1. Implement Tic –Tac –Toe Game.

Code:

```
board={1:' ',2:' ',3:' ',
      4:' ',5:' ',6:' ',
      7:' ',8:' ',9:' '
}

print("Sonal , 1BM22CS286")

def printBoard(board):
   print(board[1]+'|'+board[2]+'|'+board[3])
   print('-+-+-')
   print(board[4] + '|' + board[5] + '|' + board[6])
   print('-+-+-')
   print(board[7] + '|' + board[8] + '|' + board[9])
   print('\n')

def spaceFree(pos):
   if(board[pos]==' '):
      return True
   else:
      return False

def checkWin():
   if(board[1]==board[2] and board[1]==board[3] and board[1]!=' '):
      return True
   elif(board[4]==board[5] and board[4]==board[6] and board[4]!=' '):
      return True
   elif(board[7]==board[8] and board[7]==board[9] and board[7]!=' '):
      return True
   elif (board[1] == board[5] and board[1] == board[9] and board[1] != ' '):
      return True
   elif (board[3] == board[5] and board[3] == board[7] and board[3] != ' '):
      return True
   elif (board[1] == board[4] and board[1] == board[7] and board[1] != ' '):
      return True
   elif (board[2] == board[5] and board[2] == board[8] and board[2] != ' '):
      return True
   elif (board[3] == board[6] and board[3] == board[9] and board[3] != ' '):
      return True
   else:
      return False
```

```
def checkMoveForWin(move):
  if (board[1]==board[2] and board[1]==board[3] and board[1] ==move):
     return True
  elif (board[4]==board[5] and board[4]==board[6] and board[4] ==move):
     return True
  elif (board[7]==board[8] and board[7]==board[9] and board[7] ==move):
     return True
  elif (board[1]==board[5] and board[1]==board[9] and board[1] ==move):
     return True
  elif (board[3]==board[5] and board[3]==board[7] and board[3] ==move):
     return True
  elif (board[1]==board[4] and board[1]==board[7] and board[1] ==move):
     return True
  elif (board[2]==board[5] and board[2]==board[8] and board[2] ==move):
     return True
  elif (board[3]==board[6] and board[3]==board[9] and board[3] ==move):
     return True
  else:
     return False

def checkDraw():
  for key in board.keys():
     if (board[key]==' '):
        return False
  return True


def insertLetter(letter, position):
  if (spaceFree(position)):
     board[position] = letter
     printBoard(board)

     if (checkDraw()):
        print('Draw!')
     elif (checkWin()):
        if (letter == 'X'):
           print('Bot wins!')
        else:
           print('You win!')
     return

  else:
     print('Position taken, please pick a different position.')
     position = int(input('Enter new position: '))
     insertLetter(letter, position)
```

```
    return

player = 'O'
bot ='X'

def playerMove():
  position=int(input('Enter position for O:'))
  insertLetter(player, position)
  return

def compMove():
  bestScore=-1000
  bestMove=0
  for key in board.keys():
    if (board[key]==' '):
      board[key]=bot
      score = minimax(board, False)
      board[key] = ' '
      if (score > bestScore):
        bestScore = score
        bestMove = key

  insertLetter(bot, bestMove)
  return


def minimax(board, isMaximizing):
  if (checkMoveForWin(bot)):
    return 1
  elif (checkMoveForWin(player)):
    return -1
  elif (checkDraw()):
    return 0

  if isMaximizing:
    bestScore = -1000

    for key in board.keys():
      if board[key] == ' ':
        board[key] = bot
        score = minimax(board, False)
        board[key] = ' '
        if (score > bestScore):
          bestScore = score
    return bestScore
```

```
  else:
    bestScore = 1000

    for key in board.keys():
      if board[key] == ' ':
        board[key] = player
        score = minimax(board, True)
        board[key] = ' '
        if (score < bestScore):
          bestScore = score
    return bestScore

while not checkWin():
  playerMove()
  compMove()
```

Output :

