VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"JnanaSangama", Belgaum -590014, Karnataka.

LAB REPORT
on

Artificial Intelligence (23CS5PCAIN)

Submitted by

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in partial fulfillment for the award of the degree of
BACHELOR OF ENGINEERING
in
COMPUTER SCIENCE AND ENGINEERING

B.M.S. COLLEGE OF ENGINEERING
(Autonomous Institution under VTU)
BENGALURU-560019
Sep-2024 to Jan-2025

B.M.S. College of Engineering,
Bull Temple Road, Bangalore 560019
(Affiliated To Visvesvaraya Technological University, Belgaum)
Department of Computer Science and Engineering

CERTIFICATE

This is to certify that the Lab work entitled "Artificial Intelligence (23CS5PCAIN)" carried out by **Sharanabasappa K Tondihal(1BM22CS253),** who is bonafide student of **B.M.S. College of Engineering.** It is in partial fulfillment for the award of **Bachelor of Engineering in Computer Science and Engineering** of the Visvesvaraya Technological University, Belgaum. The Lab report has been approved as it satisfies the academic requirements in respect of an Artificial Intelligence (23CS5PCAIN) work prescribed for the said degree.

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Github Link:
https://github.com/sharan6704/AI

Program 1

Implement Tic –Tac –Toe Game
Implement vacuum cleaner agent

Algorithm:

(You should provide the screen shot of your observation book of Algorithm/Logic/Solving of respective problem)

① Tic Tac Toe

① Initilize the Game Board

Create 3x3 board represented by 2D list initilized with empty spaces

② Display the Board

Function to print the current status of the board

③ Check for a winner

- Check all rows, columns, and both diagonals for three matching symbols (either 'X' or 'O')
- Return the winner if found, otherwise return none

④ Check for a Draw

- Check if the board is full and return true if so

⑤ Game Loop

- Initilize the current player (start with 'X')
- Repeate the following untill a winner is found or the game is draw.
- Display the current Board
- Prompt the current player to entire their move(row and column)
- Validate the Input
- Ensure the selected cell is empty
- Place the current player symbol on the board

- Check for a draw
- If the board is full and there is no winner, announce the draw and end the game
- Switch the current player

(6) End the game

- Optionally ask if any player wants to play again

SBS
1/10/24

2 Implement Vacuum Cl

① Start the Vacuum Cleaner

- Turn on the power switch

② Create Suction

- Activate the motor to spin the fan
- Generate low pressure inside the

③ Draw Air and Dirt

- Air is pulled in through nozzle.
- Dirt and debris are carried into by the incomming airflow

④ Collect dirt

- The incomming air enters the dust
- Particles are collected in the contai

(7) Monitor Performance

- check for indicators (like full bag or blo
- Adjust Suction power if necessary.

(8) Regular Maintaince

- Empty the dust container or replace the
- Clean or replace filters as needed.

(9) End cleaning session.

- Turn off vacuum cleaner.
- Store it properly for feature use

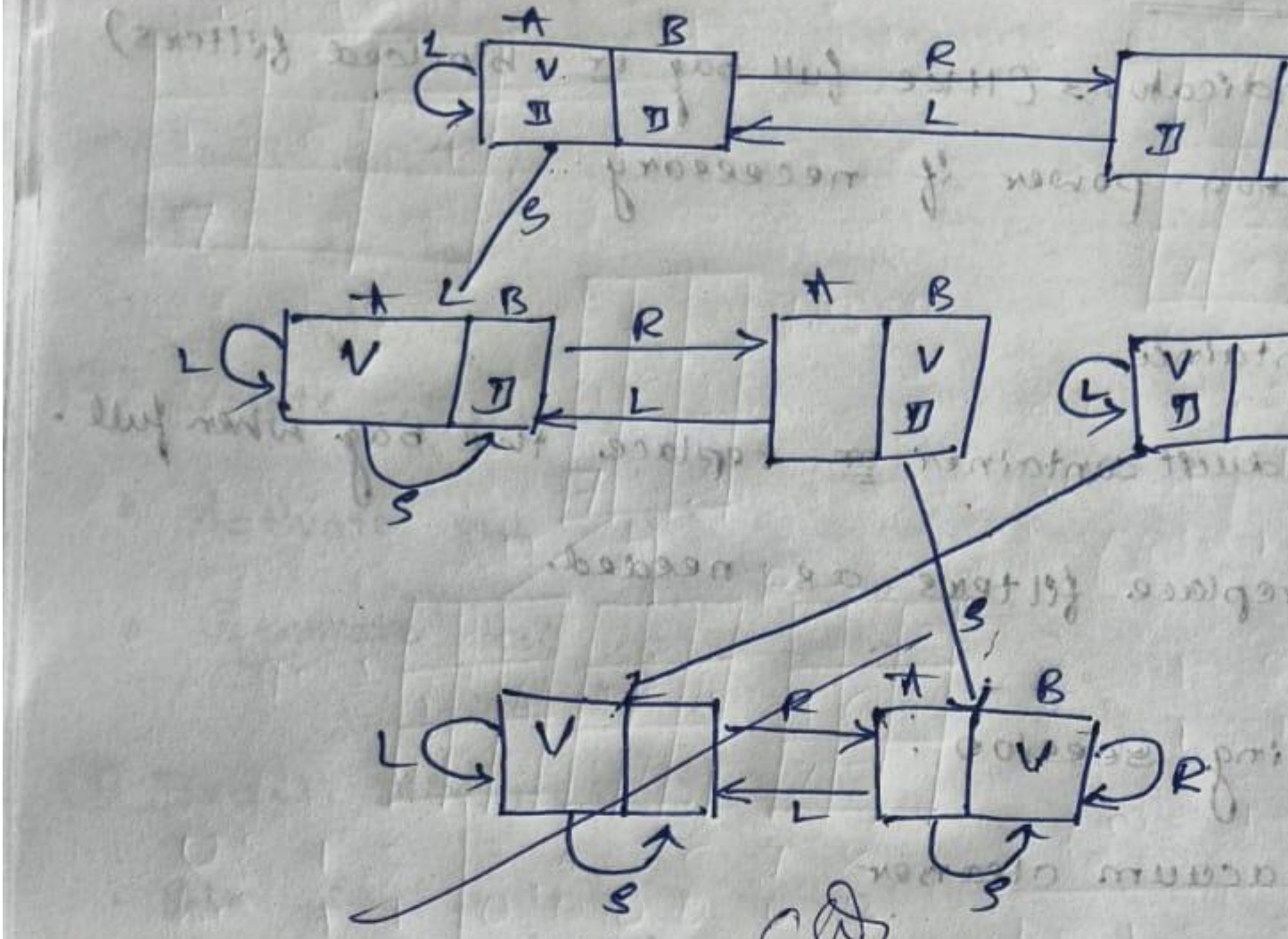
function REFLEX-VACUUM-AGENT([location,

if status = Dirty then return Suck

Else if location = A then return Right

else if location = B then return Left

The State Space diagram of Vac



Parameters

1) Location
2) Status of present room
3) Status of other room

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Code: 1: Tic - Tac - Toe

```
import numpy as np

board=np.array([['-','-','-'],['-','-','-'],['-','-','-']])

current_player='X'
flag=0

def check_win():
    for i in range(3):
        if board[i][0] == board[i][1] == board[i][2] != '-':
            return True
    for i in range(3):
        if board[0][i] == board[1][i] == board[2][i] != '-':
            return True
    if board[0][0] == board[1][1] == board[2][2] != '-':
        return True
    if board[0][2] == board[1][1] == board[2][0] != '-':
        return True
    return False

def tic_tac_toe():
    n=0
    print(board)
    while n<9:
        if n%2==0:
            current_player='X'
        else :
            current_player='O'

        row = int(input("Enter row: "))
        col = int(input("Enter column: "))

        if(board[row][col]=='-'):
            board[row][col]=current_player
            print(board)
            flag=check_win();
            if flag==1:
                print(current_player+' wins')
                break
            else:
                n=n+1
        else :
            print("Invalid Position")

    if n==9:
```

```
    print("Draw")

tic_tac_toe()
```

Output:

Win :

```
[['-' '-' '-'] ['-' '-' '-'] ['-' '-' '-']]
Enter row: 0
Enter column: 1
[['-' 'X' '-'] ['-' '-' '-'] ['-' '-' '-']]
Enter row: 0
Enter column: 0
[['O' 'X' '-'] ['-' '-' '-'] ['-' '-' '-']]
Enter row: 1
Enter column: 0
[['O' 'X' '-'] ['X' '-' '-'] ['-' '-' '-']]
Enter row: 1
Enter column: 1
[['O' 'X' '-'] ['X' 'O' '-'] ['-' '-' '-']]
Enter row: 1
Enter column: 2
[['O' 'X' '-'] ['X' 'O' 'X'] ['-' '-' '-']]
Enter row: 2
Enter column: 2
[['O' 'X' '-'] ['X' 'O' 'X'] ['-' '-' 'O']]
O wins
```

Draw :

```
[['-' '-' '-'] ['-' '-' '-'] ['-' '-' '-']]
Enter row: 1
Enter column: 1
[['-' '-' '-'] ['-' 'X' '-'] ['-' '-' '-']]
Enter row: 0
Enter column: 1
[['-' 'O' '-'] ['-' 'X' '-'] ['-' '-' '-']]
Enter row: 1
Enter column: 0
[['-' 'O' '-'] ['X' 'X' '-'] ['-' '-' '-']]
Enter row: 1
Enter column: 2
[['-' 'O' '-'] ['X' 'X' 'O'] ['-' '-' '-']]
Enter row: 2
Enter column: 2
[['-' 'O' '-'] ['X' 'X' 'O'] ['-' '-' 'X']]
Enter row: 0
Enter column: 0
[['O' 'O' '-'] ['X' 'X' 'O'] ['-' '-' 'X']]
```

```
Enter row: 0
Enter column: 2
[['O' 'O' 'X']['X' 'X' 'O'] ['-' '-' 'X']]
Enter row: 2
Enter column: 0
[['O' 'O' 'X'] ['X' 'X' 'O'] ['O' '-' 'X']]
Enter row: 2
Enter column: 1
[['O' 'O' 'X'] ['X' 'X' 'O'] ['O' 'X' 'X']]
Draw
```

2. Vacuum Cleaner :

```
cost =0
def vacuum_world(state, location):
  global cost
  if(state['A']==0 and state['B']==0):
    print('All rooms are clean')
    return

  if state[location]==1:
    state[location]=0
    cost+=1
    state[location]=(int(input('Is room '+ str(location) +' still dirty : ')))

    if state[location]==1:
      return vacuum_world(state, location)
    else:
      print('Room ' + str(location) + ' cleaned')

  next_location='B' if location=='A' else 'A'
  if state[next_location]==0:
    state[next_location]=(int(input('Is room '+ str(next_location) +' dirty : ')))
  print('Moving to room '+str(next_location))
  return vacuum_world(state, next_location)

state={}
state['A']=int(input('Enter status of room A : '))
state['B']=int(input('Enter status of room B : '))
location=input('Enter initial location of vacuum (A/B) : ')
vacuum_world(state,location)
print("Status = "+str(state))
print('Total cost: ' + str(cost))
```

