value = min (value, minimax (new_board, 'X'))
        return value

function Make move:
```

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Q1. Answer following with suitable reasoning:
(i) Is Breadth first search is intelligent search procedure? 2020M

No, BFS is not considered an intelligent search procedure because

→ It lacks knowledge and operates blindly, exploring all paths equally without any preference or guidance.

→ BFS remains static throughout the search, unable to learn from explored paths or adapt its strategy based on new information

Q1. Answer to the point following:
(i) Describe the characteristics of the control strategy. Is breadth first search a control strategy? justify. 2019M

refer 2010 M

BFS is considered a control strategy because it systematically explores the search space, ensuring progress by considering all possible paths level by level.

2[a] Consider the state space shown in Fig. 3. Numbers on the edges show the step path cost between the nodes. Use the breadth-first search algorithm to find the path from start state S to a goal state G. What should be the step path cost(instead of given values) if the optimal path is desired using the breath-first search? Show each step clearly. Answer with limited words; you may use diagrams for an explanation. Do not use large text paragraphs. 2023M

[2+1] [CO1, CO2] [L3]

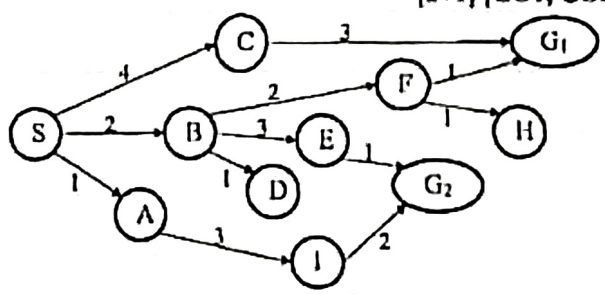
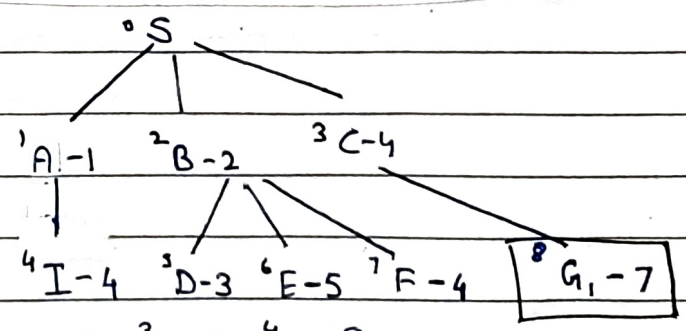


Fig. 3

Traversal



∴ path [redacted]ES: $S \xrightarrow{3} C \xrightarrow{4} G_1$

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Modified Step path Costs

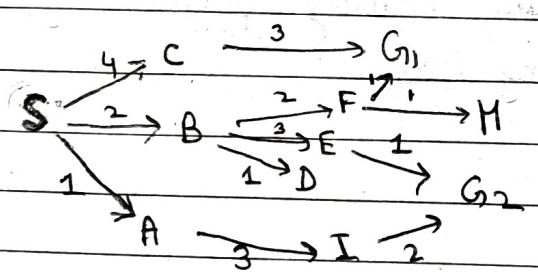
?

$S \xrightarrow{x} C \xrightarrow{y} G$ should be ≤ 5 for it to be optimal using BFS.

$\therefore x + y \leq 5$

$\boxed{Cost(S \to G) + Cost(C \to G_1) \leq 5}$

[b] Consider the state space shown in Fig. 3. Find the optimal cost path from the start state to a goal state using the uniform cost search algorithm. Compare the path cost obtain in part 2[a]. Also, explain why the difference in two path costs is given by breath-first and uniform cost search algorithms (use a maximum of three lines for explanation). [Note: if equal cost nodes are generated at any stage, the expansion order will be first-in-first-out (FIFO)]. 2023M [2+1] [CO2] [L4]



Priority Queue (open list)

~~A(1)~~	~~B(2)~~	~~C(4)~~	~~I(5)~~ G1(6)	~~F(4)~~	~~E(5)~~ ~~G1(5)~~	~~D(3)~~ M(5)	G1(7)	G2(7) (6)

visit order: $S \to A \to B \to D \to C \to I \to F \to E \to G_1$ ✓

$\boxed{\therefore \text{path is}: S \to B \to F \to G_1}$ cost = 5

This path has lower cost than BFS, it is different from BFS as BFS uses level order traversal and returns the solution at the closest depth (in lexicographic order) from start node, while uniform cost search explores the path with least cost first.

Q2.(a) Consider the graph in *Figure 1*, the node A is the start node and nodes J, G and R are goal nodes. The tree is being searched by DFS, BFS and DFID algorithm (searching left to right) Write the sequence of nodes inspected bythem till termination. Mention and show each and every step involved. 20185

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[5,5]

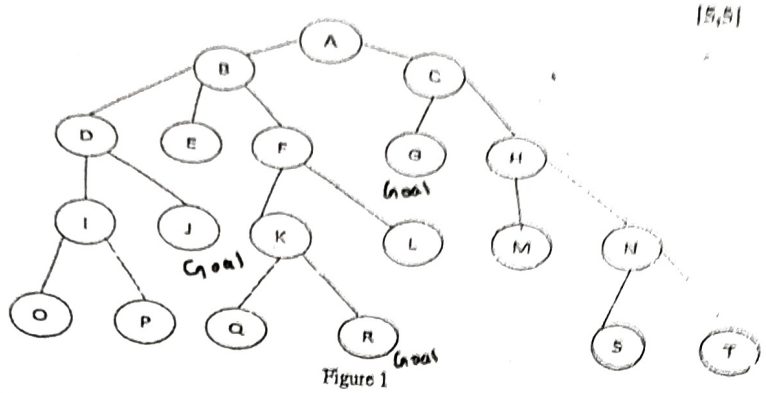
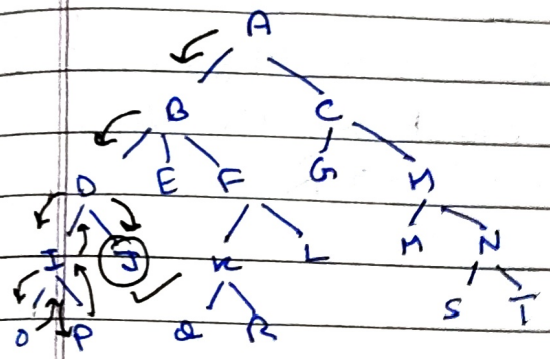


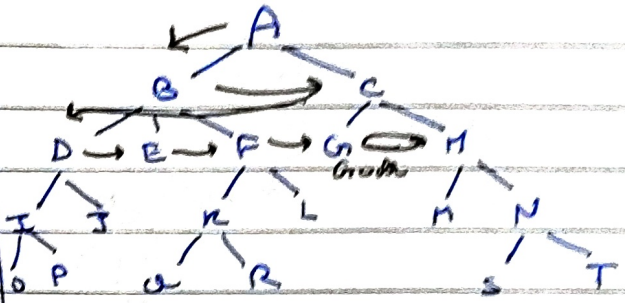
Figure 1

DFS



Order : A → B → D → I → O → P → J ✓

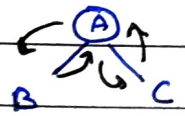
BFS



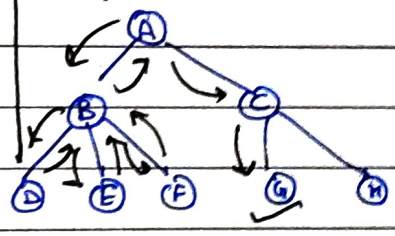
Order : A → B → C → D → E → F → G ✓

DFID

depth = 1



depth = 2



Order : A → B → C

A → B → D → E → F → C → G ✓

(b) As you get close to graduating MIT, you decide to do some career planning. *Figure 2* at end shows a graph of your options where the start node is M = MIT and your goal node is R = Retire, with a bunch of options in between. Your graph includes edge distances that represent, roughly, the "cost of transition" between these careers (don't think too hard about what this means). You also have heuristic node-to-goal distances which represent your preconceptions about how many more years you have to work until you retire. For example, you think it will take 25 years to go from MIT (M) to retirement (R), 30 years from Grad School (B), but only 2 years from Entrepreneur (E). Mention A* algorithm and Apply A* to find a respective career path after MIT till retirement. 2018E

A = Wall Street | B = Grad School | C = Professor | D = Government | E = Entrepreneur

[6,4]

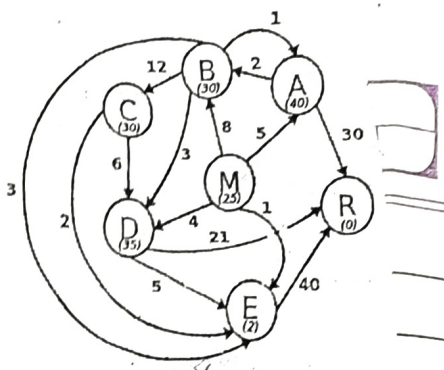
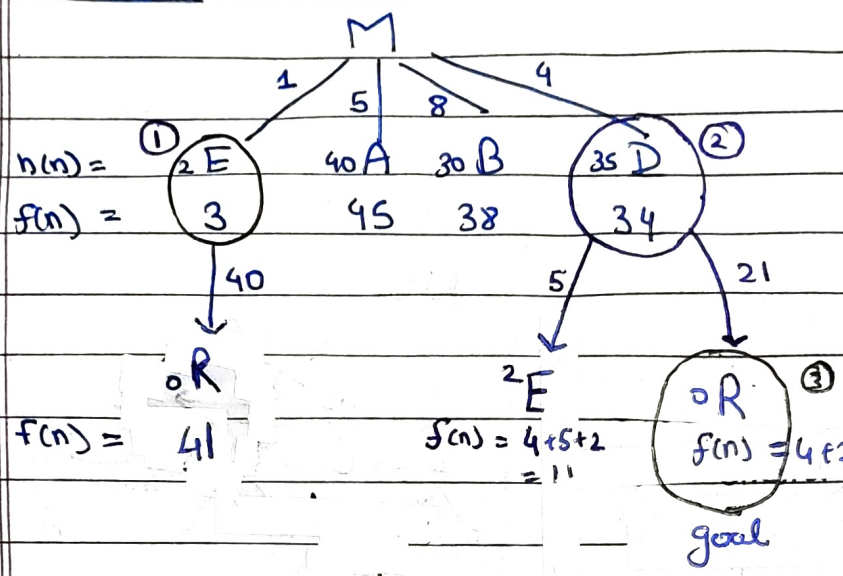


Figure 2.

A* search



∴ we need to work 25 years till retirement in the path:

M → D → R.

[b] Consider the tree shown in Fig. 1. Perform a depth-first search (DFS) of the tree. Let the start node and goal node are S and G, respectively. Also, perform a breadth-first search (BFS) of the tree. Which nodes are visited first in DFS and BFS?

2023E

[2+2] [CO2]

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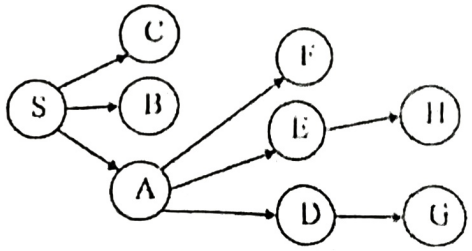
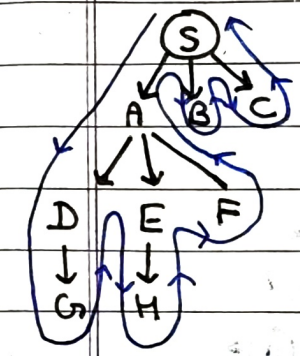


Fig. 1

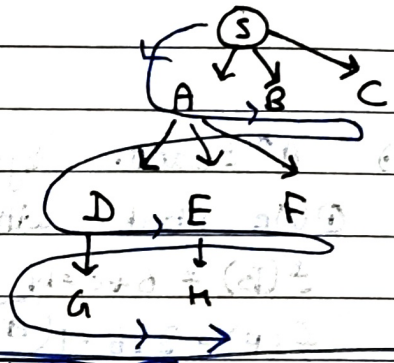


DFS

order : S → A → D → G

BFS

order : S → A → B → C → D → E → F → G



Nodes	S	A	B	C	D	E	F	G	H
Visited First	–	–	BFS	BFS	DFS	DFS	–	DFS	DFS

– = same

[c] Suppose that the search algorithm is modified to use iterative deepening depth-first search (IDDFS). Assume that the maximum depth of the tree is 3. In what order are the nodes visited? Compare the number of nodes visited by DFS, BFS, and IDDFS. Which algorithm visits the fewest nodes in this case?

2023E

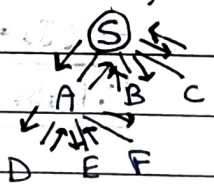
[2+1+1] [CO2]

IDDFS with depth = 3

iteration 1, d=1

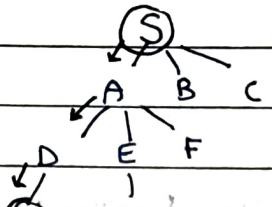
path : SABC

iteration 2, d=2



path : SADEFBC

iteration 3, d=3



path : SADG

∴ Nodes visited in DFS : S A D G

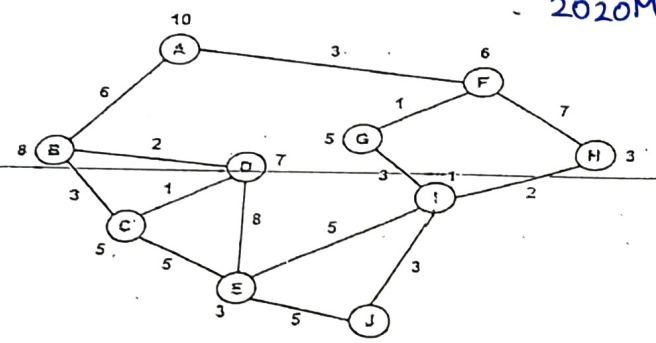
" " BFS : S A B C D E G

" " IDDFS : S A B C D E F G

∴ DFS visits fewest nodes

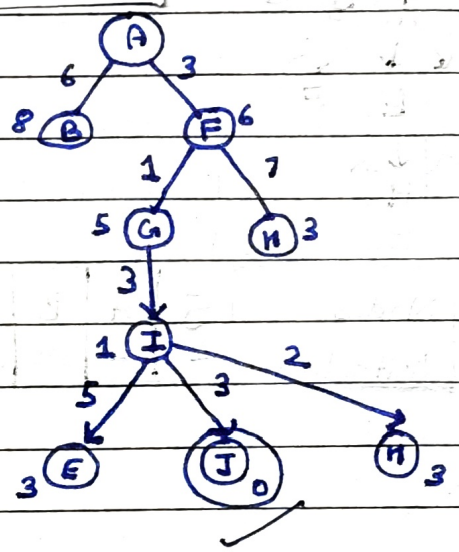
Q3. Consider the OR graph snown below, where number written on edges represent the distance between the nodes. The number written on nodes represent the heuristic values.

2020M



Find the most cost-effective path to reach from start A to final state J using: (i) A* (ii)Best first search algorithm. Explain steps used. [4]

i.) A* Search Algorithm



① We start with node A

$f(B) = 6+8=14$

$f(F) = 3+6=9$ (A)

$\therefore$ path: $A \rightarrow F$

② we are on F

$f(G) = (3+1)+5=9$

$f(H) = (3+7)+3 = 13$

$\therefore$ path: $A \rightarrow F \rightarrow G$

③ we are on G

$f(I) = (3+1+3)+1 = 8$

$\therefore$ path: $A \rightarrow F \rightarrow G \rightarrow I$

④ we are on I

$f(E) = (3+1+3+5)+3 = 15$

$f(H) = (3+1+3+2)+3 = 12$

$f(J) = (3+1+3+3)+0 = 10$

$\boxed{\therefore \text{path}: A \rightarrow F \rightarrow G \rightarrow I \rightarrow J}$

ii.) Best First Search Algorithm

OPEN		CLOSED	
Node	H(n)	Node	Parent
~~A~~	~~10~~	A	–
B	8	F	A
~~F~~	~~6~~	H	F
G	5	I	H
~~H~~	~~3~~	J	I
~~I~~	~~1~~		
E	3		
~~J~~	~~0~~		

path: $J \leftarrow I \leftarrow H \leftarrow F \leftarrow A$
(by backtracking)

[b] Consider the state-space shown in Fig. 4. The values of the heuristic function at each node are given in Table I. Find the path from start node S to the gaol node G using A* search algorithm (i) tree search version, (ii) Graph search version. Will it give the optimal path and the same path in both cases? If not, which one is an optimal path? Why does any one (or both) search versions give a sub-optimal path? 2023M

[2+2+2] [CO3] [L3, L4]

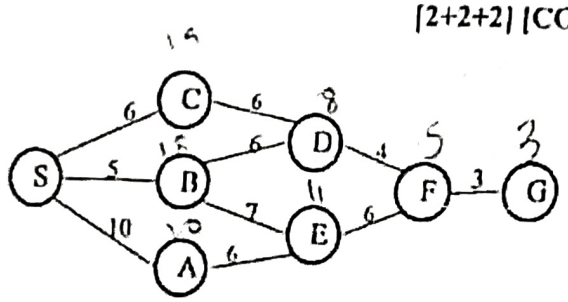
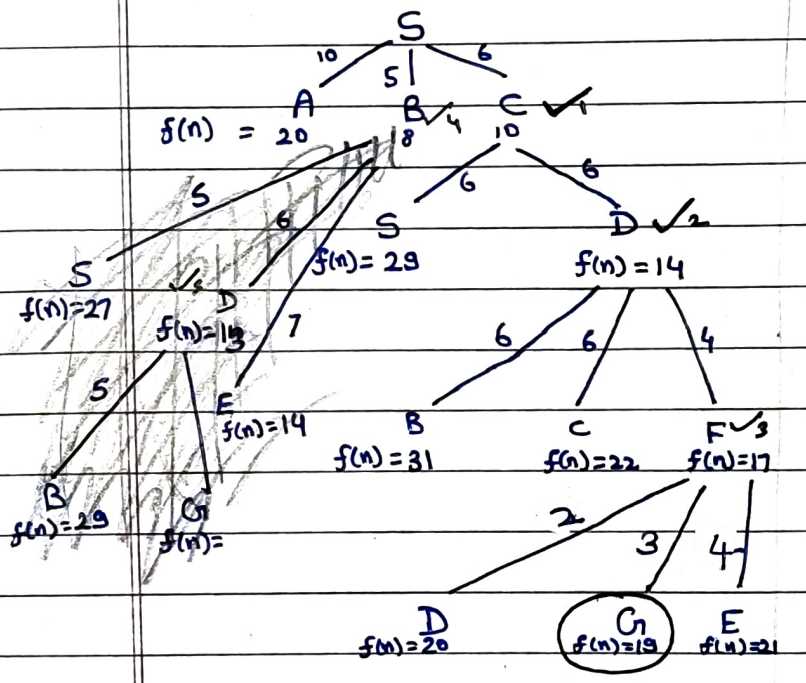


Fig. 4

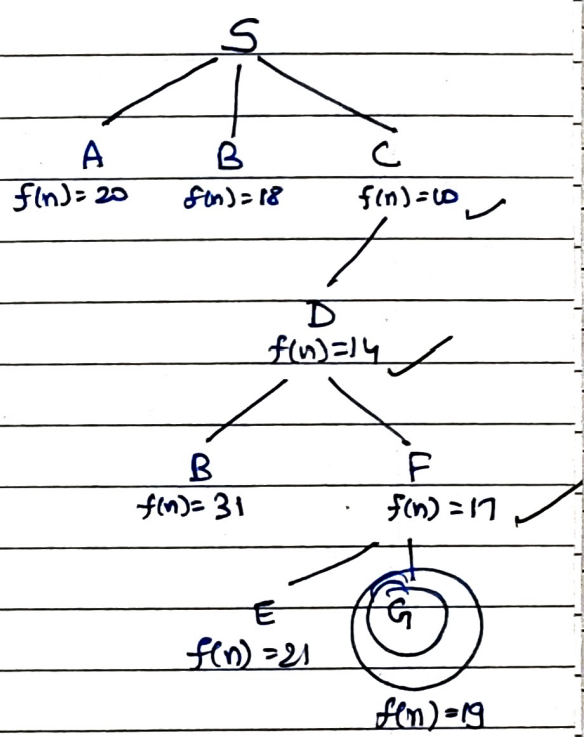
Table I

Node (n)	S	A	B	C	D	E	F	G
Heuristic $h(n)$	17	10	13	4	2	4	1	0

i) TREE VERSION (can revisit)



ii) GRAPH VERSION (cant revisit)



It gives sub-optimal path and same path in both cases.