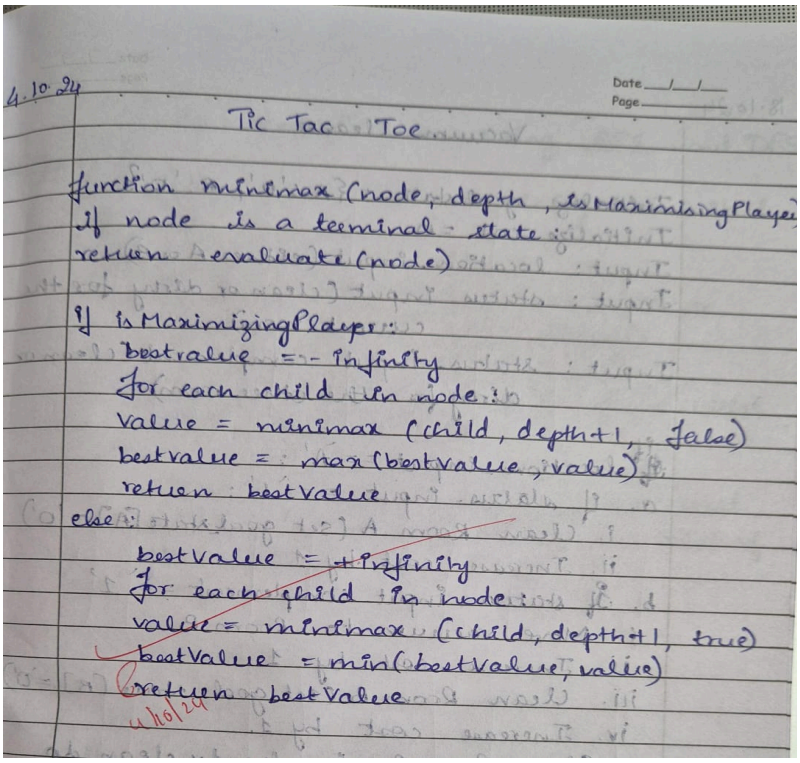
```
Sonal , 1BM22CS286
Enter position for O:1
O| |
-+-+-
 | |
-+-+-
 | |


O| |
-+-+-
 |X|
-+-+-
 | |
```

```
Enter position for O:9
O|X|O
-+-+-
O|X|X
-+-+-
X|O|O


Draw!
```

Observation book screenshots:



4.10.24

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Tic Tac Toe

```
function minimax(node, depth, isMaximizingPlayer)
if node is a terminal state:
return evaluate(node)
if isMaximizingPlayer:
    bestvalue = -Infinity
    for each child in node:
    value = minimax(child, depth+1, false)
    bestvalue = max(bestvalue, value)
    return bestValue
else:
    bestValue = +Infinity
    for each child in node:
    value = minimax(child, depth+1, true)
    bestValue = min(bestValue, value)
    return bestValue
```

4/10/24

2. Implement vacuum cleaner agent.

Code:

```
def vacuum_world():
    # Initializing goal_state
    # 0 indicates Clean and 1 indicates Dirty
    goal_state = {'A': '0', 'B': '0'}
    cost = 0
    print("Sonal,1BM22CS286")

    location_input = input("Enter Location of Vacuum (A or B): ").strip().upper()  # User input of
location
    status_input = input(f"Enter status of {location_input} (0 for Clean, 1 for Dirty): ").strip()
    status_input_complement = input("Enter status of other room (0 for Clean, 1 for Dirty):
").strip()

    print("Initial Location Condition: " + str(goal_state))

    if location_input == 'A':
        print("Vacuum is placed in Location A")
        if status_input == '1':
            print("Location A is Dirty.")
            goal_state['A'] = '0'  # Clean A
            cost += 1  # Cost for sucking
            print("Cost for CLEANING A: " + str(cost))
            print("Location A has been Cleaned.")

            if status_input_complement == '1':
                print("Location B is Dirty.")
                print("Moving right to Location B.")
                cost += 1  # Cost for moving right
                print("Cost for moving RIGHT: " + str(cost))

                goal_state['B'] = '0'  # Clean B
                cost += 1  # Cost for sucking
                print("Cost for SUCK: " + str(cost))
                print("Location B has been Cleaned.")
            else:
                print("Location B is already clean.")
        else:
            print("Location A is already clean.")
            if status_input_complement == '1':
                print("Location B is Dirty.")
                print("Moving RIGHT to Location B.")
```