Output :

```
Enter status of room A : 1
Enter status of room B : 1
Enter initial location of vacuum (A/B) : A
Is room A still dirty : 0
Room A cleaned
Moving to room B
Is room B still dirty : 0
Room B cleaned
Is room A dirty : 0
Moving to room A
All rooms are clean
Status = {'A': 0, 'B': 0}
Total cost: 2
```

Program 2

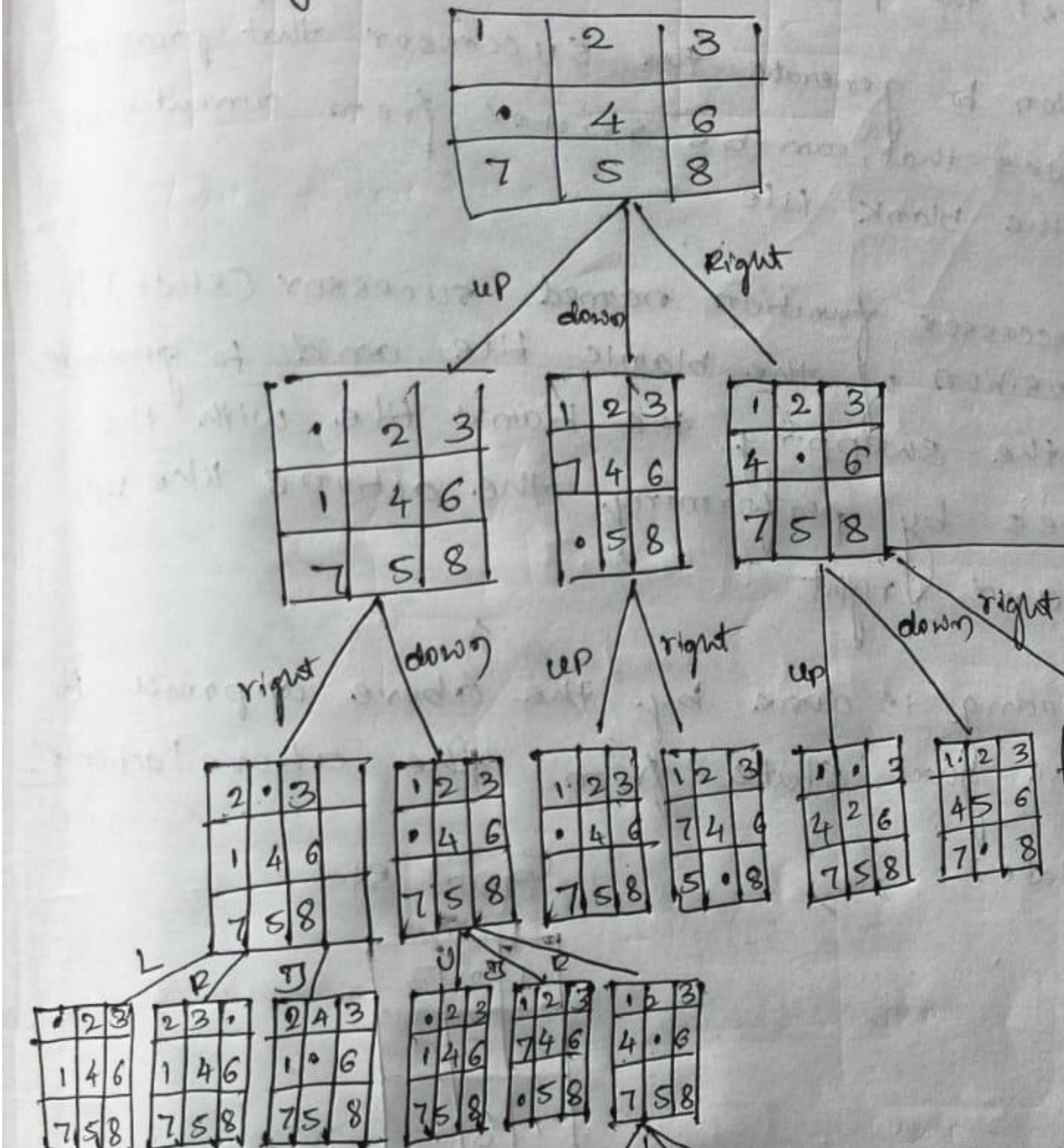
Implement 8 puzzle problems using Depth First Search (DFS)
Implement Iterative deepening search algorithm

Algorithm:

(You should provide the screen shot of your observation book of Algorithm/Logic/Solving of respective problem)

LAB => 3

① Implementing 8 Puzzle Problem using DFS and BFS



Non-Heurestric Algorithm

* At the first the puzzle is represented

* Create a function to generate the successor all valid states that can be reached fro by moving the blank tile.

* Create a successor function named succe find the position of the blank tile, a new states the swapping the blank tile adjacent ones by performing the act left, down and right

* Now the tracing is done by the above generate the goal state from the

ex:- Start State :