Same path as no loop is formed.

Both versions give a sub optimal path due to overestimated h(n).

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(iv) Does A* always find optimal solution? 2020M

[4x2]

No, A* needs an admissible heuristic function which never overestimates cost to guarantee optimality.
Otherwise it may find a good solution but not necessarily the best solution.

(ii) Work out few steps of A* algorithm for slide back puzzle having following moves. 2019M

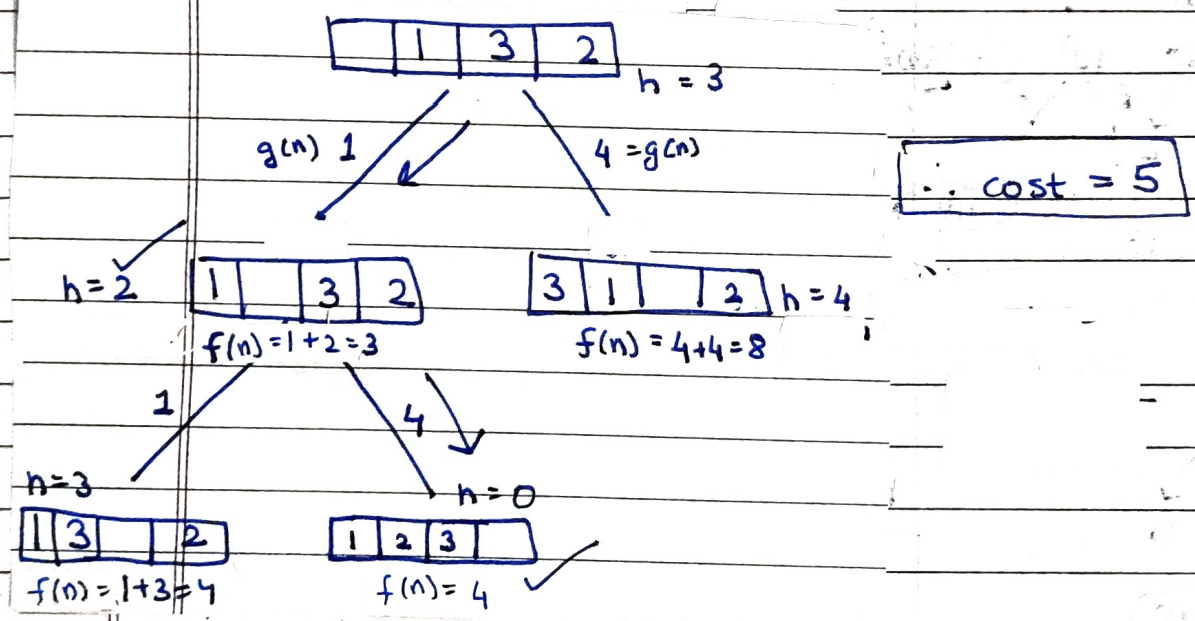
I. A tile may move to adjacent cell with unit cost
II. A tile may hope another tile with a cost of 4

Initial and goal nodes are described as:

	1	3	2

1	2	3	

h = misplaced tiles.



∴ cost = 5

Q4. Work out first two steps of A* algorithm to solve Eight puzzle problem where initial state and goal state are described below:

5	3	6
7		2
4	1	8

3	7	6
5	1	2
4		8

h(n) = no. of misplaced tiles.
g(n) = depth of node.

[3]

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Step 1.)

5	3	6
7		2
4	1	8

$g(n) = 1$

5		6
7	3	2
4	1	8

5	3	6
	7	2
4	1	8

5	3	6
7	2	
4	1	8

5	3	6
7	1	2
4		8

$h(n) =$ 5 5 6 4

$f(n) =$ 6 ✗ ✓ ✗ 6 ✗ 7 ✗ 5 ✓

Step 2

5	3	6
7	1	2
	4	8

$h(n) = 5$

$f(n) = 2+5 = 7$

✗

5	3	6
7	1	2
4	8	

$h(n) = 5$

$f(n) = 2+5 = 7$

✗

→ least cost so expand with 6-f(n)

(iii). Why is A* search superior to best first search? 2018M

It is superior due to the following advantages:

1. **Optimality**: A* finds the shortest path guaranteed, while best first search only finds potentially shortest paths.

2. **Efficiency**: A* focuses on promising paths based on heuristic function (h) and g, avoiding wasteful exploration like pure BFS.

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Q2.(a) Explain A* procedure to reach goal node from starting initial position. 2019S

(iii) A* Search 2018E

A* search is an informed search and graph traversal algorithm that finds the shortest path b/w start and goal node using a heuristic function.

$f(n) = g(n) + h(n)$ where $f(n) \rightarrow$ estimated cost
$g(n) \rightarrow$ cost to reach node
$h(n) \rightarrow$ heuristic value.

ALGORITHM.

i.) Enter starting node in OPEN list.
ii.) if open list is empty return fail
iii.) Select node from OPEN list which has smallest value (g+h)
↳ if node == Goal, return Success.
iv.) Expand node 'n' and generate all successors
↳ compute (g+h) for each successor node.
v.) if node 'n' is already OPEN/CLOSED, attach to back ptr.
vi.) Go to iii.)

Advantages:	Disadvantages:
→ Best searching algorithms.	→ Doesnt always produces shortest
→ Optimal and compute	→ Complexity issues
→ Solving complex problems	→ Requires memory.

(ii) Best first Search 2018E

Best first search is a greedy graph search algorithm that explores a graph by expanding the most promising node chosen on the basis of a specified rule, typically a heuristic function that estimates cost to reach the goal. It uses a priority queue to store cost of nodes.

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ALGORITHM

PRIORITY QUEUE 'PQ' containing initial states.

LOOP

if PQ = Empty

return fail.

else

Node ← Remove_First (PQ)

if Node == GOAL

Return Path from initial to Node

else

generate all successors of node and insert newly generated NODE into PQ according to COST value.

END LOOP.

Q2. (a) Explain with the help of suitable search tree the search procedure best first search and A* search. 2018 S

Best First Search	A* search
→ evaluation function is $f(n) = h(n)$ so no past knowledge is involved	evaluation function is $f(n) = h(n) + g(n)$ so past knowledge is involved
→ Its not complete and not optimal	Its complete and optimal (no overestimate)
→ TC: $O(b^m)$ | SC: polynomial	TC: $O(b^m)$ | SC: $O(b^m)$.

Eg.)

Consider two players playing a game. The game's setup is on a map and two pieces of knights (from chess) to indicate their positions on the map. Players can simultaneously move to a neighbouring city on the map at every turn. The time needed to move from city i to neighbour j is equal to the road distance $d(i, j)$ between the cities. The players take the next turn when both complete the previous turn. We want the two players to meet as quickly as possible. Let $D(i, j)$ be the straight-line distance between cities i and j. Which of the following heuristic functions is/are admissible? (i) $D(i, j)$;

2023 M

(ii) $2 \cdot D(i, j)$;

(iii) $D(i, j)/2$.

Give one or two lines of explanation for each. [2] [CO3] [L2]

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i) D(i,j) may be admissible as it never overestimates the actual cost to reach the goal. It provides lower bound as actual distance on node.

ii) 2D(i,j) is not admissable as it overestimates the actual cost to reach the goal.

iii) D(i,j)/2 is admissible as it underestimates actual cost. and will find soln.

(b) Suppose two friends live in different cities on a map, such as the Romania map as shown in fig.1. On every turn, we can simultaneously move each friend to a neighboring city on the map. The amount of time needed to move from city i to neighbor j is equal to the road distance d(i, j) between the cities, but on each turn the friend that arrives first must wait untilthe other one arrives (and calls the first on his/her cell phone) before the next turn can begin. We want the two friends to meet as quickly as possible. Take the heuristic functions as 2 *D(i, j). Write the pseudo code for the problem using best first search and apply that on the problem to decide among the heuristic function. Assume one friend is at Oradea and other is at Neamt. [5]

2019 E

```
function BFS (problem)
    frontier ← MAKE-QUEUE (problem.initial-state)
    explored ← MAKE-SET
    while not IS-EMPTY (frontier) do
        state ← REMOVE-FRONT (frontier)
        if state = problem.GOAL-STATE then return RECONSTRUCT-PATH (state)
        explored ← INSERT (explored, state)
        for each successor in GENERATE-SUCCESSORS (state) do
            if successor not in explored then
                cost ← g(state) + D(state, successor) + 2 (D(successor, goal))
                if successor not in frontier or FIND-IF (frontier, s|s.state = successor and s.cost > cost) then
                    INSERT (frontier, MAKE-NODE (successor, state, cost))
return failure
```

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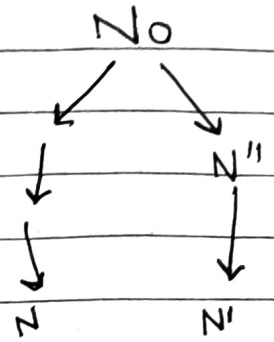
(b) Write the proof of optimality of A* 20235E [5] [CO3]



here, A* search with an admissible heuristic found a goal node N. We want to prove that cost of path to N is smallest. We will try to prove by contradiction.

i.e. we will assume that there is another goal node N' such that its cost g(N') is smaller than g(N).

∴ premise : $g(N') < g(N)$

using the way A* works, the h() is admissible, we will find contradiction.

CASE 1: N' was on open list where N was picked up for expansion.

$\therefore f(N) \leq f(N')$

$\Rightarrow g(N) \leq g(N')$

this contradicts the premise.

Case 2: N' wasn't on the list when N was picked for expansion, but some ancestor of it, N'' was in open list then.

$f(N) \leq f(N'')$

$\Rightarrow g(N) \leq g(N'') + h(N'')$

$\Rightarrow g(N) \leq g(N')$ ($\because h(N'')$ is admissible)

↳ contradicts premise

Thus, it proves by contradiction that A* is optimal.

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(b) Write down search procedure for And/or graph 2019S

(c) AO* Search technique 2018E

AO* is a best first search informed search algorithms. It is based on problem decomposition

It represents an AND-OR graph algorithm that is used to find more than one solⁿ. It is an efficient method to explore a solution path.

AO* dynamically adjusts the heuristic function during the search process, allowing it to handle cases where h(n) is not admissible or where the search space is too large to search exhaustively.

ALGORITHM

DATA: Graph, Start Node

RESULT: The minimum cost path from Start Node to Goal Node

Current Node ← Start Node

while: There is a new path with lower cost from Start Node to the Goal Node

do calculate the cost of path from the current node to the goal node by

AND-ARCS then

sum up the costs of all paths in the AND ARC;

return the ~~single~~ total cost;

end

calculate the cost of the single path in the OR side;

return the single cost,

end

find the minimum cost path

Current Node ← Successor Node of Min Cost Path

if Current Node has no successor node then

~~do~~ backpropagation and correct the estimate costs;

Current Node ← Start Node, return current node, New esti cost

else return null

end

end return The min cost path

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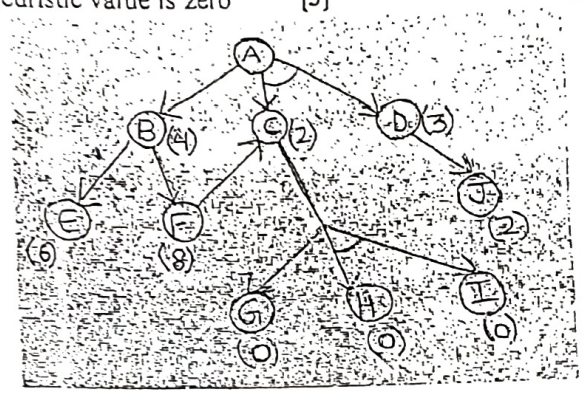
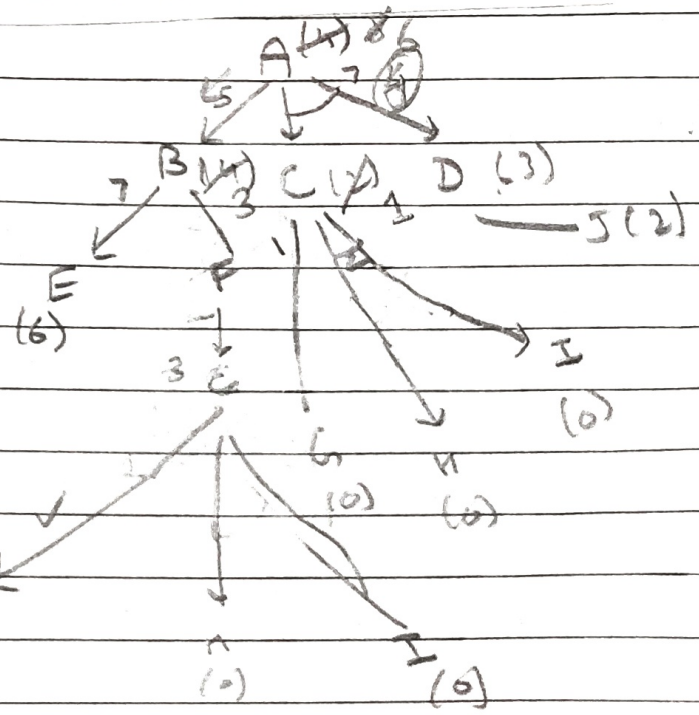
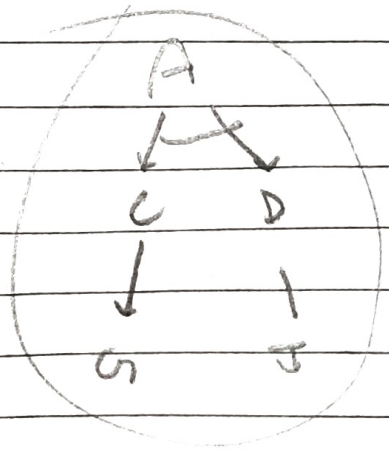
(b) Write the algorithm for AO* Search and differentiate it from A* Search 20185 (5,5)

A* Search	AO* search
A* algorithm is OR graph algo	AO* is AND-OR graph algo.
It only finds one solution	It will find more than one sol^n by ANDing two or more branches.
A* algo guarantees to give an optimal sol^n	AO* doesn't guarantee optimal sol^n.