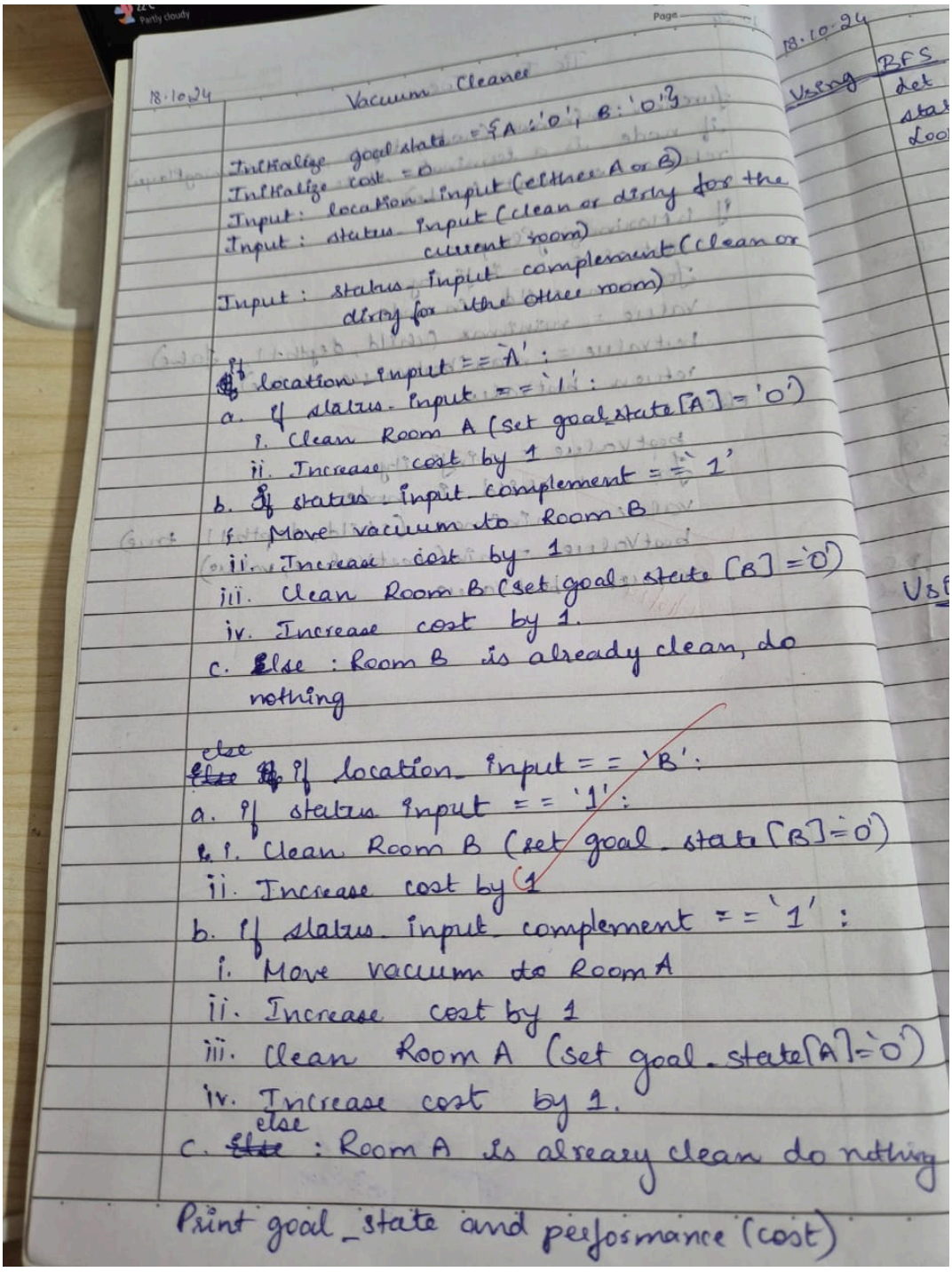
```
            cost += 1  # Cost for moving right
            print("Cost for moving RIGHT: " + str(cost))

            goal_state['B'] = '0'  # Clean B
            cost += 1  # Cost for sucking
            print("Cost for SUCK: " + str(cost))
            print("Location B has been Cleaned.")
        else:
            print("Location B is already clean.")

elif location_input == 'B':
    print("Vacuum is placed in Location B")
    if status_input == '1':
        print("Location B is Dirty.")
        goal_state['B'] = '0'  # Clean B
        cost += 1  # Cost for sucking
        print("Cost for CLEANING B: " + str(cost))
        print("Location B has been Cleaned.")

        if status_input_complement == '1':
            print("Location A is Dirty.")
            print("Moving LEFT to Location A.")
            cost += 1  # Cost for moving left
            print("Cost for moving LEFT: " + str(cost))

            goal_state['A'] = '0'  # Clean A
            cost += 1  # Cost for sucking
            print("Cost for SUCK: " + str(cost))
            print("Location A has been Cleaned.")
        else:
            print("Location A is already clean.")
    else:
        print("Location B is already clean.")
        if status_input_complement == '1':
            print("Location A is Dirty.")
            print("Moving LEFT to Location A.")
            cost += 1  # Cost for moving left
            print("Cost for moving LEFT: " + str(cost))

            goal_state['A'] = '0'  # Clean A
            cost += 1  # Cost for sucking
            print("Cost for SUCK: " + str(cost))
            print("Location A has been Cleaned.")
        else:
            print("Location A is already clean.")
```

```
    # Done cleaning
    print("GOAL STATE: ")
    print(goal_state)
    print("Performance Measurement: " + str(cost))

# Output
vacuum_world()
```