1	2	3
4		6
5	7	8

Goal s

1	2	3
4	5	6
7	8	

* Till we reach this goal state the abo

Draw the State Space Diagram For

Initial

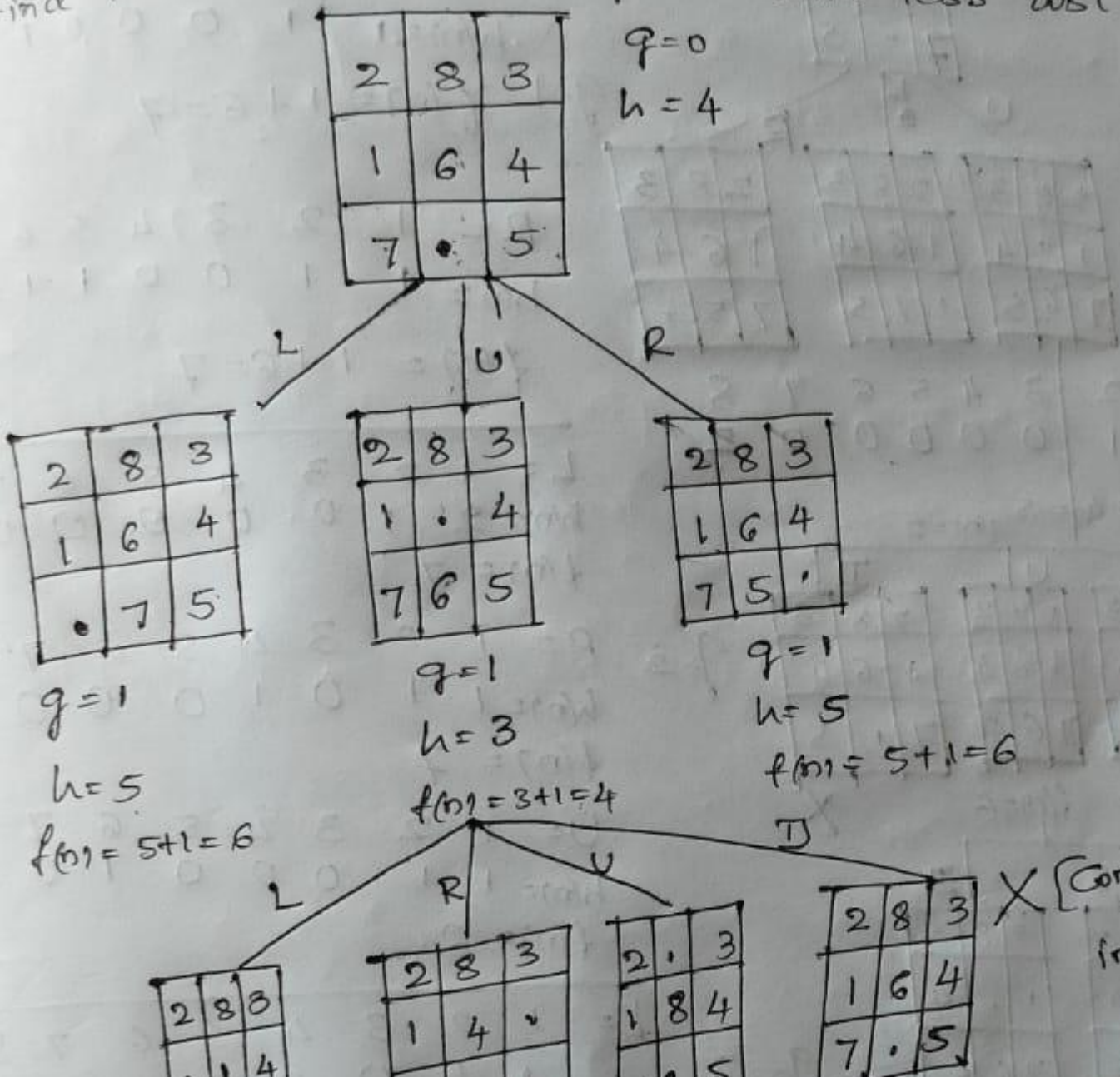
2	8	3
1	6	4
7		5

$g=0$

Final

1	2	3
8		4
7	6	5

Find the most effective path with less cost

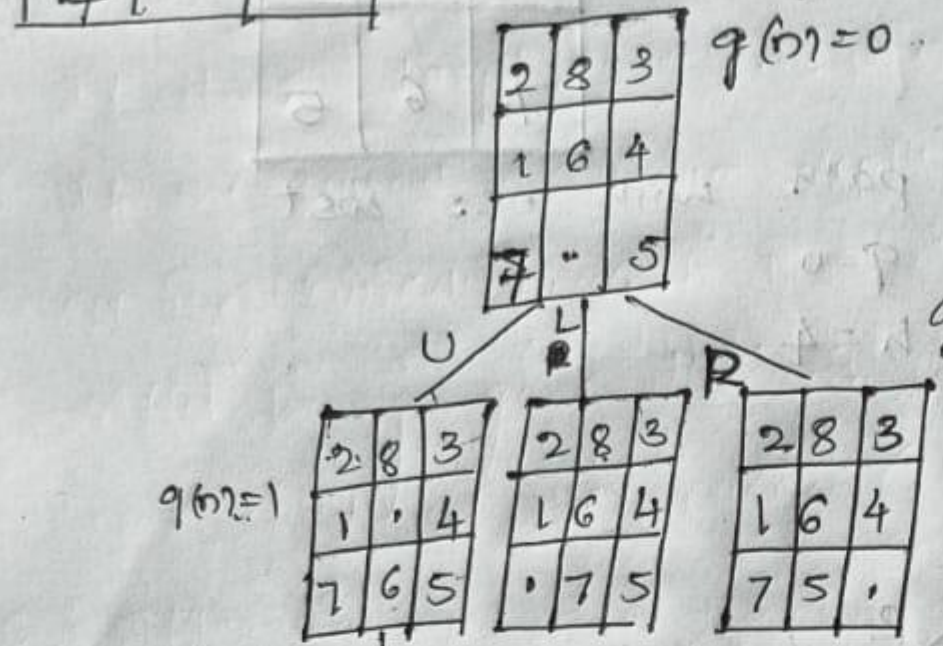


Draw the State Space Diagram For

Distance

Initial State

2	8	3
1	6	4
7		5



Fi

1	2	
8		
7	6	

L= 1 2

h(n)= 1 1

g=1 f(n) = 1

R= 1 2

h(n)= 1 1

f(n) = 1+

L= 1 2 3

h(n)= 2 1 0

f(n) = 7

R= 1 2 3

h(n)= 1 1 0

f(n) = 7

U= 1 2

h(n)= 1 1

f(n)= 6

L= 1 2 8

Code:
1: DFS

```
cnt = 0;
def print_state(in_array):
 global cnt
 cnt += 1
 for row in in_array:
  print(' '.join(str(num) for num in row))
 print()

def helper(goal, in_array, row, col, vis):

 vis[row][col] = 1
 drow = [-1, 0, 1, 0]
 dcol = [0, 1, 0, -1]
 dchange = ['U', 'R', 'D', 'L']

 print("Current state:")
 print_state(in_array)

 if in_array == goal:
  print_state(in_array)
  print(f"Number of states : {cnt}")
  return True


 for i in range(4):
  nrow = row + drow[i]
  ncol = col + dcol[i]

  if 0 <= nrow < len(in_array) and 0 <= ncol < len(in_array[0]) and not vis[nrow][ncol]:

    print(f"Took a {dchange[i]} move")
    in_array[row][col], in_array[nrow][ncol] = in_array[nrow][ncol], in_array[row][col]

    if helper(goal, in_array, nrow, ncol, vis):
      return True

    in_array[row][col], in_array[nrow][ncol] = in_array[nrow][ncol], in_array[row][col]


 vis[row][col] = 0
 return False


iniϴal_state = [[1, 2, 3], [0, 4, 6], [7, 5, 8]]
```

```
goal_state = [[1, 2, 3], [4, 5, 6], [7, 8, 0]]
visited = [[0] * 3 for _ in range(3)]
empty_row, empty_col = 1, 0
found_soluϴon = helper(goal_state, iniϴal_state, empty_row, empty_col, visited)
print("SoluϴOn found:", found_soluϴon)
```

Output :

```
Current state:
1 2 3
0 4 6
7 5 8

Took a U move
Current state:
0 2 3
1 4 6
7 5 8

Took a R move
Current state:
2 0 3
1 4 6
7 5 8

Took a R move
Current state:
2 3 0
1 4 6
7 5 8

Took a D move
Current state:
2 3 6
1 4 0
7 5 8

Took a D move
Current state:
2 3 6
1 4 8
7 5 0

Took a L move
Current state:
2 3 6
1 4 8
7 0 5

Took a U move
Current state:
2 3 6
1 0 8
7 4 5

Took a L move
Current state:
2 3 6
1 4 8
0 7 5

Took a L move
Current state:
2 3 6
1 0 4
7 5 8

Took a D move
Current state:
2 3 6
1 5 4
7 0 8

Took a R move
Current state:
2 3 6
1 5 4
7 8 0

Took a L move
Current state:
2 3 6
1 5 4
0 7 8

Took a D move
Current state:
2 4 3
1 0 6
7 5 8

Took a R move
Current state:
2 4 3
1 6 0
7 5 8

Took a U move
Current state:
2 4 0
1 6 3
7 5 8

Took a L move
Current state:
1 0 2
4 6 3
7 5 8

Took a L move
Current state:
0 1 2
4 6 3
7 5 8

Took a D move
Current state:
1 2 3
4 6 8
7 5 0

Took a L move
Current state:
1 2 3
4 6 8
7 0 5

Took a L move
Current state:
1 2 3
4 6 8
0 7 5

Took a D move
Current state:
1 2 3
4 5 6
7 0 8

Took a R move
Current state:
1 2 3
4 5 6
7 8 0

1 2 3
4 5 6
7 8 0

Number of states : 42
SoluΘon found: True
```

2 : Iterative deepening search

```
class PuzzleState:
    def __init__(self, board, empty_tile_pos, depth=0, path=[]):
        self.board = board
        self.empty_tile_pos = empty_tile_pos  # (row, col)
        self.depth = depth
        self.path = path  # Keep track of the path taken to reach this state

    def is_goal(self, goal):
        return self.board == goal

    def generate_moves(self):
        row, col = self.empty_tile_pos
        moves = []
        directions = [(-1, 0, 'Up'), (1, 0, 'Down'), (0, -1, 'Left'), (0, 1, 'Right')]  # up, down, left, right
        for dr, dc, move_name in directions:
            new_row, new_col = row + dr, col + dc
            if 0 <= new_row < 3 and 0 <= new_col < 3:
                new_board = self.board[:]
                new_board[row * 3 + col], new_board[new_row * 3 + new_col] = new_board[new_row *
3 + new_col], new_board[row * 3 + col]
                new_path = self.path + [move_name]  # Update the path with the new move
                moves.append(PuzzleState(new_board, (new_row, new_col), self.depth + 1, new_path))
        return moves

    def display(self):
        # Display the board in a matrix form
        for i in range(0, 9, 3):
            print(self.board[i:i + 3])
        print(f"Moves: {self.path}")  # Display the moves taken to reach this state
        print()  # Newline for better readability

def iddfs(initial_state, goal, max_depth):
    for depth in range(max_depth + 1):
        print(f"Searching at depth: {depth}")
        found = dls(initial_state, goal, depth)
        if found:
            print(f"Goal found at depth: {found.depth}")
            found.display()
            return found
    print("Goal not found within max depth.")
    return None

def dls(state, goal, depth):
    if state.is_goal(goal):
        return state
```

```
    if depth <= 0:
        return None

    for move in state.generate_moves():
        print("Current state:")
        move.display()  # Display the current state
        result = dls(move, goal, depth - 1)
        if result is not None:
            return result
    return None

def main():
    # User input for initial state, goal state, and maximum depth
    initial_state_input = input("Enter initial state (0 for empty tile, space-separated, e.g. '1 2 3 4 5 6 7 8
0'): ")
    goal_state_input = input("Enter goal state (0 for empty tile, space-separated, e.g. '1 2 3 4 5 6 7 8
0'): ")
    max_depth = int(input("Enter maximum depth: "))

    initial_board = list(map(int, initial_state_input.split()))
    goal_board = list(map(int, goal_state_input.split()))
    empty_tile_pos = initial_board.index(0) // 3, initial_board.index(0) % 3  # Calculate the position of
the empty tile

    initial_state = PuzzleState(initial_board, empty_tile_pos)

    solution = iddfs(initial_state, goal_board, max_depth)

if __name__ == "__main__":
    main()
```

Output :

```
Enter initial state (0 for empty tile, space-separated, e.g. '1 2 3 4 5 6 7 8 0'): 1 2 3 0 4 6 7 5 8
Enter goal state (0 for empty tile, space-separated, e.g. '1 2 3 4 5 6 7 8 0'): 1 2 3 4 5 6 7 8 0
Enter maximum depth: 2
Searching at depth: 0
Searching at depth: 1

Current state:
[0, 2, 3]
[1, 4, 6]
[7, 5, 8]
Moves: ['Up']

Current state:
[1, 2, 3]
[7, 4, 6]
[0, 5, 8]
Moves: ['Down']

Current state:
[1, 2, 3]
[4, 0, 6]
[7, 5, 8]
Moves: ['Right']

Searching at depth: 2
Current state:
[0, 2, 3]
[1, 4, 6]
[7, 5, 8]
Moves: ['Up']

Current state:
[1, 2, 3]
[0, 4, 6]
[7, 5, 8]
Moves: ['Up', 'Down']

Current state:
[2, 0, 3]
[1, 4, 6]
[7, 5, 8]
Moves: ['Up', 'Right']

Current state:
[1, 2, 3]
[7, 4, 6]
[0, 5, 8]
Moves: ['Down']

Current state:
[1, 2, 3]
[7, 4, 6]
[0, 5, 8]
Moves: ['Down']

Current state:
[1, 2, 3]
[0, 4, 6]
[7, 5, 8]
Moves: ['Down', 'Up']

Current state:
[1, 2, 3]
[7, 4, 6]
[5, 0, 8]
Moves: ['Down', 'Right']

Current state:
[1, 2, 3]
[4, 0, 6]
[7, 5, 8]
Moves: ['Right']

Current state:
[1, 0, 3]
[4, 2, 6]
[7, 5, 8]
Moves: ['Right', 'Up']

Current state:
[1, 2, 3]
[4, 5, 6]
[7, 0, 8]
Moves: ['Right', 'Down']

Current state:
[1, 2, 3]
[0, 4, 6]
[7, 5, 8]
Moves: ['Right', 'Left']

Current state:
[1, 2, 3]
[4, 6, 0]
[7, 5, 8]
Moves: ['Right', 'Right']

Goal not found within max depth.
```

Program 3

Implement A* search algorithm

Algorithm:
(You should provide the screen shot of your observation book of Algorithm/Logic/Solving of respective problem)

Algoritham for A* Search

Step1: Place the starting node in the open

Step2: Check if the open list is empty or
empty return failure and stops

Step3: Select the node from the open
the smallest value of evaluation fu
if node n is goal node then retur
stop, otherwise

Step4: Expand node n and generate all it
and put n into the closed list, For
Check wheather n is already in the
list, if not the compute evaluation
n and place into Open list

Step 5. Else if node n is already open a
should be attached to the back po
the lower g() value