Q4. Consider the AND OR graph shown below. Values in bracket represent heuristic values Work out the steps of AO* procedure on this graph and find out the path from Starting node A to goal state, where heuristic value is zero [3] 2020M

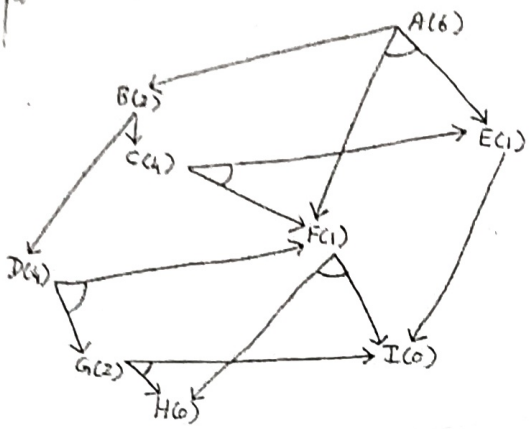


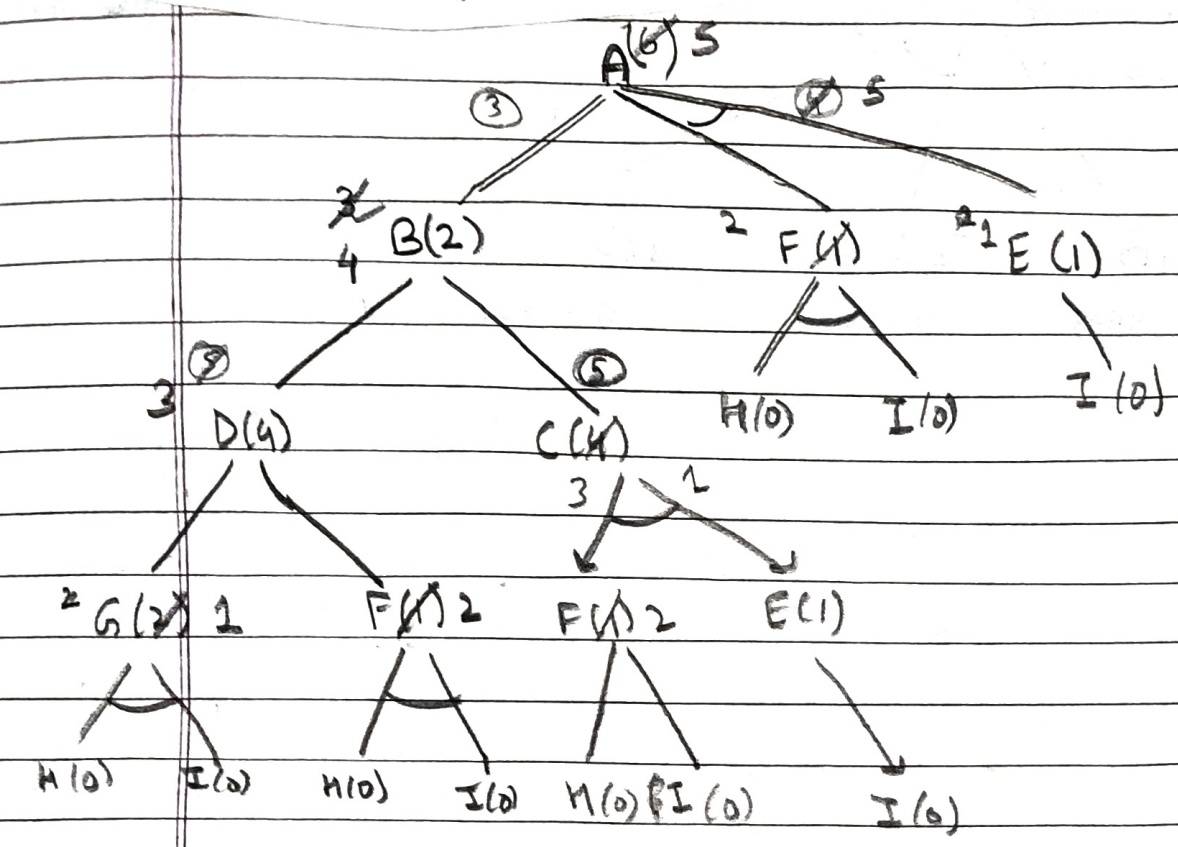




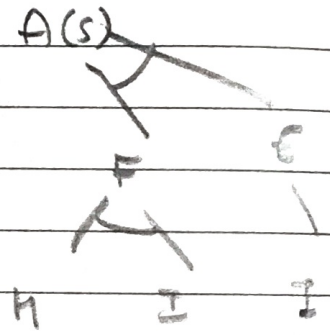
4 In the figure below, nodes H and I are goal stated nodes. Trace the AO* algorithm for this graph, and draw solution sub-graph. 2010M
Note that the heuristic is an underestimate and monotonic (function which preserves the given order). Check that the solution obtained by AO* is optimal by comparing with the other solutions. 5

www.





multiple soln are there



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Q3. Explain the traversing of graph in fig 1 using AO* procedure 2018M [2].

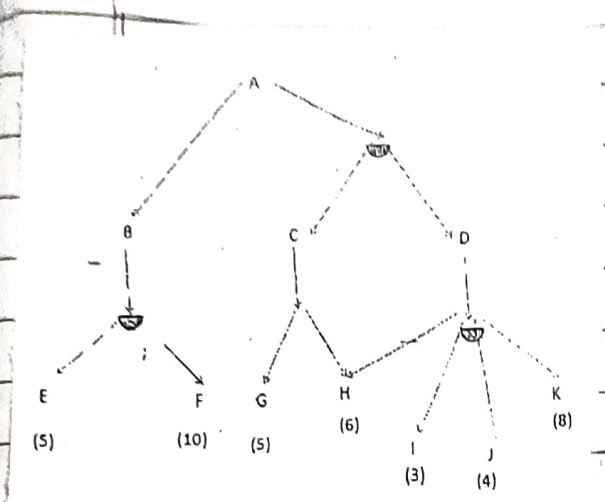
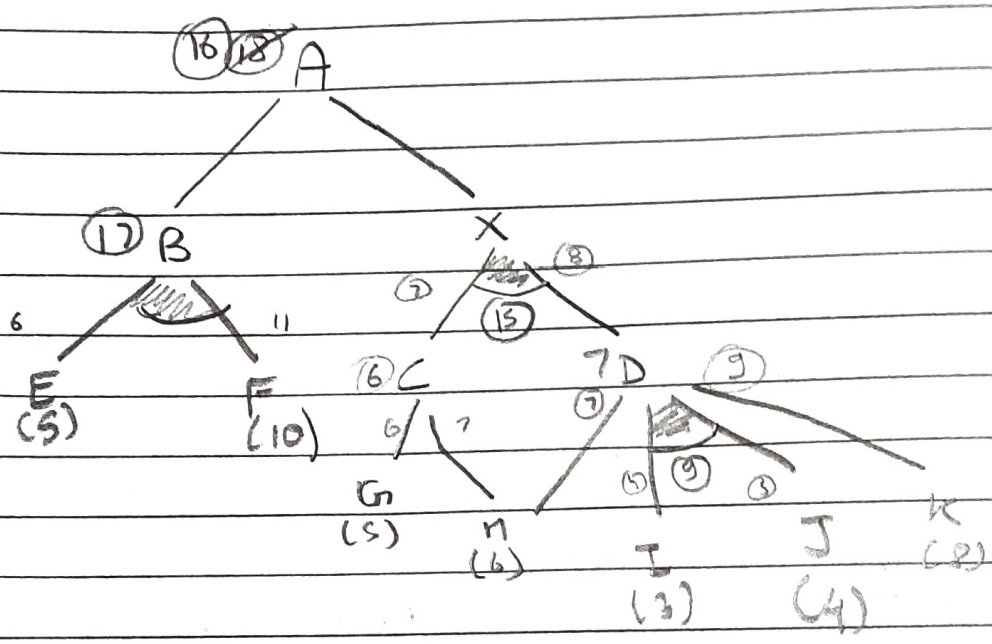


Fig.1



No soln found

Q2(a) Consider the given graph (Refer fig. 2) that represents an AND-OR graph. The terminal nodes are labelled SOLVED indicated by doubled rectangle and have zero cost. The arcs (all of them labeled 1) represent the cost of transforming the problem. Values associated with nodes are heuristic estimates of solving that node. Simulate the exploration of graph by AO^* algorithm till it terminates. Show how the graph looks at the end of each cycle. Assume FUTILITY value of 45. Clearly mark the final solution (by double-lined arcs) in the final graph. for this question. 2019E [5]

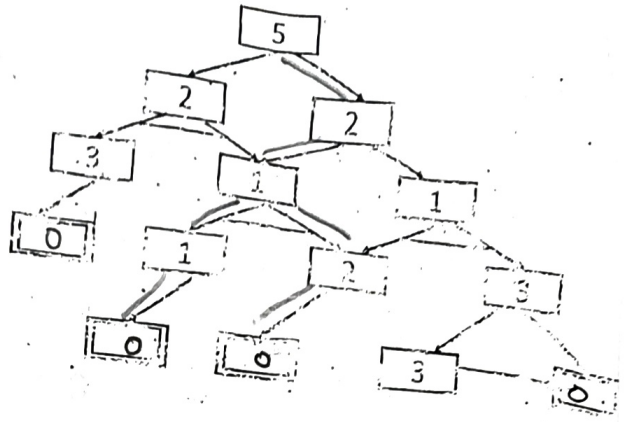
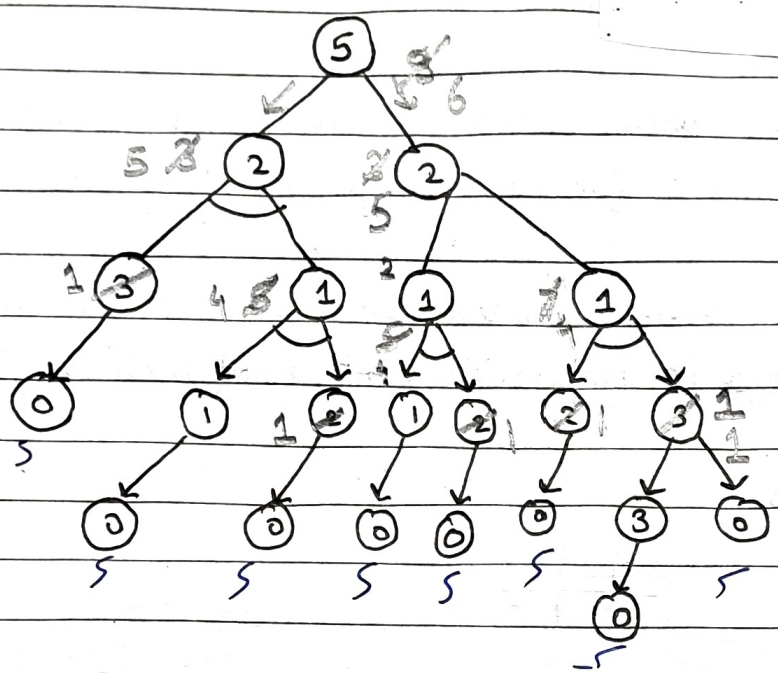
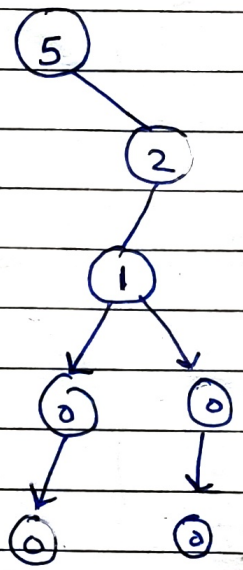


Figure2



∴ final soln



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Q.6 (a) How to minimize total estimated cost using A* search with an example [5] 2023SS

2. [a] Consider a robot that needs to navigate through a grid world from its starting position to the goal position using A* algorithm. The grid world is represented by a 4x4 grid where each cell represents a state. The robot can move up, down, left, or right in the grid world and each move has a cost of 1. Assume that the robot is initially at (0,0) and wants to reach the goal at (3,3). There are four obstacles in the grid world: (1,1), (0,2), (2,1), and (3,2). The heuristic function $h(n)$ is the Manhattan distance between node n and the goal. Apply the A* algorithm to find the optimal path from the initial state to the goal state. Show the order in which the nodes are expanded, the cost g and h values of each expanded node, and the final optimal path. 2023 E [3+1] [CO1, CO2]

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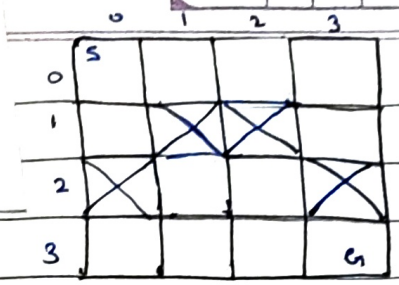
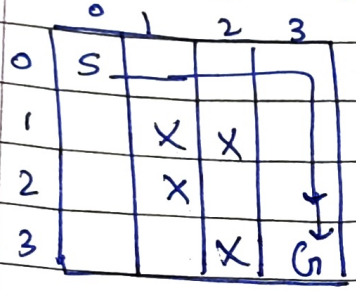


The path is blocked in original question.
So modify it for the sake of solving.



$h(n)$ = manhattan dist.

(not considering backward edges)

(0,0) $g=0$, $h=6$, $f=6$

- (1,0) $g=1 \mid h=5$, $f=6$
- (0,1) $g=1 \mid h=5$, $f=6$
  - (0,2) $g=2 \mid h=4$, $f=6$
    - (0,3) $g=3 \mid h=3$, $f=6$
      - (1,3) $g=4 \mid h=2$
        - (2,3) $g=5 \mid h=1$
          - (2,2) $g=6 \mid h=2$, $f=8$ X
          - (3,3) $g=6 \mid h=0$, $f=6$ ✓ goal

path in fig

[b] Consider the robot navigation problem in 2[a]. Apply the uniform-cost search to find the optimal path from the initial state to the goal state. Show the order in which the nodes are expanded. Compare the performance of A* search to uniform-cost search on this problem. Which algorithm is more efficient and why? 2023E [3+1] [CO1, CO2]

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(iii) Design the procedure to revise cost upward of AO*algorithm and illustrate the steps using suitable search tree 2019 M

Propagate the newly discovered information up the graph by ~~solved~~ doing the following steps.

Let S be a set of nodes that have been marked SOLVED.

Initialize S to NODE. Until S is empty the following procedure is repeated:

a.) Select a node from S call it CURRENT and remove it from S.

b.) compute h' of each of the arcs emerging from current, assign minimum ~~to~~ h' to current.

c.) Mark the minimum cost path as the best out of current.

d.) Mark CURRENT SOLVED if all of its nodes connected to it through the new marked are been labelled SOLVED.

e.) If current has been marked SOLVED or its h' has just changed, its new status must be propagated upward the graph. Hence all ancestors of current are added to S.

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(iv) Which problem solving approach used in Means End Analysis search procedure? 2019 M

[4x2]

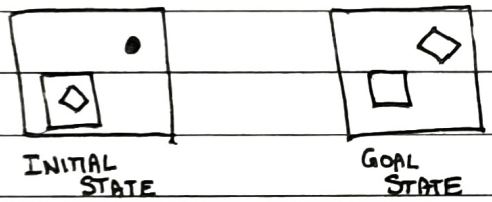
It is a mixture of forward and backward search technique. The main steps which describes the working of means end analysis technique for solving a problem are as follows:

a. Evaluate the difference b/w initial ~~goal~~ state and goal state.

b. Select the various operators that can be applied for each difference.

c. Apply the operator at each element which reduces the difference b/w current state and goal state.

Eg.)



	Diff 1	Diff 2	Diff 3
a.)	no dark circle	position of diamond	size of diamond
b.)	Delete	Move	Expand
c.)	APPLY		

Q2. Explain with example following search techniques
(i) Hill Climbing, 2018 E

Hill climbing is a greedy local search algorithm which continuously moves in the direction of increasing value to find the best solution. It terminates when no neighbour gives a higher value. It is a variant of generate and test method. It does not backtrack as it doesnt remember the search space.

It suffers from local optima.

3. Answer *any TWO* of the followings

[a] Consider the state of tic-tac-toe game as shown in Fig. 2. The objective of the game is to get three of your own symbols (either 'X' or '0') in a row, column, or diagonal. The symbol X represents AI player. The heuristic function for AI player is defined as below: 2023E

The heuristic function assigns to each move a score of: +10 for immediate win, +5 for blocking opponent's immediate win (in next move); +3 for creating potential winning position e.g. two X with one empty cell in a row, column, diagonal. +2 for blocking the opponent winning position; +1 for occupying the center cell.

Find the next two moves of AI player by applying Steepest-Ascent hill climbing algorithm with above heuristic function. Show each step clearly. Represent each by row and column number. Assume that opponent is a perfect player. [4] [CO1, CO2]

X		0
		X
0		

Fig. 2

2

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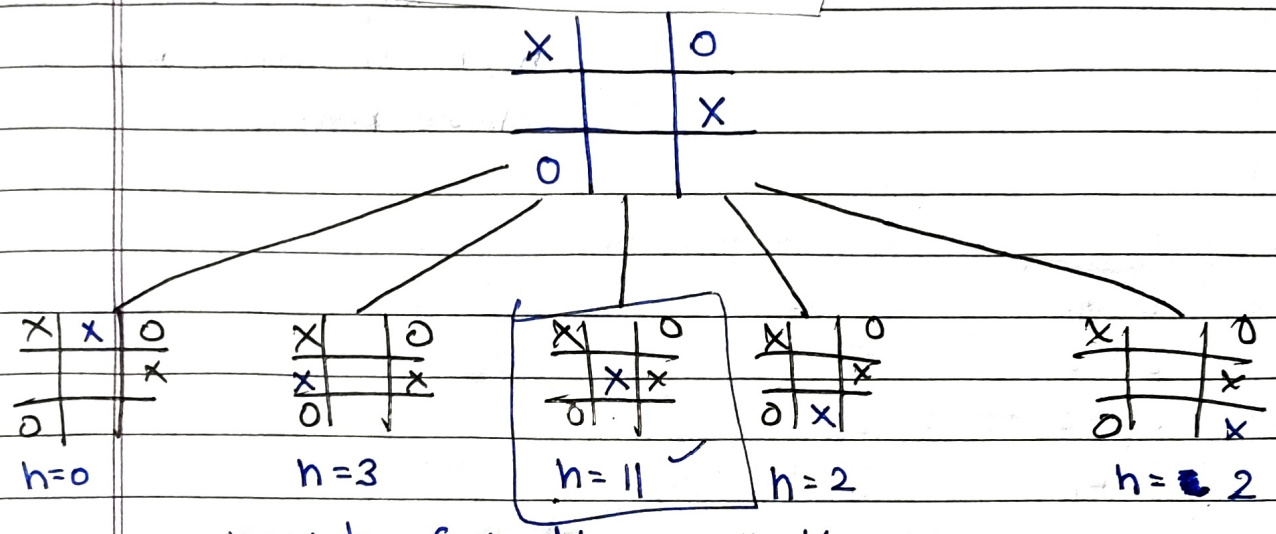
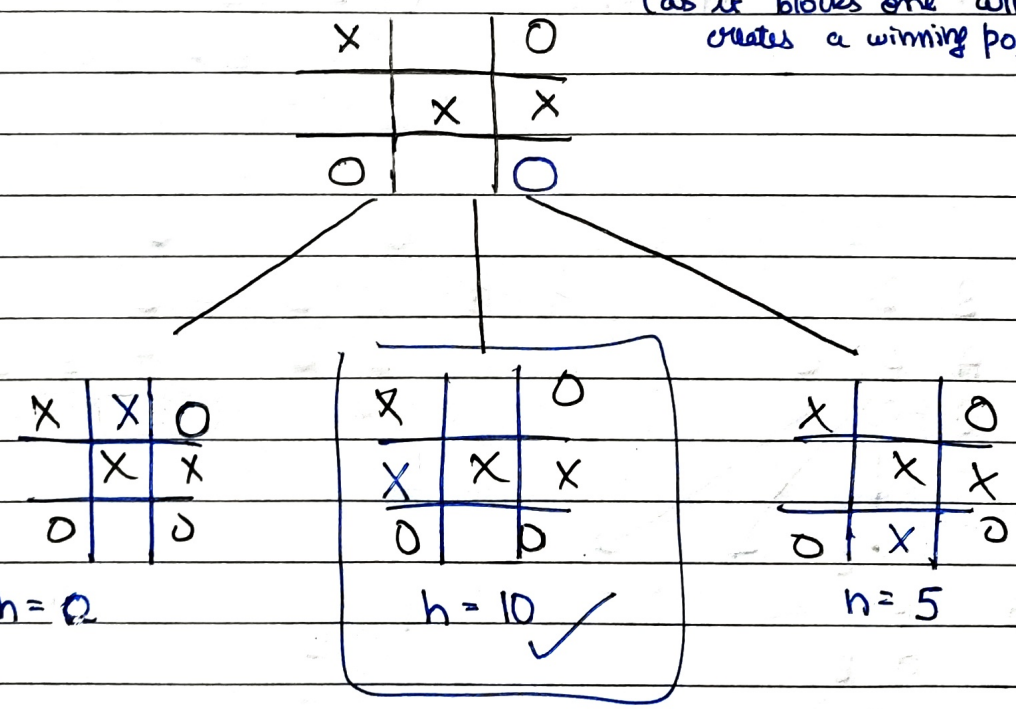


now perfect player will play this move.