Output:

```
Sonal,1BM22CS286
Enter Location of Vacuum (A or B): A
Enter status of A (0 for Clean, 1 for Dirty): 1
Enter status of other room (0 for Clean, 1 for Dirty): 1
Initial Location Condition: {'A': '0', 'B': '0'}
Vacuum is placed in Location A
Location A is Dirty.
Cost for CLEANING A: 1
Location A has been Cleaned.
Location B is Dirty.
Moving right to Location B.
Cost for moving RIGHT: 2
Cost for SUCK: 3
Location B has been Cleaned.
GOAL STATE:
{'A': '0', 'B': '0'}
Performance Measurement: 3
```

Observation book screenshots:



18.10.24

Vacuum Cleaner

Initialize goal state = {A: '0', B: '0'}
Initialize cost = 0
Input: location input (either A or B)
Input: status input (clean or dirty for the current room)
Input: status_input complement (clean or dirty for the other room)

if location_input == 'A':
a. if status_input == '1':
i. Clean Room A (set goal_state[A] = '0')
ii. Increase cost by 1
b. if status_input_complement == '1'
i. Move vacuum to Room B
ii. Increase cost by 1
iii. Clean Room B (set goal_state[B] = '0')
iv. Increase cost by 1.
c. Else : Room B is already clean, do nothing

else if location_input == 'B':
a. if status_input == '1':
i. Clean Room B (set goal_state[B] = '0')
ii. Increase cost by 1
b. if status_input_complement == '1':
i. Move vacuum to Room A
ii. Increase cost by 1
iii. Clean Room A (set goal_state[A] = '0')
iv. Increase cost by 1.
c. else : Room A is already clean do nothing

Print goal_state and performance (cost)