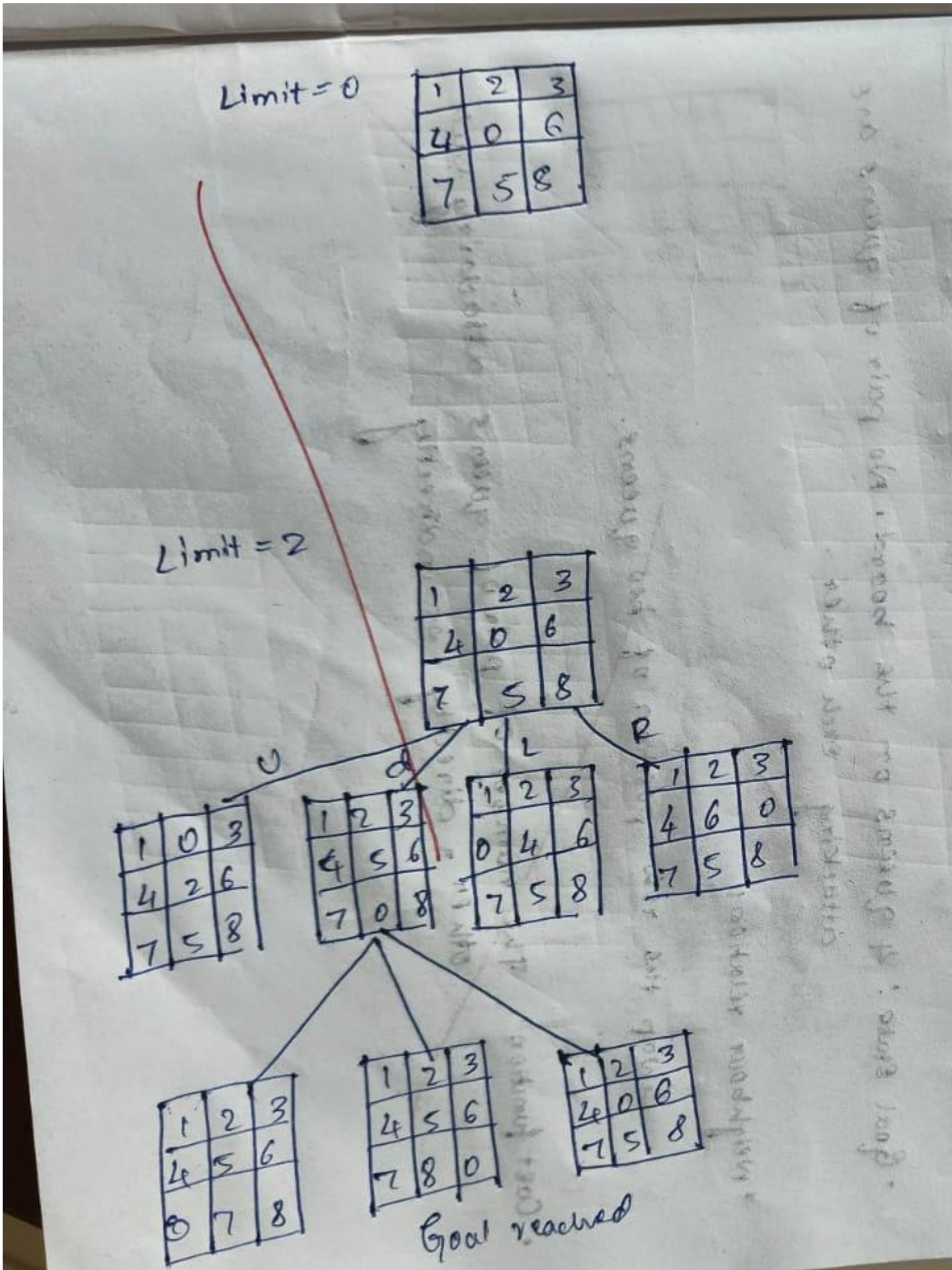
22/10/24

Implement Iterative Deepening

1. For each child of the current node
2. If it is target node, return
3. If the current maximum depth is reached, re
4. Set the current node to this node and go b
5. After having gone through all the children
   next child of the parent (the next sibbli
6. After having gone through all children o
   increase the maximum depth and go b
7. If we have reached all leaf, the goal

function ITERATIVE-DEEPINING SEARCH
a solution, or failure.

for depth = 0 to ∞
result ← Depth-Limited-Search (problem, de
if result ≠ cutoff then return result.


Limit = 0
Limit = 2
U
D
L
R
Goal reached

Code:

Misplaced Tiles :

```
class Node:
    def __init__(self, state, parent=None, move=None, cost=0):
        self.state = state
        self.parent = parent
        self.move = move
        self.cost = cost

    def heuristic(self):
        goal_state = [[1,2,3], [8,0,4], [7,6,5]]
        count = 0
        for i in range(len(self.state)):
            for j in range(len(self.state[i])):
                if self.state[i][j] != 0 and self.state[i][j] != goal_state[i][j]:
                    count += 1
        return count

def get_blank_position(state):
    for i in range(len(state)):
        for j in range(len(state[i])):
            if state[i][j] == 0:
                return i, j

def get_possible_moves(position):
    x, y = position
    moves = []
    if x > 0: moves.append((x - 1, y, 'Down'))
    if x < 2: moves.append((x + 1, y, 'Up'))
    if y > 0: moves.append((x, y - 1, 'Right'))
    if y < 2: moves.append((x, y + 1, 'Left'))
    return moves

def generate_new_state(state, blank_pos, new_blank_pos):
    new_state = [row[:] for row in state]
    new_state[blank_pos[0]][blank_pos[1]], new_state[new_blank_pos[0]][new_blank_pos[1]] = \
        new_state[new_blank_pos[0]][new_blank_pos[1]], new_state[blank_pos[0]][blank_pos[1]]
    return new_state

def a_star_search(initial_state):
    open_list = []
    closed_list = set()

    initial_node = Node(state=initial_state, cost=0)
```

```
    open_list.append(initial_node)

    while open_list:

        open_list.sort(key=lambda node: node.cost + node.heuristic())
        current_node = open_list.pop(0)


        move_description = current_node.move if current_node.move else "Start"
        print("Current state:")
        for row in current_node.state:
            print(row)
        print(f"Move: {move_description}")
        print(f"Heuristic value (misplaced tiles): {current_node.heuristic()}")
        print(f"Cost to reach this node: {current_node.cost}\n")

        if current_node.heuristic() == 0:

            path = []
            while current_node:
                path.append(current_node)
                current_node = current_node.parent
            return path[::-1]
        closed_list.add(tuple(map(tuple, current_node.state)))

        blank_pos = get_blank_position(current_node.state)
        for new_blank_pos in get_possible_moves(blank_pos):
            new_state = generate_new_state(current_node.state, blank_pos, (new_blank_pos[0],
new_blank_pos[1]))

            if tuple(map(tuple, new_state)) in closed_list:
                continue

            cost = current_node.cost + 1
            move_direction = new_blank_pos[2]
            new_node = Node(state=new_state, parent=current_node, move=move_direction, cost=cost)

            if new_node not in open_list:
                open_list.append(new_node)

    return None

initial_state = [[2,8,3], [1,6,4], [7,0,5]]
solution_path = a_star_search(initial_state)

if solution_path:
    print("Solution path:")
```

```
    for step in solution_path:
        for row in step.state:
            print(row)
        print()
else:
    print("No solution found.")
```

\

Output :

```
Current state:
[2, 8, 3]
[1, 6, 4]
[7, 0, 5]
Move: Start
Heuristic value (misplaced tiles): 4
Cost to reach this node: 0

Current state:
[2, 8, 3]
[1, 0, 4]
[7, 6, 5]
Move: Down
Heuristic value (misplaced tiles): 3
Cost to reach this node: 1

Current state:
[2, 0, 3]
[1, 8, 4]
[7, 6, 5]
Move: Down
Heuristic value (misplaced tiles): 3
Cost to reach this node: 2

Current state:
[2, 8, 3]
[0, 1, 4]
[7, 6, 5]
Move: Right
Heuristic value (misplaced tiles): 3
Cost to reach this node: 2

Current state:
[0, 2, 3]
[1, 8, 4]
[7, 6, 5]
Move: Right
Heuristic value (misplaced tiles): 2
Cost to reach this node: 3

Current state:
[1, 2, 3]
[0, 8, 4]
[7, 6, 5]
Move: Up
Heuristic value (misplaced tiles): 1
Cost to reach this node: 4

Current state:
[1, 2, 3]
[8, 0, 4]
[7, 6, 5]
Move: Left
Heuristic value (misplaced tiles): 0
Cost to reach this node: 5

Solution path:
[2, 8, 3]
[1, 6, 4]
[7, 0, 5]

[2, 8, 3]
[1, 0, 4]
[7, 6, 5]

[2, 0, 3]
[1, 8, 4]
[7, 6, 5]

[0, 2, 3]
[1, 8, 4]
[7, 6, 5]

[1, 2, 3]
[0, 8, 4]
[7, 6, 5]

[1, 2, 3]
[8, 0, 4]
[7, 6, 5]
```

Code :

Manhattan distance approach

```
class Node:
    def __init__(self, state, parent=None, move=None, cost=0):
        self.state = state
        self.parent = parent
        self.move = move
        self.cost = cost

    def heuristic(self):
        goal_positions = {
            1: (0, 0), 2: (0, 1), 3: (0, 2),
            8: (1, 0), 0: (1, 1), 4: (1, 2),
            7: (2, 0), 6: (2, 1), 5: (2, 2)
        }
        manhattan_distance = 0
        for i in range(len(self.state)):
            for j in range(len(self.state[i])):
                value = self.state[i][j]
                if value != 0:
                    goal_i, goal_j = goal_positions[value]
                    manhattan_distance += abs(i - goal_i) + abs(j - goal_j)
        return manhattan_distance

def get_blank_position(state):
    for i in range(len(state)):
        for j in range(len(state[i])):
            if state[i][j] == 0:
                return i, j

def get_possible_moves(position):
    x, y = position
    moves = []
    if x > 0: moves.append((x - 1, y, 'Down'))
    if x < 2: moves.append((x + 1, y, 'Up'))
    if y > 0: moves.append((x, y - 1, 'Right'))
    if y < 2: moves.append((x, y + 1, 'Left'))
    return moves

def generate_new_state(state, blank_pos, new_blank_pos):
    new_state = [row[:] for row in state]
    new_state[blank_pos[0]][blank_pos[1]], new_state[new_blank_pos[0]][new_blank_pos[1]] = \
        new_state[new_blank_pos[0]][new_blank_pos[1]], new_state[blank_pos[0]][blank_pos[1]]
    return new_state

def a_star_search(initial_state):
    open_list = []
```

```
    closed_list = set()

    initial_node = Node(state=initial_state, cost=0)
    open_list.append(initial_node)

    while open_list:

        open_list.sort(key=lambda node: node.cost + node.heuristic())
        current_node = open_list.pop(0)


        move_description = current_node.move if current_node.move else "Start"
        print("Current state:")
        for row in current_node.state:
            print(row)
        print(f"Move: {move_description}")
        print(f"Heuristic value (Manhattan distance): {current_node.heuristic()}")
        print(f"Cost to reach this node: {current_node.cost}\n")

        if current_node.heuristic() == 0:

            path = []
            while current_node:
                path.append(current_node)
                current_node = current_node.parent
            return path[::-1]
        closed_list.add(tuple(map(tuple, current_node.state)))

        blank_pos = get_blank_position(current_node.state)
        for new_blank_pos in get_possible_moves(blank_pos):
            new_state = generate_new_state(current_node.state, blank_pos, (new_blank_pos[0],
new_blank_pos[1]))

            if tuple(map(tuple, new_state)) in closed_list:
                continue

            cost = current_node.cost + 1
            move_direction = new_blank_pos[2]
            new_node = Node(state=new_state, parent=current_node, move=move_direction, cost=cost)

            if new_node not in open_list:
                open_list.append(new_node)

    return None

initial_state = [[2,8,3], [1,6,4], [7,0,5]]
solution_path = a_star_search(initial_state)
```

```
if solution_path:
    print("Solution path:")
    for step in solution_path:
        for row in step.state:
            print(row)
        print()
else:
    print("No solution found.")
```

Output :

```
Current state:
[2, 8, 3]
[1, 6, 4]
[7, 0, 5]
Move: Start
Heuristic value (Manhattan distance): 5
Cost to reach this node: 0

Current state:
[2, 8, 3]
[1, 0, 4]
[7, 6, 5]
Move: Down
Heuristic value (Manhattan distance): 4
Cost to reach this node: 1

Current state:
[2, 0, 3]
[1, 8, 4]
[7, 6, 5]
Move: Down
Heuristic value (Manhattan distance): 3
Cost to reach this node: 2

Current state:
[0, 2, 3]
[1, 8, 4]
[7, 6, 5]
Move: Right
Heuristic value (Manhattan distance): 2
Cost to reach this node: 3

Current state:
[1, 2, 3]
[8, 0, 4]
[7, 6, 5]
Move: Left
Heuristic value (Manhattan distance): 0
Cost to reach this node: 5

Solution path:
[2, 8, 3]
[1, 6, 4]
[7, 0, 5]

[2, 8, 3]
[1, 0, 4]
[7, 6, 5]

[2, 0, 3]
[1, 8, 4]
[7, 6, 5]

[0, 2, 3]
[1, 8, 4]
[7, 6, 5]

[1, 2, 3]
[0, 8, 4]
[7, 6, 5]

[1, 2, 3]
[8, 0, 4]
[7, 6, 5]
```

Program 4

Implement Hill Climbing search algorithm to solve N-Queens problem

Algorithm:

(You should provide the screen shot of your observation book of Algorithm/Logic/Solving of respective problem)

22/10/2024

Implement Hill Climbing Search Alg To S

Function HILL-CLIMBING (problem) returns
is a local maxima

current ← MAKE-NODE (problem.INITIA

loop do

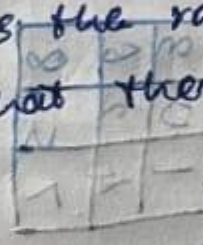
neighbor ← a highest-valued successor

if neighbour.VALUE ≤ current.VALUE

current.STATE

current ← neighbour.