(as it blocks one win and creates a winning pos



4 Consider the blocks World problem shown in Fig. 5. It consists of cubes with alphabets. Some of the blocks are placed on a table. There is a robot arm to pick up or put down the blocks. The robot arm can move only one block at a time from the top of the stack or table. The aim is to achieve the goal state from the start state. Illustrate where the simple hill-climbing algorithm can be used to achieve the goal state. If not, why? Show the steps of the simple hill-climbing. Use heuristic function h.

2023M

h: for each block at the desired height (with respect to goal state), it adds the number of blocks underneath it (for example: in goal state, for block C it adds 2, and for block E, it adds 0; thus, h at goal state = 4+3+2+1+0 = 10). For each block at wrong height (with respect to goal state), it adds minus times the number of block positions displaced above or below (for example: in start stat, for block C it adds -1, and for A, it adds -4)

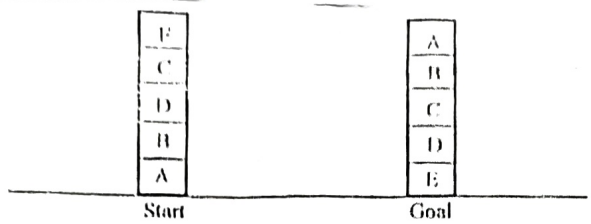


Fig. 5

Investigate whether the steepest ascent version of hill climbing will achieve the goal. [2+1] [CO3] [L3, L4]

we will add $-x$ for x displaced blocks below.

In regular hill climbing, we select any next state if less h, but in steepest ascent we choose best one

hill climbing

E -4
C -3
D -2
B -1
A 0
(h=-10)

→ C D B A E (h=-6)

→ D -2, B -1, C -1, A 0, E 0 (h=-4)

→ D -2, B -1, A 0, E 0, C 0 (h=-3)

→ B D A E C (h=0)

→ B D A E C (h=-2)

→ B A E C D (h=-1)

→ A E C B D (h=-1)

→ B C D A E (h=2)

→ A B C D E (h=3)

→ A B C D E (h=6)

→ A B C D E (h=10) goal

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Q1. Answer following to the point.

a. Differentiate between solution steps recoverable and non recoverable? Illustrate with examples. 2018E

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(ii) Compare and contrast Depth first search and Hill Climbing. 2019M

DFS	Hill Climbing
→ Its blind and uninformed	Its heuristic and informed
→ It finds any sol^n	It finds good sol^n
→ Explores as far as possible along each branch before branching	Moves in direction of increasing value of heuristic search
→ Complete for finite SS	Not complete, can stuck in LM
→ TC : $O(b^m)$	constant / linear
→ Non optimal	Non optimal
Ex) Maze Solving.	Ex) Simulated Annealing.

(iii) Is Best First Search better than Hill Climbing? 2020M 2019M

Q2. (i) Why best search is better than hill climbing

Best first search (which combines BFS, DFS) is considered better than hill climbing because it explores search space more efficiently. It evaluates nodes based on heuristic function considering long term while hill climbing only considers based on immediate neighbours without considering long term side effects.

(b) State the reason when hill climbing often gets stuck? 2023ES [2] [CO2]

Thus, Hill climbing can get stuck on local optima while BFS can avoid it by backtracking to explore other options in future. In hill climbing progress stops if no better successor nodes.

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(vi) Describe the control strategy of constraint satisfaction problem 2018 M

[5x3]

Gemini Control strategy can be :

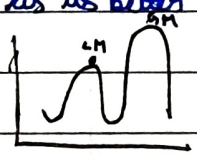
1. Backtracking: Imagine exploring a maze, trying different paths until you find a soln that doesnt lead to dead end. If hit deadend then backtrack and explore a different path.

2. Constraint propagation: This is like pruning dead ends even before entering them. It analyzes the constraints and removes impossible values from variable choices, making the maze exploration more efficient.

3. Combined approach: Pruning dead ends before backtracking helps find soln faster

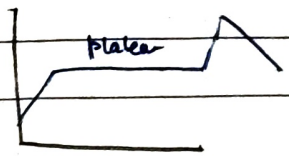
3 What are the various problems associated with Hill Climbing? Give their possible solution. 2010M 3

1. LOCAL MINIMUM:
The algorithm terminates when the current node is local max as its better than its immediate neighbours but a better global maxima exist
Soln: Back propagation can mitigate by exploring alterate paths



2. RIDGE
Ridge occurs when there are mutible peaks and all have same value / there are mutible local minima which are same as global maxima.
Soln: ridge obstacle can be solved by moving in several dirn at once.

3. PLATEAU
Plateau is the region where all neighbouring nodes have the same value of objective function so the algo finds it hard to select a approprate dir
Soln: take big jump from current to land in non plateau region.



(d) Crypt arithmetic problems 2019E

(ii) Explain steps to solve crypt arithmetic problems 2019S

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Q3. (a) With suitable example illustrate how you solve crypt arithmetic problem. 2018S

In crypt arithmetic problems, letters stand for digits and the aim is to find a substitution of digits for letters such that the resulting sum is arithmetically correct. Usually, each letter must stand for a different digit

As a CSP

States : a CAP with some letters replaced by digits

Operators: replace all occurances of letter with a digit not already in puzzle

Goal test: puzzle contains only digits, and represents a correct sum

Path cost: zero. All soln equally valid.

Eg.

FORTY	Soln : 29786	R=7, F=2, O=9 etc
+ TEN	850	
+ TEN	850	
SIXTY	31486	

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GAME PLAYING

Q3. (i) Explain the concept of game tree with suitable example 2019 S

A game tree is a directed graph which represents all possible moves and outcomes in a sequential manner for a game.

Nodes → position in game

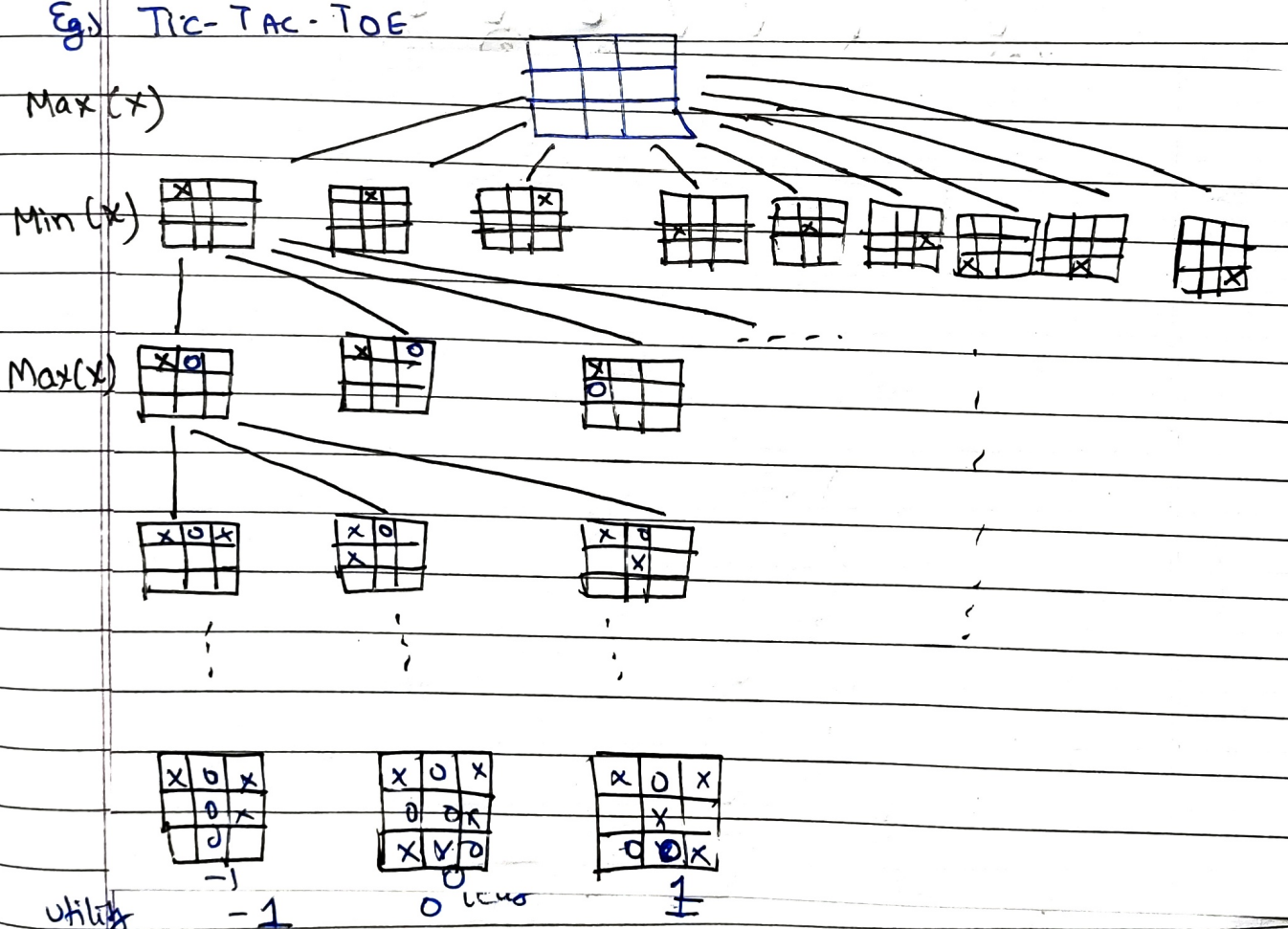
edges → moves "

It starts with current state of game and branches out to all possible moves for each player, creating tree like structure.

Complete game trees show all outcomes but for games like chess, it would be impossible to build such a tree.

2.5(a) Create a partial game tree for the game of tic-tac-toe 2022 SE [5]

Eg.) TIC-TAC-TOE



Algo such as Minimax and Monte Carlo tree search are used to evaluate the potential outcomes of certain moves.

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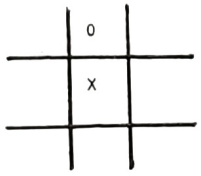
Q3. (a) Draw the Grundy Game Tree with seven coins. Explain using this game tree how player maximize and minimize decide their move 2018

Q5. Illustrate the steps of Minimax procedure to make a move for Maximizing player in response to following board position.

2018M [3]

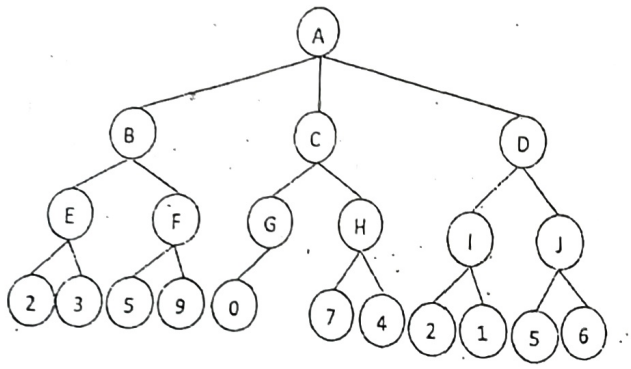


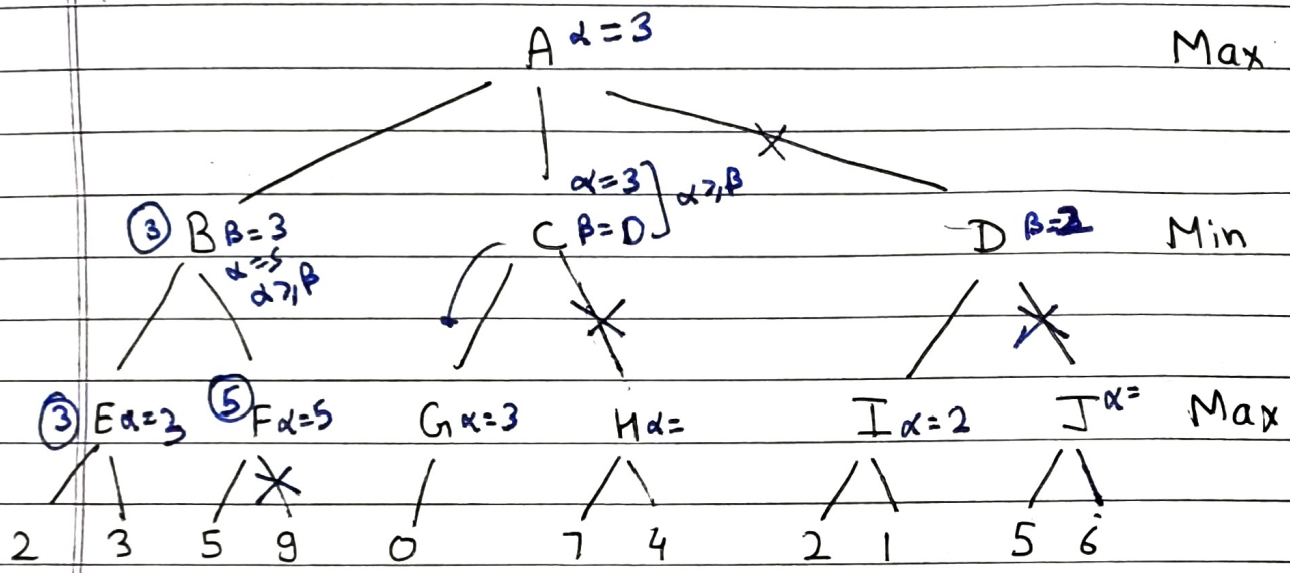
(b) Explain Minimax Procedure and show its step for Tic Tac Toe problem 2018S (5,5)

(ii) With the help of Tic Tae Toe game, show how Min max procedure help in deciding a good move for maximizing player. 2018C [7,7]

Q5. For the graph below, apply min-max procedure to decide move for Player MAX. What is the max value at the root node by applying mini-max search? Also show alpha beta pruning [4]

2020M





∴ Max Val at Root = 3

(v) Define alpha-beta cut- off and their utility. 2018M

It is a modified technique of minimax algo which is an optimization for minimax algorithm for large sample spaces like chess. Here, we compute correct minimax decision without checking each node of game tree. We prune the nodes ~~[illegible]~~ which cant affect node's final value based on parameters α and β.

Alpha – The best (highest value) choice we have found so far along the path of maximizer

Beta :– The best (lowest ———— minimizes.

Q3. For the graph in Fig (1), find the max value at the root node by applying mini max search. Also show alpha beta pruning.

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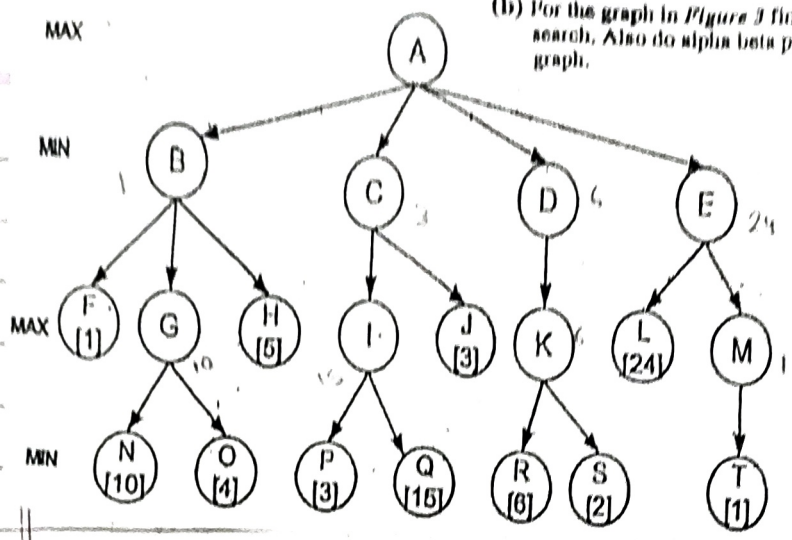
(b) For the graph in *Figure 3* find the max value at the root node by applying mini max search. Also do alpha beta pruning. Choose and highlight the best strategy for the graph.