18.10.24
Using BFS

3. Solve 8 puzzle problem using BFS and DFS.

USING BFS

Code:

```
from collections import deque
print("Sonal,1BM22CS286")

class PuzzleState:
    def __init__(self, board, zero_position, path=[]):
        self.board = board
        self.zero_position = zero_position
        self.path = path

    def is_goal(self):
        return self.board == [1, 2, 3, 4, 5, 6, 7, 8, 0]

    def get_possible_moves(self):
        moves = []
        row, col = self.zero_position
        directions = [(0, 1), (1, 0), (0, -1), (-1, 0)]  # Right, Down, Left, Up

        for dr, dc in directions:
            new_row, new_col = row + dr, col + dc
            if 0 <= new_row < 3 and 0 <= new_col < 3:
                new_board = self.board[:]
                # Swap zero with the adjacent tile
                new_board[row * 3 + col], new_board[new_row * 3 + new_col] = new_board[new_row *
    3 + new_col], new_board[row * 3 + col]
                moves.append(PuzzleState(new_board, (new_row, new_col), self.path + [new_board]))

        return moves

def bfs(initial_state):
    queue = deque([initial_state])
    visited = set()

    while queue:
        current_state = queue.popleft()

        # Show the current board
        print("Current Board State:")
        print_board(current_state.board)
        print()
```

```
        if current_state.is_goal():
            return current_state.path

        visited.add(tuple(current_state.board))

        for next_state in current_state.get_possible_moves():
            if tuple(next_state.board) not in visited:
                queue.append(next_state)

    return None

def print_board(board):
    for i in range(3):
        print(board[i * 3:i * 3 + 3])

def main():
    print("Enter the initial state of the 8-puzzle (use 0 for the blank tile, e.g., '1 2 3 4 5 6 7 8 0'): ")
    user_input = input()
    initial_board = list(map(int, user_input.split()))

    if len(initial_board) != 9 or set(initial_board) != set(range(9)):
        print("Invalid input! Please enter 9 numbers from 0 to 8.")
        return

    zero_position = initial_board.index(0)
    initial_state = PuzzleState(initial_board, (zero_position // 3, zero_position % 3))

    solution_path = bfs(initial_state)

    if solution_path is None:
        print("No solution found.")
    else:
        print("Solution found in", len(solution_path), "steps.")
        for step in solution_path:
            print_board(step)
            print()

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

Output :

```
Sonal,1BM22CS286
Enter the initial state of the 8-puzzle (use 0 for the blank tile, e.g., '1 2 3 4 5 6 7 8 0'):
1 2 3 4 0 6 7 5 8
Current Board State:
[1, 2, 3]
[4, 0, 6]
[7, 5, 8]

Current Board State:
[1, 2, 3]
[4, 6, 0]
[7, 5, 8]

Current Board State:
[1, 2, 3]
[4, 5, 6]
[7, 0, 8]

Current Board State:
[1, 2, 3]
[0, 4, 6]
[7, 5, 8]

Current Board State:
[1, 0, 3]
[4, 2, 6]
[7, 5, 8]

 Current Board State:
 [1, 0, 3]
 [4, 2, 6]
 [7, 5, 8]

 Current Board State:
 [1, 2, 3]
 [4, 6, 8]
 [7, 5, 0]

 Current Board State:
 [1, 2, 0]
 [4, 6, 3]
 [7, 5, 8]

 Current Board State:
 [1, 2, 3]
 [4, 5, 6]
 [7, 8, 0]

 Solution found in 2 steps.
 [1, 2, 3]
 [4, 5, 6]
 [7, 0, 8]

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

Observation book screenshots:

Using BFS

Let fringe be a list containing the initial state.