State: 4 queens or the board. One queen



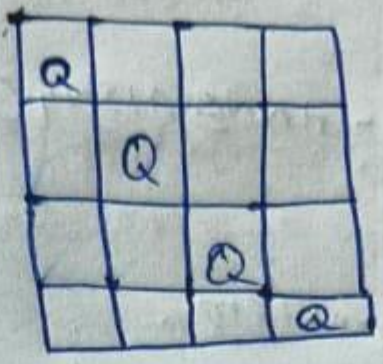
-Variables x_0, x_1, x_2, x_3 where x_i is the ro
queue in column i. Assume that the
per column.

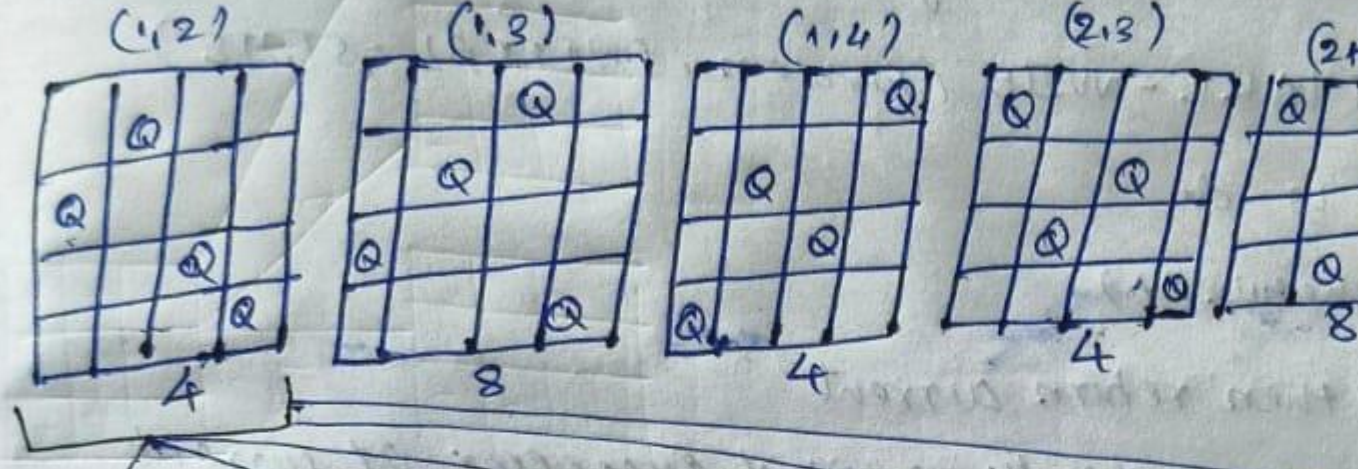
-Domain for each variable: $x_i \in \{0,1,2,3\}$

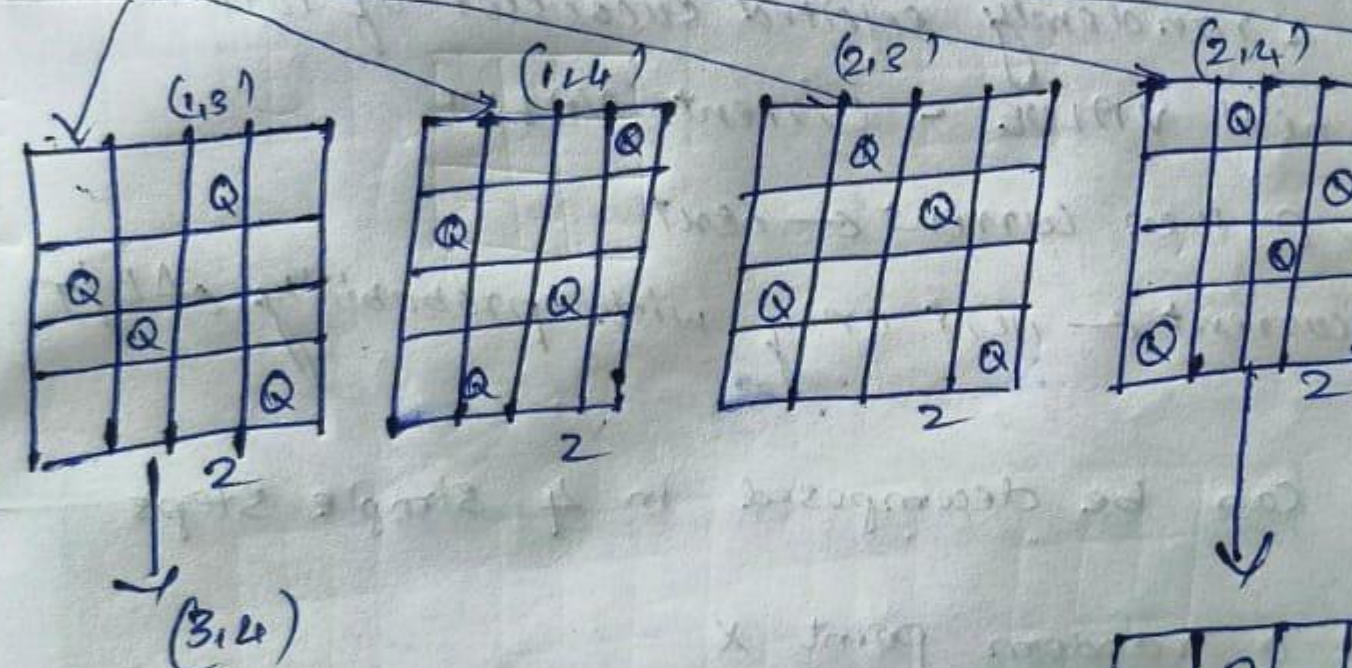
- Initial state: a random state

- Goal state: 4 queens on the board. No pa

State Space tree







Code:

```
import random
def calculate_cost(board):
    n = len(board)
    attacks = 0
    for i in range(n):
        for j in range(i + 1, n):
            if board[i] == board[j]:  # Same column
                attacks += 1
            if abs(board[i] - board[j]) == abs(i - j):  # Same diagonal
                attacks += 1
    return attacks


def get_neighbors(board):
    neighbors = []
    n = len(board)
    for col in range(n):
        for row in range(n):
            if row != board[col]:  # Only change the row of the queen
                new_board = board[:]
                new_board[col] = row
                neighbors.append(new_board)
    return neighbors
```

```
def hill_climb(board, max_restarts=100):
    current_cost = calculate_cost(board)
    print("Initial board configuration:")
    print_board(board, current_cost)
    iteration = 0
    restarts = 0

    while restarts < max_restarts:  # Add limit to the number of restarts
        while current_cost != 0:  # Continue until cost is zero
            neighbors = get_neighbors(board)
            best_neighbor = None
            best_cost = current_cost

            for neighbor in neighbors:
                cost = calculate_cost(neighbor)
                if cost < best_cost:  # Looking for a lower cost
                    best_cost = cost
                    best_neighbor = neighbor

            if best_neighbor is None:  # No better neighbor found
                break  # Break the loop if we are stuck at a local minimum

            board = best_neighbor
            current_cost = best_cost
```

```
            iteration += 1
            print(f"Iteration {iteration}:")
            print_board(board, current_cost)

        if current_cost == 0:
            break  # We found the solution, no need for further restarts
        else:
            # Restart with a new random configuration
            board = [random.randint(0, len(board)-1) for _ in range(len(board))]
            current_cost = calculate_cost(board)
            restarts += 1
            print(f"Restart {restarts}:")
            print_board(board, current_cost)

    return board, current_cost

def print_board(board, cost):
    n = len(board)
    display_board = [['.'] * n for _ in range(n)]  # Create an empty board
    for col in range(n):
        display_board[board[col]][col] = 'Q'  # Place queens on the board
    for row in range(n):
        print(' '.join(display_board[row]))  # Print the board
```

```
    print(f"Cost: {cost}\n")


if __name__ == "__main__":
    n = int(input("Enter the number of queens (N): "))  # User input for N
    initial_state = list(map(int, input(f"Enter the initial state (row numbers for each column, space-separated): ").split()))
    if len(initial_state) != n or any(r < 0 or r >= n for r in initial_state):
        print("Invalid initial state. Please ensure it has N elements with values from 0 to N-1.")
    else:
        solution, cost = hill_climb(initial_state)
        if cost == 0:
            print(f"Solution found with no conflicts:")
        else:
            print(f"No solution found within the restart limit:")
        print_board(solution, cost)
```

Output :

```
Enter the number of queens (N): 4
Enter the initial state (row numbers for each column, space-separated): 0 1 2 3
Initial board configuration:
```

```
Q . . .
. Q . .
. . Q .
. . . Q
Cost: 6

Iteration 1:
. . . .
Q Q . .
. . Q .
. . . Q
Cost: 4

Iteration 2:
. Q . .
Q . . .
. . Q .
. . . Q
Cost: 2

Restart 1:
. Q Q Q
. . . .
. . . .
Q . . .
Cost: 4

Iteration 3:
. Q . Q
. . . .
. . Q .
Q . . .
Cost: 2

Iteration 4:
. Q . .
. . . Q
. . Q .
Q . . .
Cost: 1

Restart 2:
. . . Q
. Q . .
. . . .
Q . Q .
Cost: 2

Iteration 6:
. . . .
. Q . .
. . Q Q
Q . . .
Cost: 2

Iteration 7:
. . Q .
. Q . .
. . . Q
Q . . .
Cost: 1

Restart 4:
Q . . .
. Q . Q
. . Q .
. . . .
Cost: 5

Iteration 8:
Q . . .
. Q . Q
. . . .
. . Q .
Cost: 2

Iteration 9:
Q Q . .
. . . Q
. . . .
. . Q .
Cost: 1

Iteration 10:
. Q . .
. . . Q
Q . . .
. . Q .
Cost: 0

Solution found with no conflicts:
. Q . .
. . . Q
Q . . .
. . Q .
Cost: 0
```

Program 5

Simulated Annealing to Solve 8-Queens problem

Algorithm:
(You should provide the screen shot of your observation book of Algorithm/Logic/Solving of respective problem)

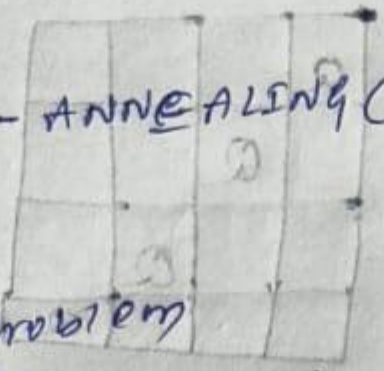
29/10/2024

Write a program to implement Simu

Algorithm

function SIMULATED-ANNEALING (Problem, sc

a solution state



inputs: problem, a problem

schedule, a mapping from time to

current ← MAKE-NODE (problem. INITI

for t = 1 to ∞ do

T ← schedule (t)

if T = 0 then return current

next ← a randomly selected successo

ΔE ← next VALUE - current VALU

if ΔE > 0 then current ← next

else current ← next only with pr

The algorithm can be decomposed in 4

. . Q . . . . .
. . . . . Q . .
. . . . . Q
. Q . . . . . .
. . . Q . . . .
Q . . . . . .
. . . . . Q .
. . . . Q . . .