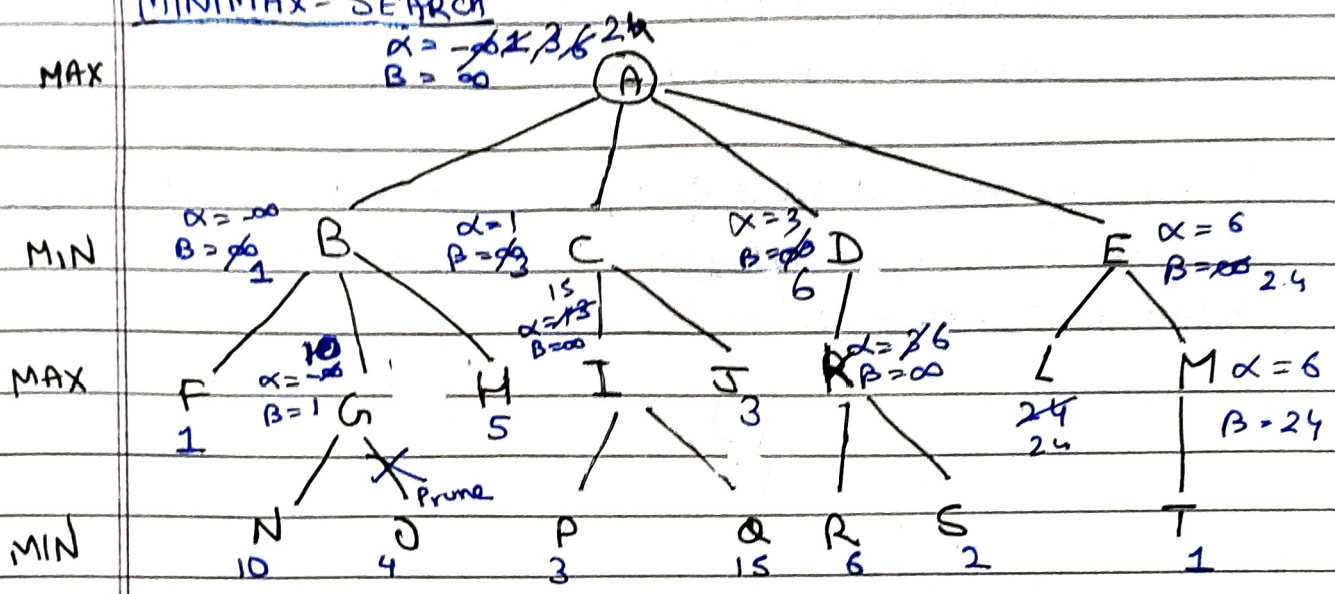
2018 E



Condition

$\alpha \geq \beta$

MINIMAX - SEARCH



Root Node optimal value = 24

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(c) Explain the purpose of alpha and beta values in the alpha-beta pruning technique in minimax algorithm. Suppose you have a game tree with a depth of 4 levels. At level 3, a beta cutoff occurs during the alpha-beta pruning process. Explain the conditions that lead to a beta cutoff and how it affects the search. 2023E [2+2] [CO2]

ALPHA VALUE: It represents the minimum score that the maximizing player is assured of. It starts at $-\infty$ and is updated during the search to the maximum value so found. Its lower bound on max node

BETA-VALUE: It represents the maximum score that the minimizing player is assured of. It starts at $+\infty$ and is updated during the search to the min. value found so far. Its upper bound on min node.

If beta cutoff occurs at lvl 3 of depth 4 tree, it means current maximizing node has found a branch that gives a score $\geq$ current β value, so further exp is not reqd.

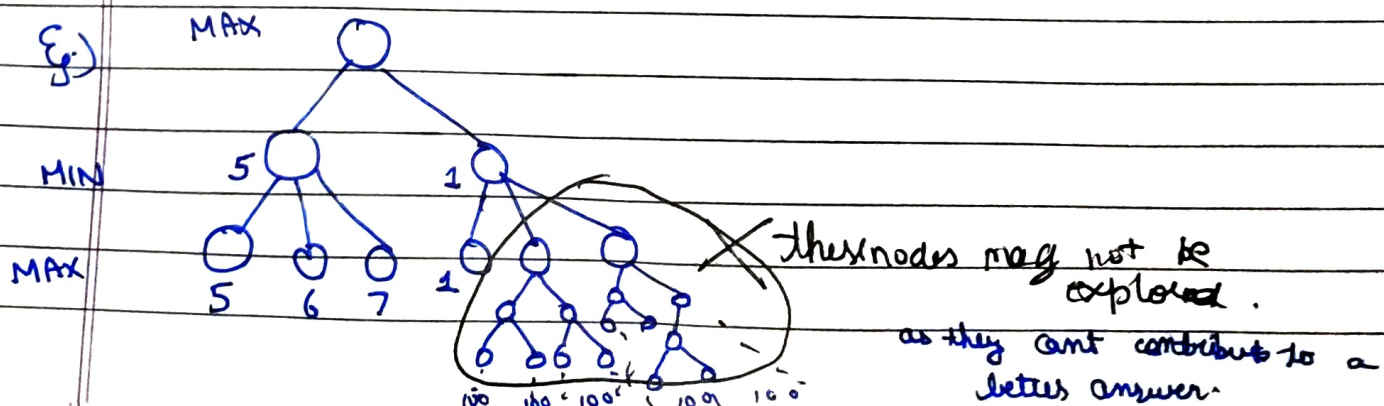
?

(b) How would you demonstrate that alpha-beta pruning outperforms the minimax search algorithm? 2023SE [5] [CO2]

The alpha-beta pruning to standard algo returns the same move as standard, but it removes all the nodes which dont really affect the final decision but make algo slow. Hence, by pruning them it make algo fast

Its effect is evident in games like chess where an infinitely deep tree is made

Eg.)



(c) Define alpha beta cut-offs? Show how the algorithm Alpha Beta explores the given game tree, searching from left to right. Refer Figure 3 2019E [5]

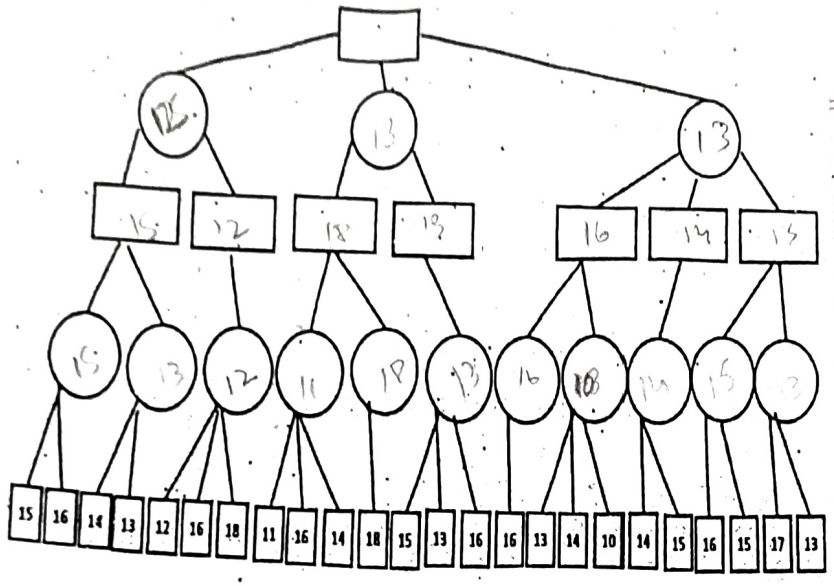
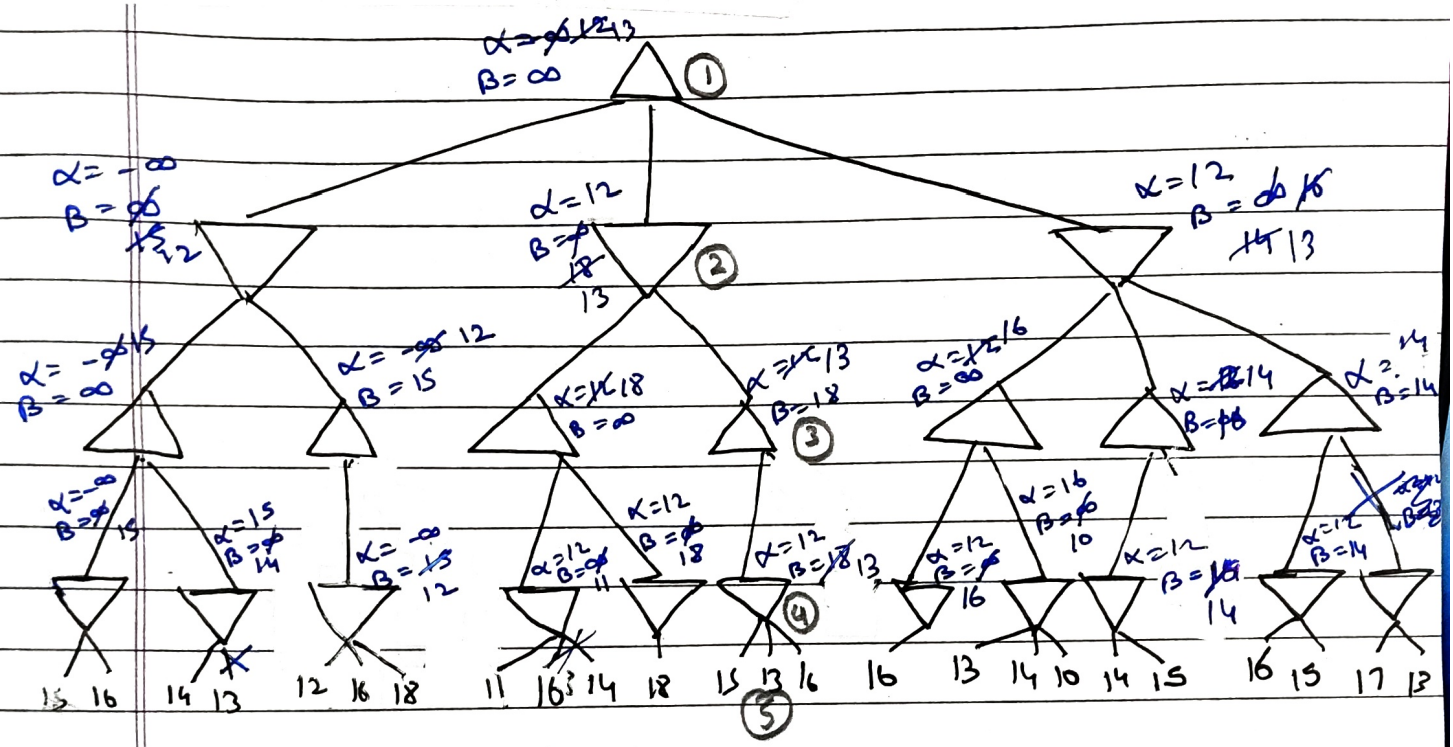


Figure 3

(i) Fill in the leaves that are inspected by AlphaBeta.Show the cutoffs and label them with their type.

(ii) Mark the move that AlphaBeta will choose for MAX at the root.



ii) Move : (see ↑)

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(b) Consider a game tree of level 5 for two players MAX and MIN. Level 1 (MAX): A; Level 2 (MIN): B, C, D; Level 3 (MAX): E, F, G, H, I, J; Level 4 (MIN): K, L, M, N, O, P; Level 5: Q, R. Nodes B, C, & D are child nodes of A. Nodes (K, L), (M, N), (O, P), and (Q, R) are child nodes of F, G, J, and M, respectively. An evaluation function is used to assigns score to leaf nodes. The evaluation scores of leaf nodes are given in Table I. Here symbol ? represents inability of function to assign score. Is it possible to find minimax value and optimal strategy to play the game for MAX players? Also, calculate alpha and beta cut-offs if possible. [4] [CO3]

2023E

Table I

Node	K	L	Q	R	N	H	I	O	P
Score	2	3	5	1	2	7	6	1	7	12

Q:

UNIT-3

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KNOWLEDGE REPRESENTATION

c. Explain the concept of knowledge. What are the different ways to represent Knowledge? 2019S

Q1. (i) Define and explain the terms: heuristic Search, knowledge.

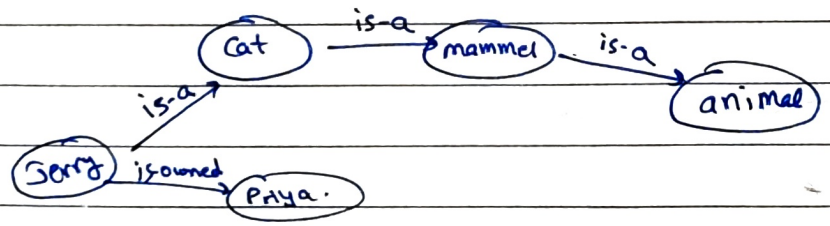
Knowledge is awareness or familiarity gained by experiences of facts, data and situations. It refers to the information about the world including facts, rules, beliefs and heuristics which enables AI systems to understand, reason, learn and make decisions to solve or acomplish tasks.

Q6. What are the different Knowledge representation methods available? What are the essential characteristics of any knowledge representation method ? 2020M [4]

Different knowledge representation methods are:-

→ LOGICAL REPRESENTATION: It is a language with some definite rules which deal with proposition and no ambiguity in representation.

→ SEMANTIC NETWORK REPRESENTATION: In semantic networks, we represent our knowledge in the form of graphical networks. This network consists of node representing objects and arcs which describe the relationship between these objects.



→ FRAME REPRESENTATION: A frame is a record like structure which consists of a collection of attributes and its values to describe an entity in the world. These are data structures which divide knowledge into substructures by representing stereotypes situations.

SLOTS	FILTERS
TITLE	Artificial Intelligence
GENRE	Comp. Sc
AUTHOR	Peter Norwig

EDITION	Third Ed.
YEAR	1996
PAGE	1152

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→ **PRODUCTION RULES**: Production rule system consists of (condition, action) pairs which mean, "If condition then action". It has mainly three parts:

→ the set of production rules.
→ working memory
→ The recognize-act-cycle.

Eg.) IF (at bus stop AND bus arrives) THEN action (get into the bus).

CHARACTERISTICS

1. Representational accuracy: ability to rep. all kind of req. knowledge.

2. Inferential Adequacy: ability to manipulate KRS to produce new knowledge corresponding to existing structure.

(iv) What do you understand by inferential efficiency in Knowledge representation method. 2018 M

3. Inferential Efficiency: ability to direct inferential knowledge mechanism into the most productive dirn for storing additions

4. Acquisitional efficiency: ability to acquire new knowledge easily using automatic methods.

(ii) Are Database and knowledgebase same? 2020M

No, a database is a structured collection of data organized for efficient retrieval, while a knowledge base is a repository where information is stored, organized, and managed for facilitating knowledge sharing and decision-making.

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b. Explain the concept of knowledge acquisition and Inferential procedure in knowledge representation scheme. 2018E

Q4. (i) Represent the sentence in clause form: Any student who is intelligent or hard working gets a good placement 2019 M

(ii) Given fact: A→ (B ^ C) and A, Use resolution procedure to prove that B is true. 2019 M

[2,2]

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i.) Any student who is intelligent or hard working gets a good placement

∴ $\forall x$: hardworking (x) V intelligent (x) → good placement (x).

HW I GP

{x/s} ∴ HW(S) V I(S) → GP(S)

¬(HW(S) V I(S)) V GP(S)

clause form

∴ 1. ¬HW(S) V GP(S)

2. ¬I(S) V GP(S)

ii.) Given,

A → (B ∧ C)

A

in clause form

1. A
2. ¬A V B
3. ¬A V C

To prove : B

∴ we prove its negation wrong.

¬B ¬A V B (from 2)

¬A A (from 1)

null

Hence, proved

Q4. (a) Explain the different steps of converting wff in to clause form with the help of suitable examples.

(b) Explain the steps of resolution in the form of flow graph. Work out these steps to infer that Jack likes mangoes from following given facts;

2018S

i. John Likes all kind of food
ii. Apples are food
iii. Any thing one eats and is not killed by is a food
iv. Bill eats mangoes and is still alive

(5.5)

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a.) FOL form

i. $\forall x : Food(x) \rightarrow likes(John, x)$

ii. food (apple)

iii. $\forall x \forall y : eats(x, y) \wedge \neg killed(x) \rightarrow Food(y)$

iv. eats (Bill, mangoes) $\wedge$ alive (Bill)

Clause Form

i. $\forall x \; \neg food(x) \vee likes(John, x)$

ii. food (apple)

iii. $\forall y \forall z \; \neg eats(y, z) \vee killed(y) \vee Food(z)$

iv. eats (Bill, mangoes) $\wedge$ alive (Bill)

b.)

$\neg$ likes (John, mangoes) — $\neg food(x) \vee likes(John, x)$

{mangoes / x}

$\neg$ food (Mangoes) — $\neg eats(y, z) \vee killed(y) \vee food(z)$

{Mangoes / z}

$\neg$ eats (y, Mangoes) $\vee$ killed (y) — eats (Bill, mangoes)

killed (Bill) — $\neg alive(k) \vee \neg killed(k)$

{Bill / k}

$\neg$ alive (Bill) — alive (Bill)

{Hence Proved}

[5,5]

Q4. Consider the following sentences:

a. Shiva, Gopal and Madhu are people.
b. Shiva likes all kind of food..
c. Any thing any one eats and is not killed is a food.
d. If you are killed you are not alive.
e. Madhu eats everything Gopal eats.
f. Gopal eats peanuts and is still alive.
g. Apple is a food

2018E

a. Represent theses sentences as wff.
b. Using backward chaining prove that (i) Shiva eats apple and (ii) shiva like peanut.
c. Convert them to clause form indicating the law used.
d. Explaining steps of resolution to prove that ~~Madhu eats peanut.~~ John likes peanut [2.2.3,3]

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modified Question answering

a.) 1. $\forall x$: food $(x) \rightarrow$ likes (John, x)

2. food (apples)

3. food (chicken)

4. $\forall x$: ($\exists y$: eats $(y, x) \wedge \neg$killed by (y, x)) $\rightarrow$ food (x)

5. eats (Bill, peanuts)

6. alive (Bill)

7. $\forall x$: eats (Bill, x) $\rightarrow$ eats (Sue, x)

8. $\forall x : \forall y$: alive $(x) \rightarrow \neg$killed by (x, y)

b.) likes (John, peanuts)
↑ (1)

food (peanuts)
↑ (4)

$\exists y$: eats (y, peanuts) $\wedge \neg$killed By (y, peanuts)
↑ (5)

$\neg$killed by (Bill, peanuts)
↑ (8)

alive (Bill)
↑ (6)

Nil

c.)

1. $\neg$food $(x_1) \vee$ likes (John, x_1)
2. food (apples)
3. food (chicken)
4. $\neg$eats $(y_4, x_4) \vee$ killed by (y_4, x_4) $\vee$ food (x_4)
5. eats (Bill, peanuts)
6. alive (Bill)
7. $\neg$eats (Bill, x_7) $\vee$ eats (Sue, x_7)
8. $\neg$alive $(x_8) \vee \neg$killed By (x_8, y_8)

d.) $\neg$likes (John, peanuts) — $\neg$food $(x_1) \vee$ likes (John, x_1)
{peanuts / x_1}

$\neg$food (peanuts) — $\neg$eats $(y_4, x_4) \vee$ killed by $(x_4, y_4) \vee$ food (x_4)
{peanuts / x_4}

$\neg$eats (y_4, peanuts) $\vee$ Killed by (y_4, peanuts) — eats (Bill, peanuts)
{Bill, y_4}

Killed by (Bill, peanuts) — $\neg$alive $(x_8) \vee \neg$killed by (x_8, y_8)

$\neg$alive (Bill) — alive Bill → Null.

Q4. Consider the following sentences:

a. Every child loves dog.
b. All dogs have fur skin or short hair.
c. Roby is a dog
d. Tina does not love dog with short hair
e. Shikha loves Roby
f. Tina does not love dog

2018E

(i) Represent theses sentences as wff.