Loop

If fringe is empty return failure

Node ← remove-first (fringe)

If Node is a goal

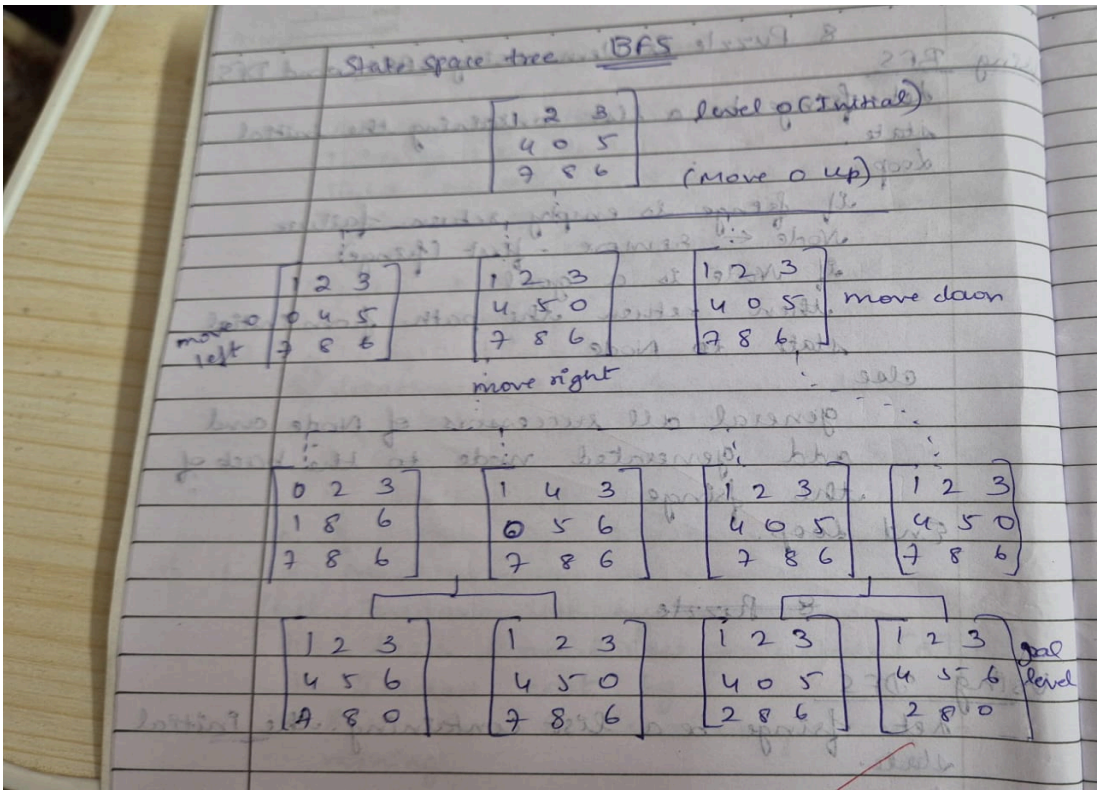
then return the path from initial state to Node

else

general all successors of Node and add generated node to the back of the fringe

End loop.