② Tower of Hanoi problem

Best state (final configuration): [2 2 2

Number of correct disks on destinatio

peg 0: [ ]
peg 1: [ ]
peg 2: [0, 1, 2]

889

29/10/24

Code:

```
#!pip install mlrose-hiive joblib
#!pip install --upgrade joblib
#!pip install joblib==1.1.0
import mlrose_hiive as mlrose
import numpy as np

def queens_max(position):
    no_attack_on_j = 0
    queen_not_attacking = 0
    for i in range(len(position) - 1):
        no_attack_on_j = 0
        for j in range(i + 1, len(position)):
            if (position[j] != position[i]) and (position[j] != position[i] + (j - i)) and (position[j] !=
            position[i] - (j - i)):
                no_attack_on_j += 1
        if (no_attack_on_j == len(position) - 1 - i):
            queen_not_attacking += 1
    if (queen_not_attacking == 7):
        queen_not_attacking += 1
    return queen_not_attacking

objective = mlrose.CustomFitness(queens_max)

problem = mlrose.DiscreteOpt(length=8, fitness_fn=objective, maximize=True, max_val=8)
T = mlrose.ExpDecay()

initial_position = np.array([4, 6, 1, 5, 2, 0, 3, 7])

#The simulated_annealing function returns 3 values, we need to capture all 3
best_position, best_objective, fitness_curve = mlrose.simulated_annealing(problem=problem,
schedule=T, max_attempts=500,
                                          init_state=initial_position)

print('The best position found is:', best_position)
print('The number of queens that are not attacking each other is:', best_objective)
```

Output :

```
The best position found is: [4 0 7 5 2 6 1 3]
The number of queens that are not attacking each other is: 8.0
```

Program 6

Create a knowledge base using propositional logic and show that the given query entails the knowledge base or not.

Algorithm:
(You should provide the screen shot of your observation book of Algorithm/Logic/Solving of respective problem)

12-11-2024 LAB-6

Truth-table enumeration algorithm for d
Propositional entailment

A truth-table enumeration algorithm for d
propositional entailment. CTT stands for tr
returns true if a sentance holds within a
variable model represents a partial mode
to some of the symbols. The keyword "
as a logic operation on its two argume
true or false.

function TT-ENTAILS ?(KB, α) returns tr
inputs : KB, the knowledge base, a sent
propositional logic α, the query, a se
propositional logic

Symbols ← a list of the proposition sy
return TT-CHECK-ALL(KB, α, symbols, {}

function TT-CHECK-ALL(KB, α, symbols, mo
or false if EMPTY?(symbols) th

$\alpha = A \vee B$ $KB = (A \vee C) \wedge (B \vee \neg C)$

A	B	C	$A \vee C$	$B \vee \neg C$	KB
F	F	F	F	T	F
F	F	T	T	F	F
F	T	F	F	T	F
F	T	T	T	T	T
T	F	F	T	T	T
T	F	T	T	F	F
T	T	F	T	T	T
T	T	T	T	T	T

12/11/24

Code:

```
import pandas as pd

# Define the truth table for all combinations of A, B, C
truth_values = [(False, False, False),
                (False, False, True),
                (False, True, False),
                (False, True, True),
                (True, False, False),
                (True, False, True),
                (True, True, False),
                (True, True, True)]

# Columns: A, B, C
table = pd.DataFrame(truth_values, columns=["A", "B", "C"])

# Calculate intermediate columns
table["A or C"] = table["A"] | table["C"]       # A ∨ C
table["B or not C"] = table["B"] | ~table["C"]   # B ∨ ¬C

# Knowledge Base (KB): (A ∨ C) ∧ (B ∨ ¬C)
table["KB"] = table["A or C"] & table["B or not C"]

# Alpha (α): A ∨ B
table["Alpha (α)"] = table["A"] | table["B"]

# Define a highlighting function
def highlight_rows(row):
    if row["KB"] and row["Alpha (α)"]:
        return ['font-weight: bold; color: black'] * len(row)
    else:
        return [''] * len(row)

# Apply the highlighting function
styled_table = table.style.apply(highlight_rows, axis=1)

# Display the styled table
styled_table
```

Output :

	A	B	C	A or C	B or not C	KB	Alpha (α)
0	False	False	False	False	True	False	False
1	False	False	True	True	False	False	False
2	False	True	False	False	True	False	True
3	**False**	**True**	**True**	**True**	**True**	**True**	**True**
4	**True**	**False**	**False**	**True**	**True**	**True**	**True**
5	True	False	True	True	False	False	True
6	**True**	**True**	**False**	**True**	**True**	**True**	**True**
7	**True**	**True**	**True**	**True**	**True**	**True**	**True**

Program 7

Implement unification in first order logic

Algorithm:
(You should provide the screen shot of your observation book of Algorithm/Logic/Solving of respective problem)

19-11-2024

Implement Unification in First

Algorithm: Unify(ψ_1, ψ_2)

Step 1: if ψ_1, ψ_2 is a variable or constant

a) If ψ_1 or ψ_2 are identical, then ret

b) Else if ψ_1 is a variable,

a. then if ψ_1 occures in ψ_2, then

b. Else return $\{(\psi_2 / \psi_1)\}$.

c) Else if ψ_2 is a variable,

a. If ψ_2 occures in ψ_1 then retur

b. Else return $\{(\psi_1 / \psi_2)\}$.

d) Else return FAILURE

Step 2: If the initial Predicate symbol in ψ_1 not same, then return FAILURE

Step 3: IF ψ_1 and ψ_2 have a differeint num arguments, then return FAILURE

Step 4: Set substitution set (SUBST) to NIL

Code:

```
import re

def occurs_check(var, x):
    """Checks if var occurs in x (to prevent circular substitutions)."""
    if var == x:
        return True
    elif isinstance(x, list):  # If x is a compound expression (like a function or predicate)
        return any(occurs_check(var, xi) for xi in x)
    return False


def unify_var(var, x, subst):
    """Handles unification of a variable with another term."""
    if var in subst:  # If var is already substituted
        return unify(subst[var], x, subst)
    elif isinstance(x, (list, tuple)) and tuple(x) in subst:  # Handle compound expressions
        return unify(var, subst[tuple(x)], subst)
    elif occurs_check(var, x):  # Check for circular references
        return "FAILURE"
    else:
        # Add the substitution to the set (convert list to tuple for hashability)
        subst[var] = tuple(x) if isinstance(x, list) else x
        return subst


def unify(x, y, subst=None):
    """
    Unifies two expressions x and y and returns the substitution set if they can be unified.
    Returns 'FAILURE' if unification is not possible.
    """
    if subst is None:
        subst = {}  # Initialize an empty substitution set

    # Step 1: Handle cases where x or y is a variable or constant
    if x == y:  # If x and y are identical
        return subst
    elif isinstance(x, str) and x.islower():  # If x is a variable
        return unify_var(x, y, subst)
    elif isinstance(y, str) and y.islower():  # If y is a variable
        return unify_var(y, x, subst)
    elif isinstance(x, list) and isinstance(y, list):  # If x and y are compound expressions (lists)
        if len(x) != len(y):  # Step 3: Different number of arguments
            return "FAILURE"

        # Step 2: Check if the predicate symbols (the first element) match
```

```
        if x[0] != y[0]:  # If the predicates/functions are different
            return "FAILURE"

        # Step 5: Recursively unify each argument
        for xi, yi in zip(x[1:], y[1:]):  # Skip the predicate (first element)
            subst = unify(xi, yi, subst)
            if subst == "FAILURE":
                return "FAILURE"
        return subst
    else:  # If x and y are different constants or non-unifiable structures
        return "FAILURE"


def unify_and_check(expr1, expr2):
    """
    Attempts to unify two expressions and returns a tuple:
    (is_unified: bool, substitutions: dict or None)
    """
    result = unify(expr1, expr2)
    if result == "FAILURE":
        return False, None
    return True, result


def display_result(expr1, expr2, is_unified, subst):
    print("Expression 1:", expr1)
    print("Expression 2:", expr2)
    if not is_unified:
        print("Result: Unification Failed")
    else:
        print("Result: Unification Successful")
        print("Substitutions:", {k: list(v) if isinstance(v, tuple) else v for k, v in subst.items()})


def parse_input(input_str):
    """Parses a string input into a structure that can be processed by the unification algorithm."""
    # Remove spaces and handle parentheses
    input_str = input_str.replace(" ", "")

    # Handle compound terms (like p(x, f(y)) -> ['p', 'x', ['f', 'y']])
    def parse_term(term):
        # Handle the compound term
        if '(' in term:
            match = re.match(r'([a-zA-Z0-9_]+)\((.*)\)', term)
            if match:
                predicate = match.group(1)
                arguments_str = match.group(2)
```

```
            arguments = [parse_term(arg.strip()) for arg in arguments_str.split(',')]
            return [predicate] + arguments
        return term

    return parse_term(input_str)


# Main function to interact with the user
def main():
    while True:
        # Get the first and second terms from the user
        expr1_input = input("Enter the first expression (e.g., p(x, f(y))): ")
        expr2_input = input("Enter the second expression (e.g., p(a, f(z))): ")

        # Parse the input strings into the appropriate structures
        expr1 = parse_input(expr1_input)
        expr2 = parse_input(expr2_input)

        # Perform unification
        is_unified, result = unify_and_check(expr1, expr2)

        # Display the results
        display_result(expr1, expr2, is_unified, result)

        # Ask the user if they want to run another test
        another_test = input("Do you want to test another pair of expressions? (yes/no): ").strip().lower()
        if another_test != 'yes':
            break


if __name__ == "__main__":
    main()
```

Output :

```
Enter the first expression (e.g., p(x, f(y))): p(b,x,f(g(z)))
Enter the second expression (e.g., p(a, f(z))): p(z,f(y),f(y))
Expression 1: ['p', 'b', 'x', ['f', ['g', 'z']]]
Expression 2: ['p', 'z', ['f', 'y'], ['f', 'y']]
Result: Unification Successful
Substitutions: {'b': 'z', 'x': ['f', 'y'], 'y': ['g', 'z']}
Do you want to test another pair of expressions? (yes/no): yes
Enter the first expression (e.g., p(x, f(y))): p(x,h(y))
Enter the second expression (e.g., p(a, f(z))): p(a,f(z))
Expression 1: ['p', 'x', ['h', 'y']]
Expression 2: ['p', 'a', ['f', 'z']]
Result: Unification Failed
Do you want to test another pair of expressions? (yes/no): yes
Enter the first expression (e.g., p(x, f(y))): p(f(a),g(y))
Enter the second expression (e.g., p(a, f(z))): p(x,x)
Expression 1: ['p', ['f', 'a'], ['g', 'y']]
Expression 2: ['p', 'x', 'x']
Result: Unification Failed
Do you want to test another pair of expressions? (yes/no): no
```

Program 8

Create a knowledge base consisting of first order logic statements and prove the given query using forward reasoning.