(ii) Using backward chaining prove that Tina is not child.
(iii) Convert them to clause form indicating the law used.
(iv) Explaining steps of resolution, prove that Roby has fur skin.

13.3.4

$C(x) \rightarrow x$ is a child
$L(x,y) \rightarrow x$ loves y
$D(x) \rightarrow x$ is a dawg
$F(x) \rightarrow x$ has fur skin
$H(x) \rightarrow x$ has short flair
$R \rightarrow$ roby | $T \rightarrow$ tina | $S \rightarrow$ shikha

i.) $\forall x (C(x) \rightarrow \exists y (D(y) \wedge L(x,y))$
$\forall x (D(x) \rightarrow (F(x) \vee H(x))$
$D(R)$
$\forall x (D(x) \wedge H(x) \rightarrow \neg L(T,x))$
$L(S,R)$
$\forall x (D(x) \rightarrow \neg L(T,x)$

ii.) $\neg C(Tina)$?

$\{x \mid Tina\}$ using (c)?

$\neg Child(Tina)$

iii.) $\neg C(x) \vee D(y)$, $\neg C(x) \vee L(x,y)$
$\neg D(x) \vee F(x) \vee H(x)$
$D(R)$
$\neg D(x) \vee \neg H(x) \vee \neg L(T,x)$
$L(S,R)$
$\neg D(x) \vee \neg L(T,x)$
$C(S)$ → Shikha is child.

iv.)

$\neg F(Roby)$ — $\neg D(x) \vee F(x) \vee H(x)$
$\{x / Roby\}$
$\neg D(R) \vee H(R)$ — $\neg D(x) \vee \neg H(R) \vee \neg L(y,x)$
$\{x / R\}$
$\neg D(R) \vee \neg L(y,R)$ — $\neg C(x) \vee L(x,y)$
$\{x / S\}$
$\neg D(R) \vee \neg C(S)$ — $\neg C(x) \vee D(y)$
$\neg C(S)$ — $C(S)$
$\{\}$ H.P.

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Q3. (a) Consider the following facts:

i. All students who are intelligent or hard working pass the exam.

ii. All students who pass the exam and have good communication skill get placement.

iii. Gaurav is intelligent and has good communication skill

iv. Gautam is neither intelligent nor hard working [10]

(b) 2019 E

(i) Represent theses sentences as wff.

(ii) Using backward chaining prove that Gautam does not get placed.

(iii) Convert them to clause form indicating the law used.

(iv) Explaining steps of resolution, prove that gaaurav gets placed

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$I(x) \rightarrow x$ is intelligent

$H(x) \rightarrow x$ is hardworking

$P(x) \rightarrow x$ passes exam

$C(x) \rightarrow x$ has good commn skills

$G \rightarrow$ Gaurav | $T \rightarrow$ Gautam.

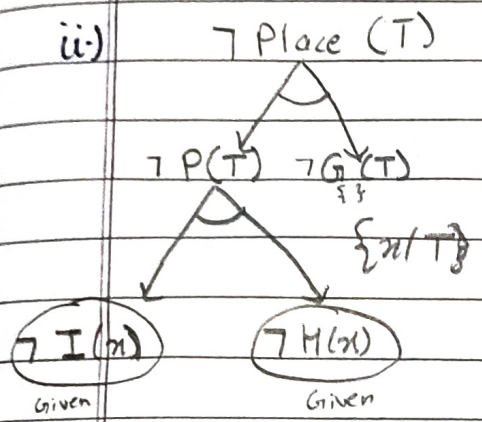
i.) i.) $\forall x\ ((I(x) \vee H(x)) \rightarrow P(x))$

ii.) $\forall x\ ((P(x) \wedge C(x)) \rightarrow Place(x))$

iii.) $I(G)$, $C(G)$

iv.) $\neg I(T)$, $\neg H(T)$

ii.)



Hence proved

iii.) law : $P \rightarrow Q = \neg P \vee Q$

i.) $\neg I(x) \vee P(x)$, $\neg H(x) \vee P(x)$

ii.) $\neg P(x) \vee \neg C(x) \vee$ Place (x)

iii.) $I(G)$, $C(G)$

iv.) $\neg I(T)$, $\neg H(T)$

iv.) To prove : Place (Gaurav)

To disprove : ¬ Place (Gaurav)

¬ Place (Gaurav) — Place $(x) \vee \neg P(x) \vee \neg (C(x))$ from (ii)

$\{x/G\}$

$\neg P(G) \vee \neg C(x)$ — $C(G)$ from (iii)

$\neg P(G)$ — $P(x) \vee \neg I(x)$ from (i)

$\{x/G\}$

$\neg I(G)$ — $I(G)$ from (iii)

{}, ϕ, null

Hence proved

4. (a) Consider the following propositional logic statements:

If a computer system has insufficient memory (M), then the performance degrades (D). If the performance degrades (D) or the CPU is overheating (O), then the system crashes (C). If the system crashes (C) and the hard disk fails (H), then data loss occurs (L). If data loss occurs (L), then the backup process is initiated (B) and the system is restored (S), then the downtime is minimized (X).

2023E

Prove by resolution that *if a computer system has insufficient memory (M) and the hard disk fails (H), then the downtime is minimized (X).* [4] [CO2]

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The statements can be written as:

1. $M \rightarrow D$ $\qquad \neg M \vee D$
2. $D \vee O \rightarrow C$ $\qquad (\neg D \vee C) \wedge (\neg O \vee C)$
3. $C \wedge H \rightarrow L$ $\xrightarrow{\text{clause form}}$ $(\neg C \vee \neg H) \vee L$
4. $L \rightarrow B$ $\qquad \neg L \vee B$
5. $B \wedge S \rightarrow X$ $\qquad \neg B \vee \neg S \vee X$

$\Rightarrow$ 1. $\neg M \vee D$
2. $\neg D \vee C$
3. $\neg O \vee C$
4. $\neg C \vee \neg H \vee L$
5. $\neg L \vee B$ ✓
7. $\neg B \vee \neg S \vee X$ ✓

we have to prove

$M \wedge H \rightarrow X$

∴ we can add

8. M
9. H

to disprove: $\neg X$

$\neg X \qquad \neg B \quad \neg S \quad X$

$\neg B \quad \neg S \qquad \neg L \quad B$

$\neg S \quad \neg L \qquad \neg C \quad \neg H \quad L$

$\neg S \quad \neg C \quad \neg H \qquad \neg D \quad C$

$\neg S \quad \neg D \quad \neg H \qquad \neg M \quad D$

$\neg S \quad \neg H \quad \neg M \qquad M$

$\neg S \quad \neg H \qquad H$

$\neg S$

Thus, system has to restored for the statement to be true (Missing Data).

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STRUCTURED KNOWLEDGE REP.

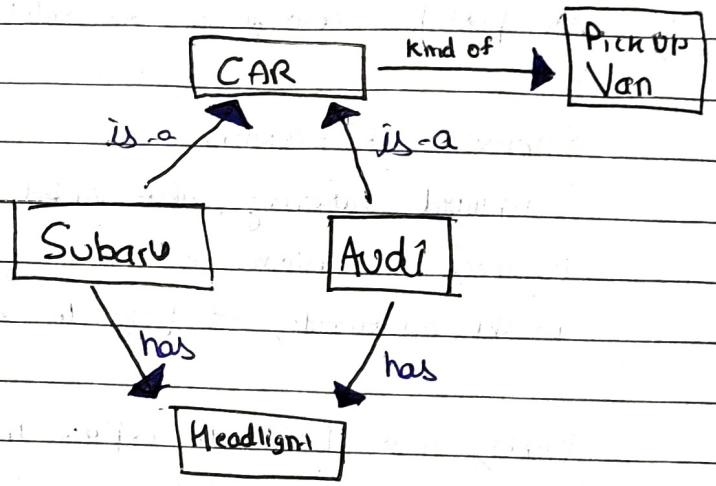
Q5. (a) What are the main constituents of knowledge representation techniques: Semantic Nets.? How are they represented ?, Give the required inference procedures to infer new facts. 2018

Knowledge representation techniques include logical rep, semantic networks, production rules, frame representations.

SEMANTIC NETS

Semantic nets are a form of storing propositional knowledge. These are 2D representation in the form of a graph with nodes representing objects in the world and arcs representing relationships b/w those objects.

It consists of
→ is-a relation
→ Kind-of relation.



They convey info in a transparent, simple ~~are~~ manner.

Inference procedures

1. Forward Chaining : starts with facts and apply rules to derive new facts

2. Backward Chaining : Start with desired conclusion and work backwards to find supporting facts/premises.

3. Resolution : Convert statements to clausal form, add negation of desired conclusion, apply resolution rule to derive contradiction and prove conclusion.

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(b) What are the limitations in semantic nets. How are they overcome in frames. Give a general structure of frame and its declaration in a programming language. How inference is done in frames. 2018S

LIMITATIONS OF SEMANTIC NETS (5,5)

1. Computational inefficiency: Traversing the entire network for information retrieval or inference can be computationally expensive
2. Difficulty in modelling human-like memory: Nets attempt to model human memory, but it is challenging to create such vast and complex networks.
3. Lack of Quantifiers: Semantic nets lack the ability to represent quantifiers like "for-all", "for some", "none", etc.
4. The link names to connect nodes can be arbitrary and lack standardized semantics.
5. They rely heavily on knowledge engineer's understanding and representation of knowledge.

Frames overcome semantic network drawbacks by introducing structured inheritance for efficient retrieval, modular hierarchical organization aligning with human knowledge, procedural attachments representing complex relationships, standardized slot definitions providing well-defined semantics, and a modular extensible approach reducing creator dependence.

FRAME STRUCTURE

Frame is a collection of attributes or slots and associated values that describe some real world entity.

- uses datastructure (record) to represent the knowledge in the semantic nets
- each frame represents the node in semantic n/w as a class, or as an instance and each relation as slot.

Eg.) Dog (SLOT-NAME / SLOT VALUE)

```
{ is-a : mammal ;
  no_of_legs : 4 ;
  type_of_teeth : Sharp ;
  has tail : yes ;
  owner : ;
  :
}
```

SLOT can have the attributes:

(1) Instance	(6) Range
(2) Definition	(7) to-compute
(3) Domain	(8) Single-Valued
(4) Default	(9) Inverse
(5) Range constraint	(10) Transfer-through.

Q5. (1) Explain the different concepts used in Semantic Net using suitable example. Also write the inference procedure 2018 E

(i) How semantic nets are extended to semantic Frames. What are its merit and demerits over semantic nets.

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Q5. Explain the different concepts used in Semantic Net using suitable example. Also write the corresponding inference procedure. How semantic nets are extended to semantic Frames. What are its merit and demerits over semantic nets. 2018 S

15

Semantic frames extend semantic nets by adding more structured information and attribute valued slots within the node. It is easy to convert a frame for each node of a semantic net by heading off the links.

ADVANTAGES

→ The frame knowledge representation makes the programming easier by grouping the similar data.
→ It is comparably flexible and used by many applications in AI.
→ It is very easy to add slots for new attribute and relations.
→ It is easy to include default data and to search for missing values.
→ Easy to understand and visualize.

DISADVANTAGES

→ Inference mechanism cannot be smoothly proceeded by frame representation
→ Frame representation has a much generalized approach.

Inference Procedure

→ Look for candidate frame or instances

→ Look for the availability of values
if available
solved
else
go to preceeding level or so on (from is-a / SLOT instance of)

→ If solved at higher level, try to have a specific answer.

ans

Q5. Construct the semantic net representations for the following text:

All Moving vehicles have fuel system and engine. All moving vehicles are ground or water vehicles. Car, Scooter, Truck are ground Vehicles which have breaks and water vehicles have navigation system. Scooter is two wheeler, car is four wheeler and truck is large four wheeler. All cars have air condition and safety belts. Maruti Swift is a car Swift car has 10 years free service of spare parts. Dl-12c 7788 is swift car having black color

a. Illustrate the steps of infer procedure to show that above car has safety system

b. Construct the semantic frame representation and give prolog implementation.

2018 E

[5,5]

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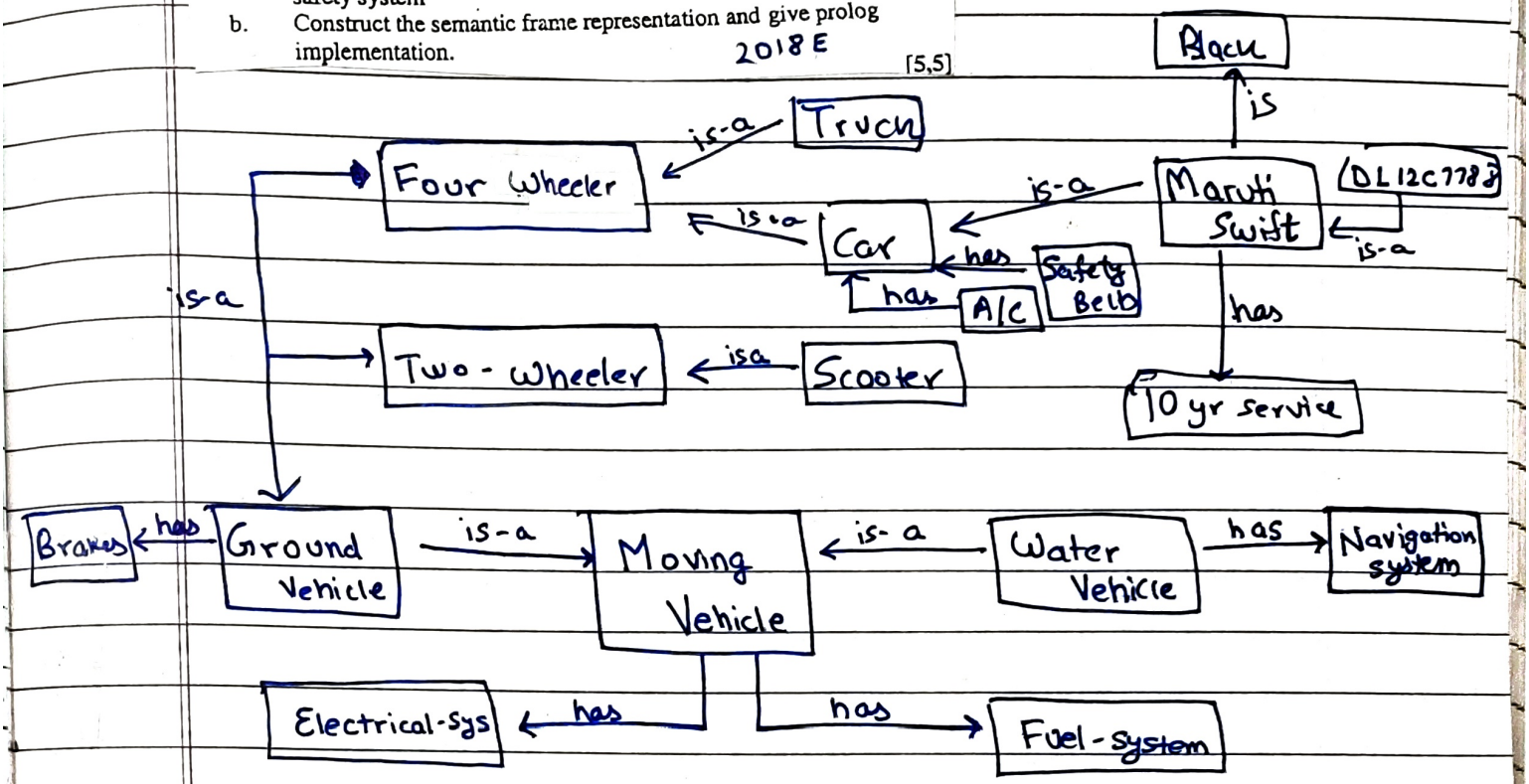

a.) All cars have safely system
Maruti Swift is a car
∴ Maruti Swift has a safely system.

b.) Prolog

```
vehicle (V) :- ground_vehicle (V).
water_vehicle (V).
ground_vehicle (car).
ground_vehicle (scooter).
ground_vehicle (truck).
water_vehicle (x) :-
has_nav_system (x).
has_feule_system (x) :-
moving_vehicle (x).
has_engine (x) :- moving_vehicle (x).
has_breaks (car)
has_breaks (truck)
two_wheeler (scooter).
car (maruti_swift).
has_ac (maruti_swift).
has_safety_belt (maruti_swift).
service_period (maruti_swift, 10).
```

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Q4. (a) Every vehicle is a physical object consisting of engineand fuel system. Vehicles can be land vehicles having wheels, water vehicles having swimming system or air vehicles having flying wings. Land Vehicle can be road vehicle or railway vehicle. Air vehicle can be aircraft or space vehicle. Water vehicle can be river vehicle or sea vehicle. Road Vehicles can be cars having four wheels, or scooters having two wheels auto having three wheels. All cars have air condition and safety belt. Honda City is a car having 10 years of free service. Bajaj is a scooter having good average in terms of fuel. INS Vikrant is an instance of sea vehicle. MIG-21 is and instance of air craft. Dl-10c..3145 is an instance of car having red colour and model 2018.Represent the above knowledge using (i)Semantic Net and (ii) Semantic frame Write down the corresponding prolog representation and prolog rules to answer following queries. 2019E

a. Maruti has four wheels?

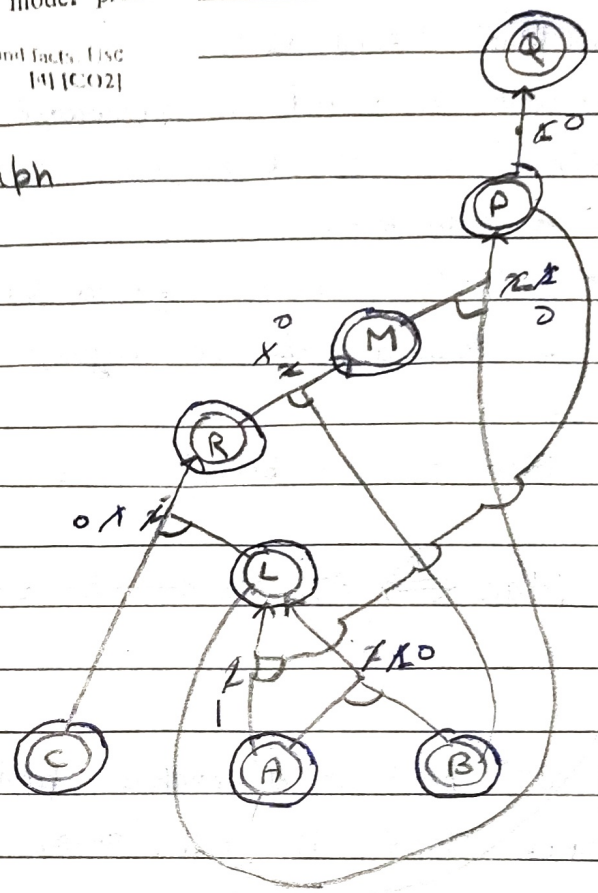
b. Vikrant cannot fly. [10]

[b] Consider the following set of Horn clauses and facts: 2023E

If the model is well-trained (P), then it produces accurate predictions (Q). If the dataset is large (L) and the preprocessing is done correctly (M), then the model is well-trained (P). If the regularization is applied (R) and the batch size is optimized (B), then the preprocessing is done correctly (M). If the learning rate is set appropriately (L) and the cost function is minimized (C), then regularization is applied (R). If the features are well-defined (A) and the dataset is balanced (B), then the dataset is large (L). If the features are well-defined (A) and the model produces accurate predictions (P), then the dataset is large (L). The features are well-defined (A). The dataset is balanced (B). The cost function is minimized (C).

Using forward chaining, determine whether the model produces accurate predictions (Q) based on the given Horn clauses and facts. Use AND-OR graphs for explanation. [4] [CO2]

Given: Clauses	Graph
$P \rightarrow Q$ ✓	
$L \wedge M \rightarrow P$ ✓	
$R \wedge B \rightarrow M$ ✓	
$L \wedge C \rightarrow R$ ✓	
$A \wedge B \rightarrow L$ ✓	
$A \wedge P \rightarrow L$	
A ✓	
B ✓	
C ✓	



To find: Q using forward chaining

A B L R M P Q ✓ hence proved.

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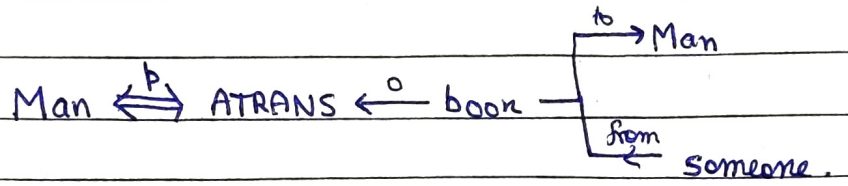
Q7. Write short notes on following (Any two)
(a) Conceptual Dependency 2018E

Q7. Write short notes on following (Any two)
(a) Conceptual Dependency 2019C

Conceptual dependency is a theory described by Schank of how to represent the kind of knowledge about the events that are usually contained in natural language sentences. It represents knowledge in a way that:

- facilitates drawing inferences from the sentences.
- Is independent of the language in which sentences were originally stated.

Eg.) Man took a book from someone.



They are built out of conceptual primitive acts like ATRANS, PTRANS, PROPEL, MOVE, INGEST, SPEAK etc.

Categorical concepts include ACT, PP, AA, PA

ADVANTAGES

→ using these primitives involve fewer inference rules.
→ many inference rules are already present in CD structure.
→ the holes in the initial structure help to focus on the points still to be established.

DISADVANTAGES

→ knowledge must be decomposed into fairly low level primitives.
→ impossible or difficult to find correct set of primitives.
→ A lot of inference may still be required.
→ Complex representations require a lot of storage.

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PROGRAMMING LANGUAGES

(1.) Prolog and knowledge Representation. 2018 s

Prolog (Programming in logic) is a declarative logic programming language based on first-order predicate logic. It was developed in the 1970s and is particularly useful for problems involving objects and relations, such as NLP, expert systems and DB applications.

Some key concepts in prolog:-

- Facts: statements of relationships b/w objects, similar to records/tuples in DB
  Eg.) father (john, mary)

- Rules: Logical implications allowing derivation of new facts from existing ones
  Eg.) grandfather (x,y) :- father (x,z), father (z,y)

- Queries: Questions asked about the facts/rules in the KB.
  Eg.) ?- grandfather (john, x).

- In unification, prolog attempts to find values for variables that make the query logically true based on fact/rules.
  In backtracking, if a partial solution fails to satisfy all conditions, prolog backtracks and explores other possibilities.

KR in prolog involves declaring facts about objects and their relationships, defining rules to derive new relationships and then querying the KB.

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(d) Forward reasoning inference and Backward reasoning inference in Prolog 2018E

4. Forward Reasoning and Backward reasoning in Prolog **(10 Points)**

FORWARD REASONING

Forward reasoning, also called data driven reasoning starts with the given facts and rules, and derives new conclusions by applying rules to the existing facts. It begins with the known information and works towards finding the solⁿ.

In prolog, forward reasoning is implemented using "assert" predicate, which adds new facts or clauses to the knowledge base dynamically during program execution. This approach is useful when dealing with problems where initial state is known, and the goal is to explore all possible consequences or solutions.

BACKWARD REASONING

Backward reasoning, also called goal-driven reasoning is the primary inference mechanism used in Prolog. It starts with a goal or query and works backward, attempting to find facts or rules that support/prove the goal.

Prolog uses DFS to explore the possible solutions. It tries to unify the goal with the head of a clause, and if successful, it recursively tries to satisfy the subgoals in the body of the clause. This process continues until all subgoals are satisfied or the search fails. BR is most commonly used in Prolog.

Eg)
```
parent (john, mary)
parent (john, bob)
parent (jane, mary)
```
} Facts.

```
grandparent (X,Y) :- parent (X,Z), parent (Z,Y)
```
} Rules.

```
?- parent (john, mary), assert (father (john, mary)).
Yes true
?- parent (jane, mary), assert (mother (jane, mary)).
Yes true
```
} Forward Reasoning

```
?- grandparent (X, mary).
X = john;
X = jane.
```
} Backward reasoning.

UNIT-5

REASONING

d. What are the different techniques for non monotonic reasoning? 2018E

(b) Explain the different techniques to handle non monotonic reasoning 2018S

(5,5)

(d) Non monotonic reasoning Logic 2019S

In non-monotonic reasoning, some conclusions may be invalidated if we add more information to our knowledge base. Logic is said to be non-monotonic if some conclusions can be invalidated with new info. This type of reasoning deals with incomplete and uncertain models.

Human perception for various things in life use this.

Ex) KB {
Birds can fly
Penguins cannot fly
Pitty is a bird
}
∴ Pitty can fly

add →

KB {
Birds can fly
Penguins cannot fly
Pitty is a bird
Pitty is a penguin
}
∴ Pitty cannot fly

Techniques

1. Default logic: It allows for conclusions to be drawn unless there is evidence to the contrary. Defaults can be overwritten by additional info.

2. Autoepistemic logic: It deals with reasoning about one's beliefs and what can be inferred from them, even when those might change over time.

3. Circumscription: It involves minimizing exceptions by assuming the smallest possible domain of discourse that still satisfy the known facts.

4. Argumentation Frameworks: These allow for representation and evaluation of arguments, including the ability to handle conflicts and revise conclusions based on strength of arg.

5. Theory Revision: This allows revising a set of beliefs when new info contradicts existing one.

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7. Write short notes on any two:
(a) Default reasoning or statistical reasoning. 2018G
c. State Bayes theorem and support with example for statistical reasoning. 2018E

STATISTICAL REASONING

Statistical reasoning involves the use of statistical methods to analyze data, identify patterns and make predictions. AI systems leverage statistical reasoning to learn from data and generalize knowledge.

Bayes Theorem describe how to revise the probability of a hypothesis (H) after observing new evidence (E)

$$\therefore \boxed{P(H/E) = \frac{P(E/H) \cdot P(H)}{P(E)}}$$

It helps to rationally update beliefs by incorporating new evidence.

Ex) Test has 95% accuracy when disease is present, $P(Pos/dis) = 0.95$

Prevalence of disease $= 0.01$

$\therefore$ Prob that he has disease if +ve $= P(D/P) = \frac{P(P/D) \times P(D)}{P(P)} = 0.16$

When prevalence is low, the chance of having disease is 16% not 95%. This counter intuitive result highlights the importance of considering prior info and base rates in statistical reasoning.

Q. (a) Given the following statistics, what is the probability that a woman has cancer if she has a positive mammogram result?
I. One percent of women over 50 have breast cancer.
II. Ninety percent of women who have breast cancer test positive on mammograms.
III. Eight percent of women will have false positives. [2]

Let the event of having cancer is A and getting positive result is X.

$P(A) = 0.01$, $P(\bar{A}) = 0.99$

$P(X|A) = 0.9$, $P(X|\bar{A}) = 0.8$

by Bayes theorem

$$\therefore P(A|X) = \frac{P(A \cap X)}{P(A \cap X) + P(\bar{A} \cap X)} = \frac{P(A) \cdot P(X|A)}{P(A) \cdot P(X|A) + P(\bar{A}) \cdot P(X|\bar{A})}$$

$$= \frac{0.01 \times 0.9}{0.01 \times 0.9 + 0.99 \times 0.08} = \frac{0.009}{0.009 + 0.0792} = \frac{0.009}{0.0882}$$

$$\boxed{P(A/X) = 0.102} \rightarrow \boxed{10.2\%}$$

5. [a] Consider two deep learning models, A and B, used for detecting fraudulent transactions. Model A is 98% effective at recognizing fraudulent transactions when they occur but has a 15% false positive rate (indicating that a transaction is fraudulent, when it is not). Model B is 93% effective at recognizing fraudulent transactions, but has a 7% false positive rate. The two models use independent techniques for identifying fraud. Fraudulent transactions constitute 0.5% of all transactions. Let's say a transaction is evaluated using only one of these models, and that model flags the transaction as fraudulent. Which model's positive result is more indicative of a transaction genuinely being fraudulent? Justify your answer mathematically. 2023 B [4] [CO2, CO3]

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Let us calculate precision of both models.

$$P = \frac{\text{True Positives}}{\text{True Positive} + \text{False Positive}}$$

and

$\therefore$ TP = True positive rate * prob of fraud

FP = false positive rate * prob of no fraud.

MODEL A	MODEL B
$TP_A = 0.98 \times 0.005$	$TP_B = 0.93 \times 0.005$
$FP_A = 0.15 \times 0.995$	$FP_B = 0.07 \times 0.995$
$\therefore P_A = \frac{TP_A}{TP_A + FP_A}$	$P_B = \frac{TP_B}{TP_B + FP_B}$
$= 3.18\%$	$= 6.26\%$

Thus, Model B is better

Q.3 (a) Marie's marriage is tomorrow. In recent years, each year it has rained only 5 days. The weatherman has predicted rain for tomorrow. When it actually rains, the weatherman correctly forecasts rain 90% of the time. When it doesn't rain, the weatherman incorrectly forecasts rain 10% of the time. The question: What is the probability that it will rain on the day of Marie's wedding? 2023E [6]

(b) Given that P(A)=0.3, P(A |B)=0.4 and P(B)=0.5, compute P(B|A). [4][CO4]

a.) It rains 5 times a year

weatherman forecasts with accuracy = 0.9

weatherman predict wrong = 0.1

$\therefore$ Probability $= \dfrac{0.9 \times 5}{360 \times 0.1 + 0.9 \times 5} = \dfrac{4.5}{40.5}$

$\boxed{= 0.9}$

b.) Given,

$P(A) = 0.3$

$P(B) = 0.5$

$P(A|B) = 0.4$

$\therefore P(A|B) = \dfrac{P(A \cap B)}{P(B)} \Rightarrow 0.4 = \dfrac{P(A \cap B)}{0.5} \Rightarrow P(A \cap B) = 0.2$

$\therefore P(B|A) = \dfrac{P(A \cap B)}{P(A)} = \dfrac{0.2}{0.3} = \boxed{2/3}$

Q.4 Consider the following facts: (i) I saw my cat in the living room 3 hours ago, (ii) 2 hours ago my door blew open, (iii) Three quarters of the time my door blows open, my cat runs outside the door, (iv) One hour ago I thought I heard a cat noise in my living room. Assume I was half certain, (v) In one hour period the probability that cat will leave the room is 0.2. There is also 0.2 probability that he may enter the room. What is the uncertainty that the cat is in the living room? Use Bayesian networks to evaluate this. 2023E [10] [CO3]

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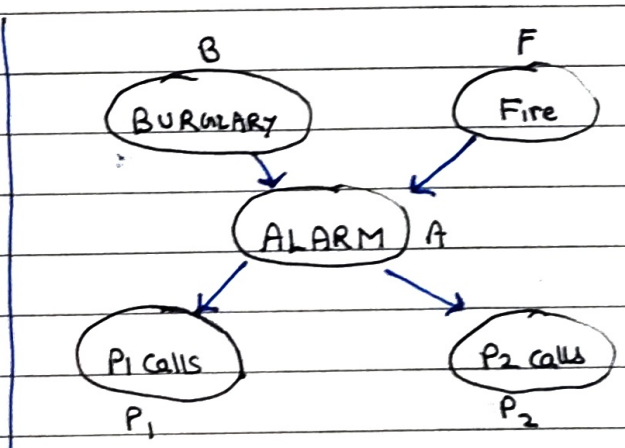
Explain the Baysian Network

Bayesian belief network is a graphical representation of b/w diff probabilistic relationships among random variables in a particular set. It is a classifier with no dependency or attribute i.e. condition independent. Due to its feature of joint probability, the probability in a n/w is derived based on a condition.

P(attribute / parent)

Ex) There's an Alarm (A) triggered by burglary (B) or Fire (F). It alerts 2 people P_1 and P_2 to call owner. But P_1 may not call and P_2 may not hear. We need to take prob. in account



$\therefore$ P(B) = 0.001 | P(F) = 0.002

$\therefore$ P(A) →

B	F	P(A=T)	P(A=F)
T	T	0.95	0.05
T	F	0.94	0.06
F	T	0.29	0.71
F	F	0.001	0.999

P(P1) →

A	P(P1=T)	P(P1=F)
T	0.95	0.05
F	0.05	0.95

P(P2) →

A	P(P2=T)	P(P2=F)
T	0.80	0.20
F	0.01	0.99

[b] Consider a Bayesian network representing the relationship between weather conditions and two variables: "*Rain*" (R) and "*Slippery Roads*" (S). The network consists of the following conditional probability Tables (CPTs): *P(Rain)* = 0.3; *P(Slippery Roads* = true | *Rain* = true) = 0.8; *P(Slippery Roads* = false | *Rain* = true) = 0.2; *P(Slippery Roads* = true | *Rain* = false) = 0.1; *P(Slippery Roads* = false | *Rain* = false) = 0.9. You encounter a situation where the roads are slippery (S = true). Based on this information and the provided Bayesian network, calculate the probability of rain (R) being true. 2023 E [4] [CO2, CO3

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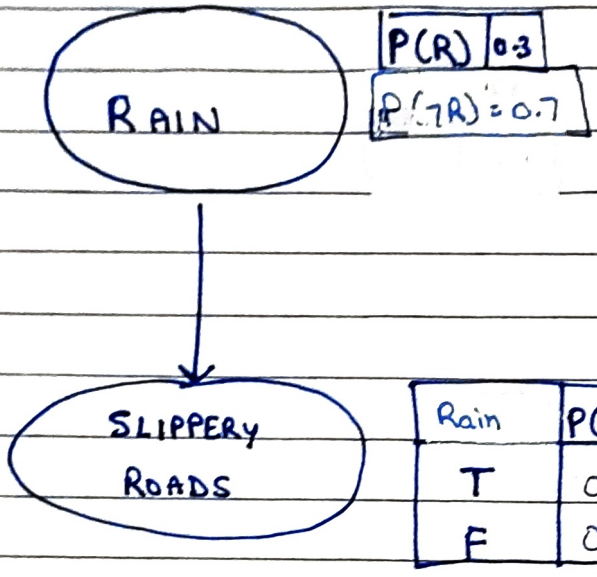
----Best of Luck----



P(R)	0.3
P(¬R) = 0.7	

Rain	P(S|R)	P(¬S|R)
T	0.8	0.2
F	0.1	0.9

$$\therefore P(R|S) = \frac{P(S|R) * P(R)}{P(S)} = \frac{P(S|R) * P(R)}{P(S|R) * P(R) + P(S|\neg R) * P(\neg R)}$$

$$= \frac{0.8 * 0.3}{0.8 * 0.3 + 0.1 * 0.7} = \frac{0.24}{0.24 + 0.07} = \boxed{\frac{24}{31}}$$

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Q7. Write short notes on any two from followings:
(a) Probabilistic Reasoning 2023

Probablictic reasoning is a way of drawing conclusions and making decisions in the face of uncertainity. Unlike classical logic which deals with strictly true or false statements, probabilistic reasoning uses numerical probabilities to represent likelihood of diff possible scenarios or outcomes.

Need to use this in AI arise: ~~due to~~:

→ when there are unpredictable outcomes.
→ when specifications or possibilities of predicates became too large to handle
→ when an unknown error occurs on an experiment.

We use bayesian stats and bayesian networks to represent joint probability distributions over many linked random variables.

This has many applications in areas like medical diagnosis, robot mapping, speech recognition and ML in general.

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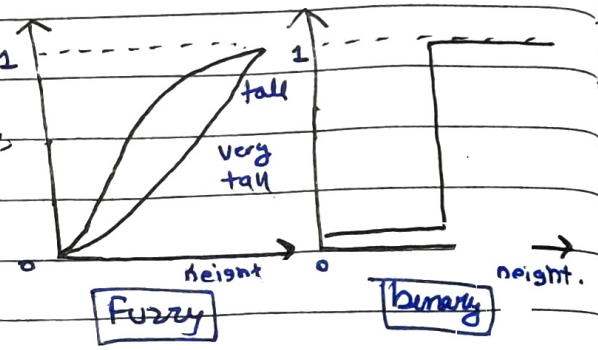
(c) Fuzzy Logic and Uncertainty 2018 ..... (5,5)

Fuzzy logic is a mathematical approach that deals with imprecision and uncertainity, allowing for partial truths and degrees of membership. It is inspired by the way humans reason and make decisions in the presence of vagueness and ambiguity.

In traditional binary Logic, a statement is either true or false, but in fuzzy logic, a statement may hay have varying degrees of truth, ranging from completely true to completely false.



Uncertainity is an inherent aspect of many real world problems, and arise from various sources, such as incomplete or imprecise data, noise and inherent complexity of the system being modelled. AI systems need to handle uncertainity to make reliable decisions and provide accurate predictions.