Algorithm:

(You should provide the screen shot of your observation book of Algorithm/Logic/Solving of respective problem)

First Order Logic

Q) Create a knowledge base consisting
Logic Statements and prove the g
using forward reasoning

function FOL-FC-ASK (KB, α) returns a sub

input: KB, the knowledge base, a
definite clauses α, the query,

local variables: new, the new sentences
each iteration.

repeat until: new is empty.

new ← { }

for each rule in KB do

(A ∧ ... ∧ Pn ⇒ q) ← STA
VA

· for each θ such that SUBSET(θ, P
SUBSET(θ,

Representation in FOL

-> It is a crime for an American to sell we
nations.

Let's say p,q and r are variables.

American(p) ∧ weapon(q) ∧ sells(p,q,r) ∧ t

-> Country A has some missiles

∃x owns(A,x) ∧ missile(x)

Existential Instantiation, introducing a

owns(A,T1)

Missile(T1)

-> All the missiles were sold to countr

∀x Missile(x) ∧ owns(A,x) ⇒ sells(

-> Missiles are weapons

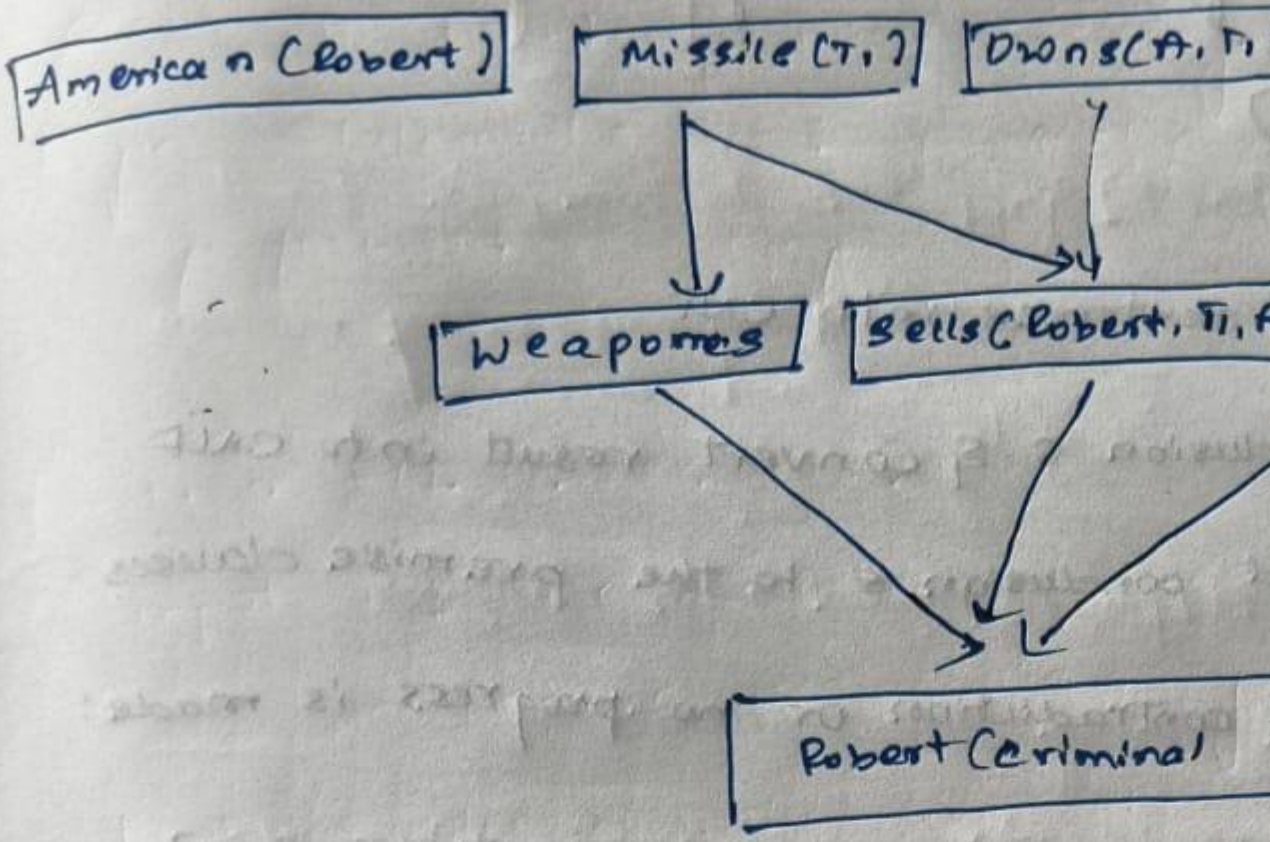
Missibles(x) ⇒ weapon(x)

Robert

Amer

-> Enemy of American is known a host

∀x Enemy(x,America) ⇒ Hostile(x)



American (P) ∧ Weapon (Q) ∧ sells (P, Q, R)

⇒ Criminal (P)

Code:

```
class KnowledgeBase:
    def __init__(self):
        self.facts = set()   # Set of known facts
        self.rules = []      # List of rules

    def add_fact(self, fact):
        self.facts.add(fact)

    def add_rule(self, rule):
        self.rules.append(rule)

    def infer(self):
        inferred = True
        while inferred:
            inferred = False
            for rule in self.rules:
                if rule.apply(self.facts):
                    inferred = True

# Define the Rule class
class Rule:
    def __init__(self, premises, conclusion):
        self.premises = premises  # List of conditions
        self.conclusion = conclusion  # Conclusion to add if premises are met

    def apply(self, facts):
        if all(premise in facts for premise in self.premises):
            if self.conclusion not in facts:
                facts.add(self.conclusion)
                print(f"Inferred: {self.conclusion}")
                return True
        return False

# Initialize the knowledge base
kb = KnowledgeBase()

# Facts in the problem
kb.add_fact("American(Robert)")
kb.add_fact("Missile(T1)")
kb.add_fact("Owns(A, T1)")
kb.add_fact("Enemy(A, America)")

# Rules based on the problem
# 1. Missile(x) implies Weapon(x)
kb.add_rule(Rule(["Missile(T1)"], "Weapon(T1)"))
```

```
# 2. Enemy(x, America) implies Hostile(x)
kb.add_rule(Rule(["Enemy(A, America)"], "Hostile(A)"))

# 3. Missile(x) and Owns(A, x) imply Sells(Robert, x, A)
kb.add_rule(Rule(["Missile(T1)", "Owns(A, T1)"], "Sells(Robert, T1, A)"))

# 4. American(p) and Weapon(q) and Sells(p, q, r) and Hostile(r) imply Criminal(p)
kb.add_rule(Rule(["American(Robert)", "Weapon(T1)", "Sells(Robert, T1, A)", "Hostile(A)"],
"Criminal(Robert)"))

# Infer new facts based on the rules
kb.infer()

# Check if Robert is a criminal
if "Criminal(Robert)" in kb.facts:
    print("Conclusion: Robert is a criminal.")
else:
    print("Conclusion: Unable to prove Robert is a criminal.")
```

Output :

```
Inferred: Weapon(T1)
Inferred: Hostile(A)
Inferred: Sells(Robert, T1, A)
Inferred: Criminal(Robert)
Conclusion: Robert is a criminal.
```

Program 9

Create a knowledge base consisting of first order logic statements and prove the given query using Resolution

Algorithm:

(You should provide the screen shot of your observation book of Algorithm/Logic/Solving of respective problem)

26-11-2024

4) Convert a first order logic Statemen

Resolution

1. Convert all sentences into CNF

2. Negative conclusion S & convert result in

3. Add negated conclusion S to the premis

4. Repeat until contradiction or no progress

a. Select 2 clauses (call them present c

b. Resolve them together performing all unifications.

c. if resolvent is the empty clause, a con has been found (i.e. S follows from th

d. if not, add resolvent to the premises.

If we succesed in step 4, we have proved Conclusion.

Program Number 9 example

Resolution in First-Order Logic

Basic steps for proving a conclusion S given premis

1> Convert all sentences to CNF

2> Negate conclusion S & convert result to CNF

3> Add negated conclusion S to the premise clause

4> Repeat until contradiction or no progress is mad

Proof by Resolution

Given the KB or Premises.

John likes all kind of food.

Apple and vegetables are food.

Anything anyone eats and not killed is food.

Anil eats peanuts and still alive.

Harry eats everything that anil eats.

Anyone who is alive implies not killed.

Anyone who is not killed implies alive.

Representation in FOL

Given the KB or Premises.

a) John likes all kind of food

b) Apple and vegetables are food

c) Anything Anyone eats and not killed is food.

d) Anil eats peanuts and still alive

e) Harry eats everything that Anil eats.

f) Anyone who is alive implies not killed

g) Anyone who is not killed implies alive

h) likes(John, Peanuts)
John likes peanuts

a) $\forall x$: food(x) $\rightarrow$ likes (Joh

b) food(apple) $\wedge$ food (veg

c) $\forall x \forall y \neg$ eats (x, y) $\vee$ kill
food (y)

d) eats(Anil, Peanuts) $\wedge$ al

e) $\forall x \neg$ eats(Anil, x) $\vee$ eats

f) $\forall x$ killed(x) ~~$\vee$ eats (Harry~~
alive (x

g) $\forall x \neg$ alive(x) $\vee \neg$ killed

h) likes (John, Peanuts)

Code:

```
from sympy import symbols, And, Or, Not, Implies, to_cnf

# Define constants (entities in the problem)
John, Anil, Harry, Apple, Vegetables, Peanuts = symbols('John Anil Harry Apple Vegetables
Peanuts')
x, y = symbols('x y')

# Define predicates as symbols
Food = lambda x: symbols(f'Food({x})')
Eats = lambda a, b: symbols(f'Eats({a},{b})')
Likes = lambda a, b: symbols(f'Likes({a},{b})')
Alive = lambda a: symbols(f'Alive({a})')
Killed = lambda a: symbols(f'Killed({a})')

# Knowledge Base (Premises) in First-Order Logic
premises = [
    # 1. John likes all kinds of food: Food(x) → Likes(John, x)
    Implies(Food(x), Likes(John, x)),

    # 2. Apples and vegetables are food: Food(Apple) ∧ Food(Vegetables)
    And(Food(Apple), Food(Vegetables)),

    # 3. Anything anyone eats and is not killed is food:
    # (Eats(y, x) ∧ ¬Killed(y)) → Food(x)
    Implies(And(Eats(y, x), Not(Killed(y))), Food(x)),

    # 4. Anil eats peanuts and is still alive:
    # Eats(Anil, Peanuts) ∧ Alive(Anil)
    And(Eats(Anil, Peanuts), Alive(Anil)),

    # 5. Harry eats everything that Anil eats:
    # Eats(Anil, x) → Eats(Harry, x)
    Implies(Eats(Anil, x), Eats(Harry, x)),

    # 6. Anyone who is alive implies not killed:
    # Alive(x) → ¬Killed(x)
    Implies(Alive(x), Not(Killed(x))),

    # 7. Anyone who is not killed implies alive:
    # ¬Killed(x) → Alive(x)
    Implies(Not(Killed(x)), Alive(x)),
]

# Negated conclusion to prove: ¬Likes(John, Peanuts)
negated_conclusion = Not(Likes(John, Peanuts))
```

```
# Convert all premises and the negated conclusion to Conjunctive Normal Form (CNF)
cnf_clauses = [to_cnf(premise, simplify=True) for premise in premises]
cnf_clauses.append(to_cnf(negated_conclusion, simplify=True))

# Function to resolve two clauses
def resolve(clause1, clause2):
    """
    Resolve two CNF clauses to produce resolvents.
    """
    clause1_literals = clause1.args if isinstance(clause1, Or) else [clause1]
    clause2_literals = clause2.args if isinstance(clause2, Or) else [clause2]
    resolvents = []
    for literal in clause1_literals:
        if Not(literal) in clause2_literals:
            # Remove the literal and its negation and combine the rest
            new_clause = Or(
                *[l for l in clause1_literals if l != literal],
                *[l for l in clause2_literals if l != Not(literal)]
            ).simplify()
            resolvents.append(new_clause)
    return resolvents

# Function to perform resolution on the set of CNF clauses
def resolution(cnf_clauses):
    """
    Perform resolution on CNF clauses to check for a contradiction.
    """
    clauses = set(cnf_clauses)
    new_clauses = set()
    while True:
        clause_list = list(clauses)
        for i in range(len(clause_list)):
            for j in range(i + 1, len(clause_list)):
                resolvents = resolve(clause_list[i], clause_list[j])
                if False in resolvents:  # Empty clause found
                    return True  # Contradiction found; proof succeeded
                new_clauses.update(resolvents)
        if new_clauses.issubset(clauses):  # No new information
            return False  # No contradiction; proof failed
        clauses.update(new_clauses)

# Perform resolution to check if the conclusion follows
result = resolution(cnf_clauses)
print("Does John like peanuts? ", "Yes, proven by resolution." if result else "No, cannot be proven.")
```

OUTPUT:

```
Does John like peanuts?  Yes, proven by resolution.
```

Program 10

Implement Alpha-Beta Pruning.

Algorithm:
(You should provide the screen shot of your observation book of Algorithm/Logic/Solving of respective problem)

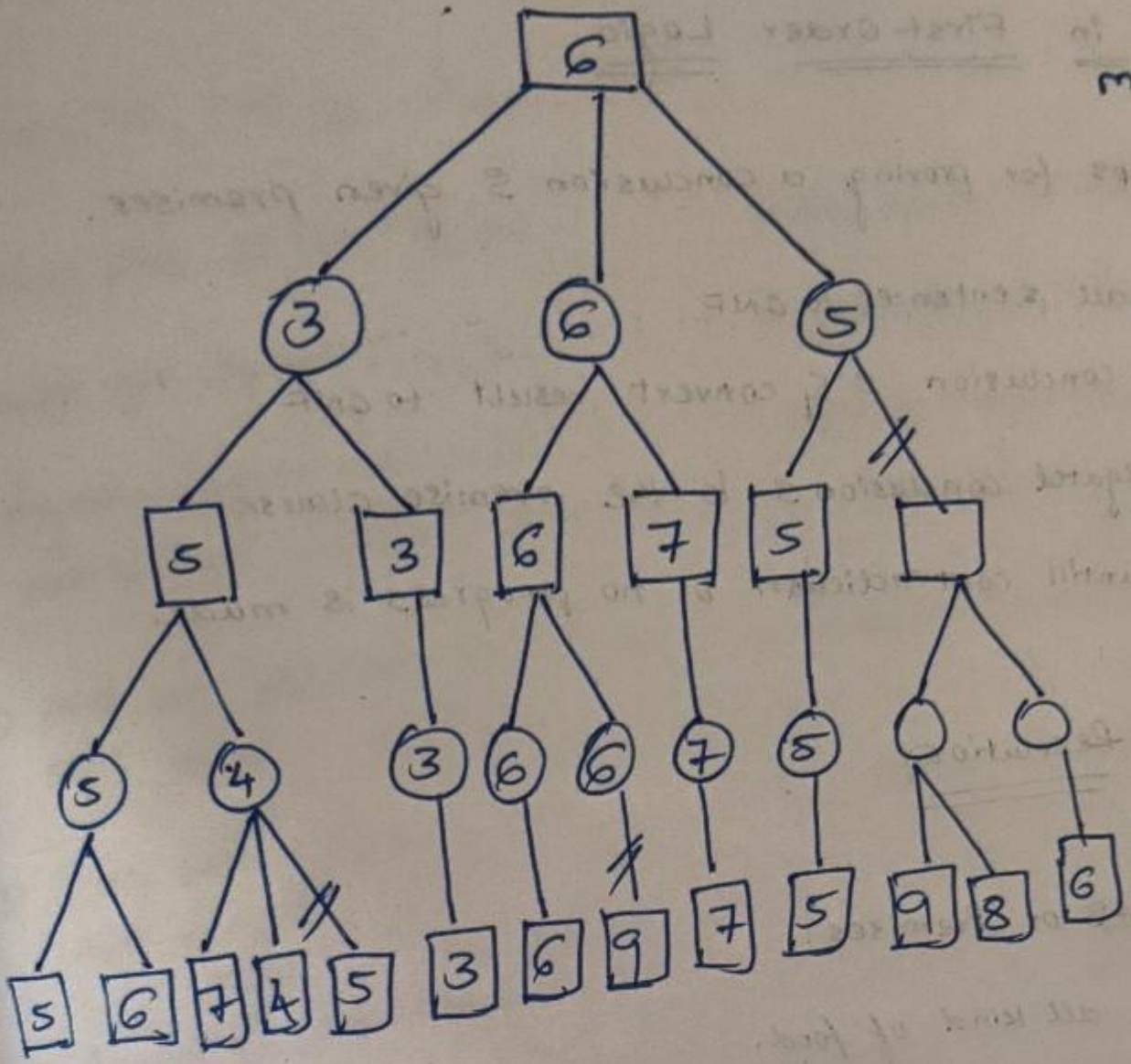
Alpha Beta Pruning Algorithm

Alpha(α) - Beta(β) proposes to compute fi
the optimal path without looking at every n
the game tree

Max contains Alpha(α) and Min contains
Beta(β) bound during the calculation.
In both MIN and MAX node, we return when
with compares with its parent node only
Both minimax and Alpha(α) - Beta(β) cut-
give same path
Alpha(α) - Beta(β) gives optimal solution as
takes less time to get the value for the ro

Input
□ max
○ min

output



Code:

```
# Python3 program to demonstrate
# working of Alpha-Beta Pruning with detailed step output

# Initial values of Alpha and Beta
MAX, MIN = 1000, -1000

# Returns the optimal value for the current player
def minimax(depth, nodeIndex, maximizingPlayer, values, alpha, beta):
    # Terminating condition: leaf node is reached
    if depth == 3:
        print(f"Leaf node reached: Depth={depth}, NodeIndex={nodeIndex},
Value={values[nodeIndex]}")
        return values[nodeIndex]

    if maximizingPlayer:
        best = MIN
        print(f"Maximizer: Depth={depth}, NodeIndex={nodeIndex}, Alpha={alpha}, Beta={beta}")
        # Recur for left and right children
        for i in range(2):
            val = minimax(depth + 1, nodeIndex * 2 + i, False, values, alpha, beta)
            best = max(best, val)
            alpha = max(alpha, best)
            print(f"Maximizer updated: Depth={depth}, NodeIndex={nodeIndex}, Best={best},
Alpha={alpha}, Beta={beta}")
            # Alpha Beta Pruning
            if beta <= alpha:
                print(f"Maximizer Pruned: Depth={depth}, NodeIndex={nodeIndex}, Alpha={alpha},
Beta={beta}")
                break
        return best
    else:
        best = MAX
        print(f"Minimizer: Depth={depth}, NodeIndex={nodeIndex}, Alpha={alpha}, Beta={beta}")
        # Recur for left and right children
        for i in range(2):
            val = minimax(depth + 1, nodeIndex * 2 + i, True, values, alpha, beta)
            best = min(best, val)
            beta = min(beta, best)
            print(f"Minimizer updated: Depth={depth}, NodeIndex={nodeIndex}, Best={best},
Alpha={alpha}, Beta={beta}")
            # Alpha Beta Pruning
            if beta <= alpha:
                print(f"Minimizer Pruned: Depth={depth}, NodeIndex={nodeIndex}, Alpha={alpha},
Beta={beta}")
                break
        return best
```

```
# Driver Code
if __name__ == "__main__":
    values = [3, 5, 6, 9, 1, 2, 0, -1]  # Leaf node values
    print("Starting Alpha-Beta Pruning...")
    optimal_value = minimax(0, 0, True, values, MIN, MAX)
    print(f"\nThe optimal value is: {optimal_value}")
```

OUTPUT:

```
Starting Alpha-Beta Pruning...
Maximizer: Depth=0, NodeIndex=0, Alpha=-1000, Beta=1000
Minimizer: Depth=1, NodeIndex=0, Alpha=-1000, Beta=1000
Maximizer: Depth=2, NodeIndex=0, Alpha=-1000, Beta=1000
Leaf node reached: Depth=3, NodeIndex=0, Value=3
Maximizer updated: Depth=2, NodeIndex=0, Best=3, Alpha=3, Beta=1000
Leaf node reached: Depth=3, NodeIndex=1, Value=5
Maximizer updated: Depth=2, NodeIndex=0, Best=5, Alpha=5, Beta=1000
Minimizer updated: Depth=1, NodeIndex=0, Best=5, Alpha=-1000, Beta=5
Maximizer: Depth=2, NodeIndex=1, Alpha=-1000, Beta=5
Leaf node reached: Depth=3, NodeIndex=2, Value=6
Maximizer updated: Depth=2, NodeIndex=1, Best=6, Alpha=6, Beta=5
Maximizer Pruned: Depth=2, NodeIndex=1, Alpha=6, Beta=5
Minimizer updated: Depth=1, NodeIndex=0, Best=5, Alpha=-1000, Beta=5
Maximizer updated: Depth=0, NodeIndex=0, Best=5, Alpha=5, Beta=1000
Minimizer: Depth=1, NodeIndex=1, Alpha=5, Beta=1000
Maximizer: Depth=2, NodeIndex=2, Alpha=5, Beta=1000
Leaf node reached: Depth=3, NodeIndex=4, Value=1
Maximizer updated: Depth=2, NodeIndex=2, Best=1, Alpha=5, Beta=1000
Leaf node reached: Depth=3, NodeIndex=5, Value=2
Maximizer updated: Depth=2, NodeIndex=2, Best=2, Alpha=5, Beta=1000
Minimizer updated: Depth=1, NodeIndex=1, Best=2, Alpha=5, Beta=2
Minimizer Pruned: Depth=1, NodeIndex=1, Alpha=5, Beta=2
Maximizer updated: Depth=0, NodeIndex=0, Best=5, Alpha=5, Beta=1000

The optimal value is: 5
```