(b) Explain the concept of Fuzzy set with example. What operations can be performed on these set. Illustrate with example. 2019S

[6,4]

A fuzzy set is a set that allows partial membership, unlike classical crisp sets where element either does or does not belong to the set. In a fuzzy set, an element can have a degree of membership from 0-1 representing the extent to which it belongs to the set

→ Component
→ Union
→ Intersection
→ Algebraic prod / sum
→ Concentration / Dilation.

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(c) For following fuzzy sets, find their Union, Intersection and also find union of their complements sets

2018E

$$A = \left\{\frac{1}{2.0} + \frac{0.65}{4.0} + \frac{0.5}{6.0} + \frac{0.35}{8.0} + \frac{0}{10.0}\right\}$$

$$B = \left\{\frac{0}{2.0} + \frac{0.35}{4.0} + \frac{0.5}{6.0} + \frac{0.65}{8.0} + \frac{1}{10.0}\right\}.$$

[4,3,3]

Union : $A \cup B = \max\{\mu_A(x), \mu_B(x)\}$

$$A \cup B = \left\{\frac{1}{2.0} + \frac{0.65}{4.0} + \frac{0.5}{6.0} + \frac{0.35}{8.0} + \frac{0}{10.0}\right\}$$

Intersection : $A \cap B = \min\{\mu_A(x), \mu_B(x)\}$

$$A \cap B = \left\{\frac{0}{2.0} + \frac{0.35}{4.0} + \frac{0.5}{6.0} + \frac{0.35}{8.0} + \frac{0}{10.0}\right\}$$

Union of Complements : $\bar{A} \cup \bar{B} = \max\{\mu_{\bar{A}}(x), \mu_{\bar{B}}(x)\}$

$\bar{A} \cup \bar{B}$

$$= \max\left\{\left(\frac{0}{2.0} + \frac{0.35}{4.0} + \frac{0.5}{6.0} + \frac{0.65}{8.0} + \frac{1}{10.0}\right), \left(\frac{1}{20} + \frac{0.65}{4.0} + \frac{0.5}{6.0} + \frac{0.35}{8.0} + \frac{0}{10.0}\right)\right\}$$

$$= \left\{\frac{1}{2.0} + \frac{0.65}{4.0} + \frac{0.5}{6.0} + \frac{0.65}{8.0} + \frac{1}{10.0}\right\}$$

(b) Assume universe of discourse for the set of salary structures (in terms of K) per month is defined as U = {2, 5, 10, 20, 30, 40, 50, 60, 70, 80}. The Fuzzy sets defined on U based on salaries are:

2019 E

Poor = {(2,1), (5,1), (10, 0.8), (20, 0.5), (30, 0.2)}

Average {(10, 0.2), (20, 0.5), (30, 0.6), (40, 0.8), (50, 0.6), (60, 0.2)}

Rich = {(40, 0.2). (50, 0.5), (60,0.8), (70,1), (80,1)}

Draw the graphs of all three fuzzy sets on truth value such as very false, fairly false, false, true, very true. Find the membership value of salaries 30k and 60k [5]

.8) , (50, 0.6), (60, 0.2)}

1) , (80, 1)}

Draw The graph of all the ~~tru~~ fuzzy sets on the same coordinate axis.

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(ii) Develop logic for representation using fuzzy set with an example of car speed which can be slow, fast and super fast 2018E [10,4]

Let us assume the speed of cars (in Km/h) be in ranges:

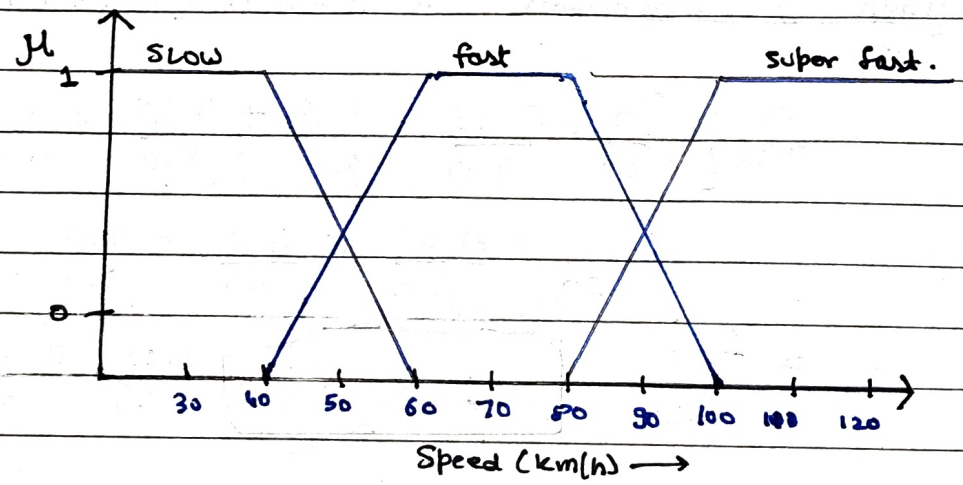
- SLOW : 0 - 60 km/h
- FAST : 40 - 100 km/h
- SUPER FAST : 80 - 140 km/h

∴ Membership functions:

$\mu_{slow}(x) = \max(0, \min((60-x)/20, (x-0)/20))$

$\mu_{fast}(x) = \max(0, \min((x-40)/20, (100-x)/20))$

$\mu_{s.fast}(x) = \max(0, \min(((x-80)/20), (140-x)/20))$



(a) Different Learning algorithm. 2018S

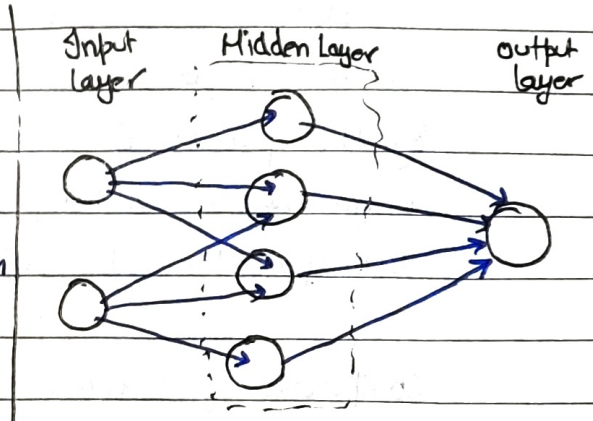
(b) Learning using Neural Network or Genetic algorithm. 2018

(c) Learning using Neural Network or Genetic algorithm. 2018E

(d) Learning using neural Nets 2018S

NEURAL NETWORK

Neural networks are a type of ML model inspired by the structure and function of biological NN in the brain. They consists of interconnected nodes or units organized into input, hidden and output layers.

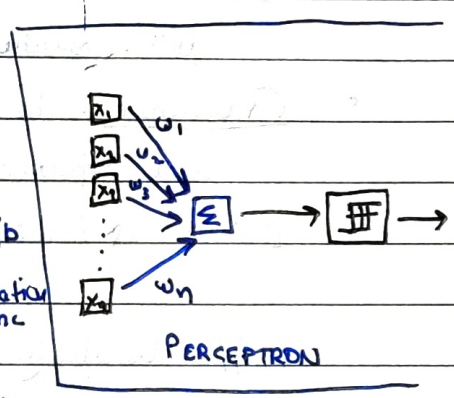


NEURAL NETWORK.

Each connection b/w nodes has an associated weight that determines the strength and importance of that connection. During the learning process, these weights are adjusted to minimize the error between the predicted o/p and the true outputs on the training data.

Learning process

1. Initialize connection weights randomly.



PERCEPTRON

2. Forward Propagation:
   - Input data is propagated through the NN to give o/p
   - At each node, weighted sum of i/p is passed through activation func

3. Calculate error b/w predicted and true outputs.

4. Backpropagation:
   - Errors are propagated backwards through the network from the o/p layer
   - Gradients of the errors wrt weights are computed using chain rule.

5. Connection weights are updated using an optimizer (Eg. grad descent) to minimize errors.

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6. Iterate:
- Steps 2-5 are repeated over many epochs over the training data.
- Weights are adjusted iteratively to reduce errors on the training set.

7. Regularization techniques like early stopping or weight decay can help prevent overfitting.

GENETIC ALGORITHM

Genetic Algorithms (GA) are a type of optimization algorithm inspired by the process of natural selection. They are a form of stochastic beam search where successor states are generated by combining two parents states rather than modifying a single state.

Components of GA are:
- **Population**: A set of k randomly generated states / solutions.
- **Fitness Functions**: A function that evaluates how 'fit' or good each sol^n in the population is. Better solutions have higher fitness scores.
- **Selection**: Solutions are selected from the population to reproduce, with better solutions having a higher probability of being selected.
- **Crossover**: The selected solutions reproduce by combining portions of their state representations to create new offspring solutions.
- **Mutation**: The offspring solutions undergo random mutations to introduce variation.

GAs iteratively generate populations by selecting fit solutions, recombining them, and mutating offspring to converge towards better solutions. Learning occurs through combining and mutating operations exploring the search space across generations. Effective application requires careful engineering of problem representation, genetic operators, population size and balancing exploration and exploitation.

UNIT-6

APPLICATIONS.

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e. Explain rule based expert system 2018E (5 X 2)

Q6. (a) Explain the block diagram to design Expert System. 2018S

Q6. (i)) Draw the architecture of Expert system defining functionality of different components 2018E

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(b)What are the contents of knowledge Base in Expert system.
2018E

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Q6. (a)) What are the steps to build Expert system such as Medical diagnostic system. 2013 E

. (a)) What are the steps to build Expert system such as Medical diagnostic system. Explain its architecture. 2019S

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Q5. (a) Describe the general architecture of expert system? How will you evaluate expert system like MYCIN? 2019E [5]

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(b) Different phases of Natural Languge processing 2018E

(b) Different phases of Natural Language processing 2019S

(c) Syntactic Analysis and Semantic Analysis for NLP 2018

Natural language Processing (NLP) is the field of AI that focuses on enabling computers to understand, interpret, and generate human language.

The phases of NLP are :-

MORPHOLOGICAL ANALYSIS : This phase analyzes individual words into their components (Eg. prefixes, suffixes, roots) and separates words from non-word tokens like punctuation.

SYNTACTIC ANALYSIS : Also known as parsing, this phase takes a linear sequence of words and transform it into a structural representation that shows how the words relate to each other grammatically. Syntactically incorrect sentences may be rejected.

SEMANTIC ANALYSIS: The structures created by the syntax analyzer are assigned meaning in this phase. A mapping is made between the syntactic structures and objects / concepts in the domain knowledge base. Semantically anomalous structures may be rejected.

DISCOURSE INTEGRATION: The meaning of the sentence can depend on and influence the meanings of preceding and following sentences in the discourse context. This phase resolves contextual references like pronouns.

PRAGMATIC ANALYSIS : This final phase interprets the literal meaning representation to determine the intended or pragmatic meaning, using the cooperative rules of dialogue and context.

Prepared by Madhav Gupta (2K21/CO/262)
2K21/CO/262

Total No. of Pages **2** Roll No.....

VI SEMESTER

B.Tech

MID TERM EXAMINATION ***March-2024***

COURSE CODE CO304 **COURSE TITLE** Artificial Intelligence

Time: 1:30 Hours ***Max. Marks: 25***

Note : All questions are compulsory.
Assume suitable missing data, if any.

Q.1 You are given two jugs, a 4-gallon one and a 3-gallon one, a pump which has unlimited water which you can use to fill the jug, and the ground on which water may be poured. Neither jug has any measuring markings on it. How can you get exactly 2 gallons of water in the 4-gallon jug?

i. Formulate this as an AI problem.

ii. Represent the entire possible state space as a set of rules.

iii. Come up with a possible solution of the problem, specifying which rule is applicable for each state transition.

iv. Represent the solution as a breadth first and depth first search procedure.

v. Discuss the time and space complexity as well as the optimality.

[1.5x5=7.5][CO1]

Q.2 Consider the graph given in Figure 1. The numbers written on edges represent the distance between the nodes. The numbers written on nodes represent the heuristic value. Find the most cost-effective path to reach from start state A to final state J using A* Algorithm, showing at each step the values of f, g, and h.

[5][CO3]

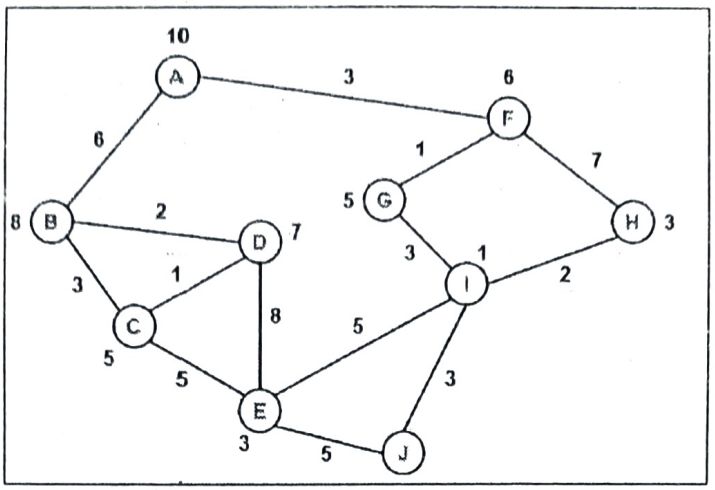

Figure 1

Q.3 For the Figure 2, apply Alpha beta pruning on the Min-max game tree and also calculate the alpha and beta values for each non-pruned edge. Show pruned edges by a cross mark in the game tree.

[5][CO2]

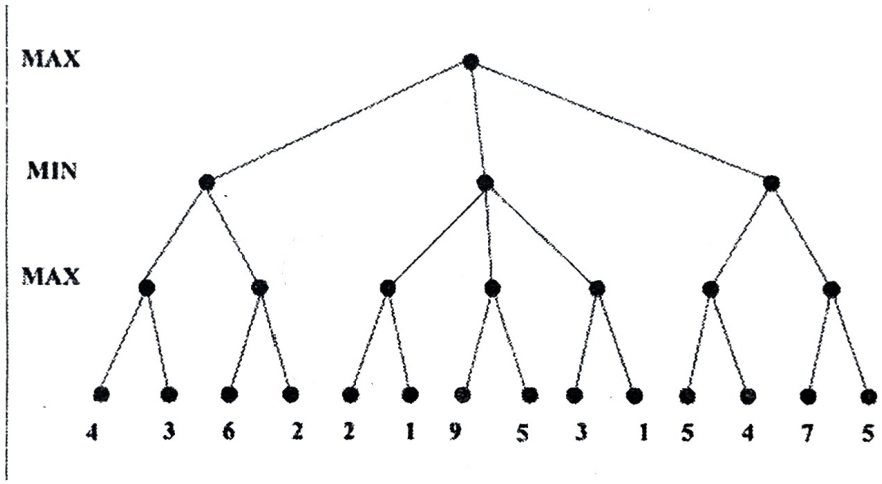

Figure 2

Q.4 Differentiate between the following:

i) Uniform Cost Search and Greedy Search

ii) A* and AO* algorithms

iii) Intelligent Agent and Intelligent Program

iv) Local maxima and Global maxima

v) Un-informed Search and Informed Search

[1.5x5=7.5][CO4]

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ELECTIVE

B. Tech.

MID SEMESTER EXAMINATION

MARCH-2024

C0-304 ARTIFICAL INTELLIGENCE

Time: 1.30 Hours

Max. Marks: 25

Note: Attempt all questions. Assume suitable missing data, if any.

Q1. Consider a biometric system involving face recognition, fingerprint identification and speech recognition, that has been installed for the students in the University.

a) Identify the agents and the environment in this particular case.

[2 MARKS] [CO1]

b) Create the PEAS description for this case.

[2 MARKS] [CO1]

c) Apply detailed reasoning to identify whether the above system is:

i. Discrete or Continuous
ii. Episodic or Sequential
iii. Fully or Partially observable
iv. Static or Dynamic

[2*4=8 MARKS] [CO1,6]

Q2. a) Let *b* be the branching factor of a search tree. If the optimal goal is reached after *d* actions from the initial state, in the worst case, how many times will the initial state be expanded for iterative deepening depth first search (IDDFS) and iterative Deepening A* search (IDA*)?

[3 MARKS] [CO2]

b) Differentiate BFS, DFS and IDDFS. Also Analysis the optimal path, completeness, time complexity and space complexity of the given graph in figure 1.

[5 MARKS] [CO2]

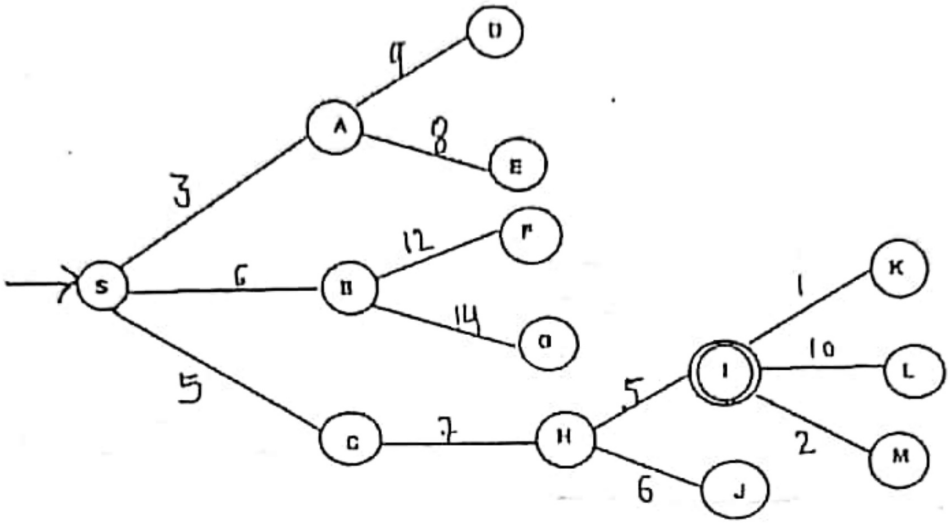

Figure 1: Graph

Q3. Consider the following distance between cities. Plan the route from city A to F using A*(A star) algorithm illustrating ALL steps involved in making tree. An empty cell indicate no routes exists between two cities.

[5 MARKS]

[CO2]

CITIES	A	B	C	D	E	F
A	0		15	8		
B		0		20	10	
C	15		0			5
D	8	20		0		
E		10			0	3
F			5		3	0