~~8 Puzzle~~



USING DFS

Code :

```
from collections import deque
print("Sonal,1BM22CS286")

def get_user_input(prompt):
    board = []
    print(prompt)
    for i in range(3):
        row = list(map(int, input(f"Enter row {i+1} (space-separated numbers, use 0 for empty
      space): ").split()))
        board.append(row)
    return board

def is_solvable(board):
    flattened_board = [tile for row in board for tile in row if tile != 0]
    inversions = 0
    for i in range(len(flattened_board)):
        for j in range(i + 1, len(flattened_board)):
            if flattened_board[i] > flattened_board[j]:
                inversions += 1
    return inversions % 2 == 0

class PuzzleState:
    def __init__(self, board, moves=0, previous=None):
        self.board = board
        self.empty_tile = self.find_empty_tile()
        self.moves = moves
        self.previous = previous

    def find_empty_tile(self):
        for i in range(3):
            for j in range(3):
                if self.board[i][j] == 0:
                    return (i, j)

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

    def get_possible_moves(self):
        row, col = self.empty_tile
        possible_moves = []
        directions = [(1, 0), (-1, 0), (0, 1), (0, -1)]  # down, up, right, left

        for dr, dc in directions:
```

```
            new_row, new_col = row + dr, col + dc
            if 0 <= new_row < 3 and 0 <= new_col < 3:
                # Make the move
                new_board = [row[:] for row in self.board]  # Deep copy
                new_board[row][col], new_board[new_row][new_col] =
        new_board[new_row][new_col], new_board[row][col]
                possible_moves.append(PuzzleState(new_board, self.moves + 1, self))

        return possible_moves

def dfs(initial_state, goal_state):
    stack = [initial_state]
    visited = set()

    while stack:
        current_state = stack.pop()

        if current_state.is_goal(goal_state):
            return current_state

        # Convert board to a tuple for the visited set
        state_tuple = tuple(tuple(row) for row in current_state.board)

        if state_tuple not in visited:
            visited.add(state_tuple)
            for next_state in current_state.get_possible_moves():
                stack.append(next_state)

    return None  # No solution found

def print_solution(solution):
    path = []
    while solution:
        path.append(solution.board)
        solution = solution.previous
    for state in reversed(path):
        for row in state:
            print(row)
        print()

if __name__ == "__main__":
    # Get user input for initial and goal states
    initial_board = get_user_input("Enter the initial state of the puzzle:")
    goal_board = get_user_input("Enter the goal state of the puzzle:")
```

```
if is_solvable(initial_board):
    initial_state = PuzzleState(initial_board)
    solution = dfs(initial_state, goal_board)

    if solution:
        print("Solution found in", solution.moves, "moves:")
        print_solution(solution)
    else:
        print("No solution found.")
else:
    print("This puzzle is unsolvable.")
```

Output:

```
Streaming output truncated to the last 5000 lines.
[2, 5, 6]
[0, 3, 1]
[4, 7, 8]

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

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

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

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

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

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

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

Observation book screenshots:

Using DFS

Let fringe be a list containing the initial state.

Loop

if fringe is empty return failure

Node ← remove-first (fringe)

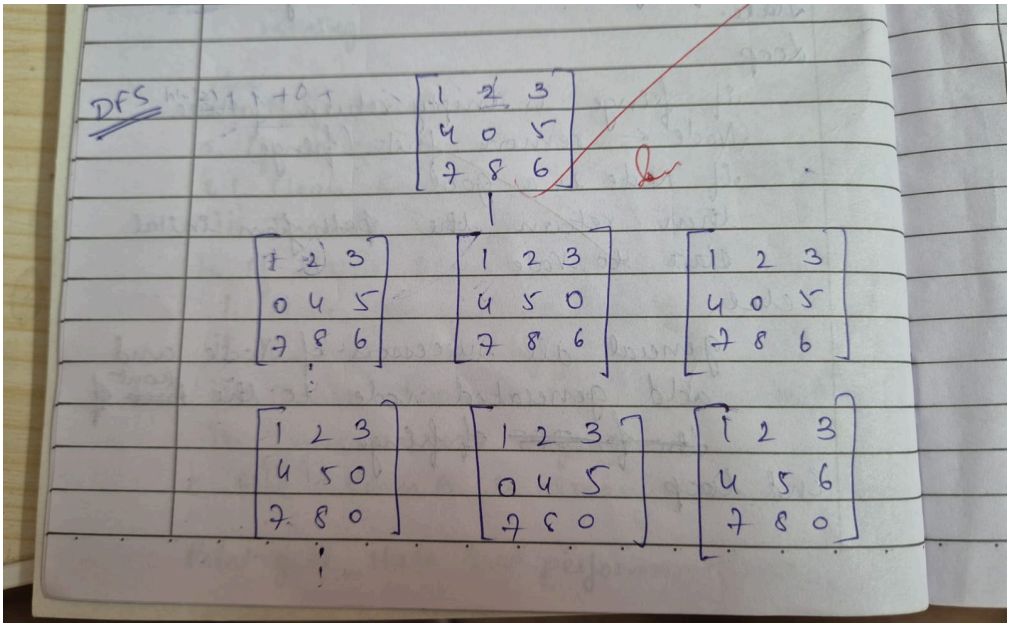
If Node is a goal

then return the path from initial state to Node

else

general all successors of Node and add generated node to the front of fringe.

End loop.



4. Solve 8 puzzle problem using A* algorithm

Using misplaced tiles

Code:

```
import heapq
print("Sonal,1BM22CS286")

# Define the goal state for the 8-puzzle
GOAL_STATE = [
    [2, 8, 1],
    [0, 4, 3],
    [7, 6, 5]
]

# Define the position moves (up, down, left, right)
MOVES = [
    (-1, 0),  # Up
    (1, 0),   # Down
    (0, -1),  # Left
    (0, 1)    # Right
]

class PuzzleNode:
    def __init__(self, state, parent=None, g=0, h=0):
        self.state = state
        self.parent = parent
        self.g = g  # Cost from start to current node
        self.h = h  # Heuristic cost to goal
        self.f = g + h  # Total cost

    def __lt__(self, other):
        return self.f < other.f

def misplaced_tiles(state):
    """Heuristic function that counts the number of misplaced tiles."""
    misplaced = 0
    for i in range(3):
        for j in range(3):
            if state[i][j] != 0 and state[i][j] != GOAL_STATE[i][j]:
                misplaced += 1
    return misplaced
```

```
def get_zero_position(state):
    """Find the position of the zero (empty tile) in the puzzle."""
    for i in range(3):
        for j in range(3):
            if state[i][j] == 0:
                return i, j
    return None

def generate_successors(node):
    """Generate successors by moving the empty tile in all possible directions."""
    successors = []
    zero_x, zero_y = get_zero_position(node.state)

    for move_x, move_y in MOVES:
        new_x, new_y = zero_x + move_x, zero_y + move_y
        if 0 <= new_x < 3 and 0 <= new_y < 3:
            new_state = [row[:] for row in node.state]
            new_state[zero_x][zero_y], new_state[new_x][new_y] = new_state[new_x][new_y],
new_state[zero_x][zero_y]
            h = misplaced_tiles(new_state)
            successors.append(PuzzleNode(new_state, parent=node, g=node.g + 1, h=h))
    return successors

def is_goal(state):
    """Check if the current state is the goal state."""
    return state == GOAL_STATE

def reconstruct_path(node):
    """Reconstruct the path from the start state to the goal state."""
    path = []
    while node:
        path.append(node.state)
        node = node.parent
    return path[::-1]

def a_star(start_state):
    """A* algorithm to solve the 8-puzzle problem."""
    start_node = PuzzleNode(start_state, g=0, h=misplaced_tiles(start_state))
    open_list = []
    closed_set = set()

    heapq.heappush(open_list, start_node)

    while open_list:
        current_node = heapq.heappop(open_list)
```

```
        if is_goal(current_node.state):
            return reconstruct_path(current_node)

        closed_set.add(tuple(map(tuple, current_node.state)))

        for successor in generate_successors(current_node):
            if tuple(map(tuple, successor.state)) in closed_set:
                continue
            heapq.heappush(open_list, successor)

    return None

def get_user_input():
    """Get a valid 8-puzzle input state from the user."""
    print("Enter your 8-puzzle configuration (0 represents the empty tile):")
    state = []
    values = set()

    for i in range(3):
        row = input(f"Enter row {i+1} (space-separated numbers between 0 and 8): ").split()
        if len(row) != 3:
            print("Each row must have exactly 3 numbers. Please try again.")
            return None

        row = [int(x) for x in row]

        if not all(0 <= x <= 8 for x in row):
            print("Values must be between 0 and 8. Please try again.")
            return None

        state.append(row)
        values.update(row)

    if values != set(range(9)):
        print("All numbers from 0 to 8 must be present exactly once. Please try again.")
        return None

    return state

# Main function
def main():
    start_state = None
    while start_state is None:
        start_state = get_user_input()
```

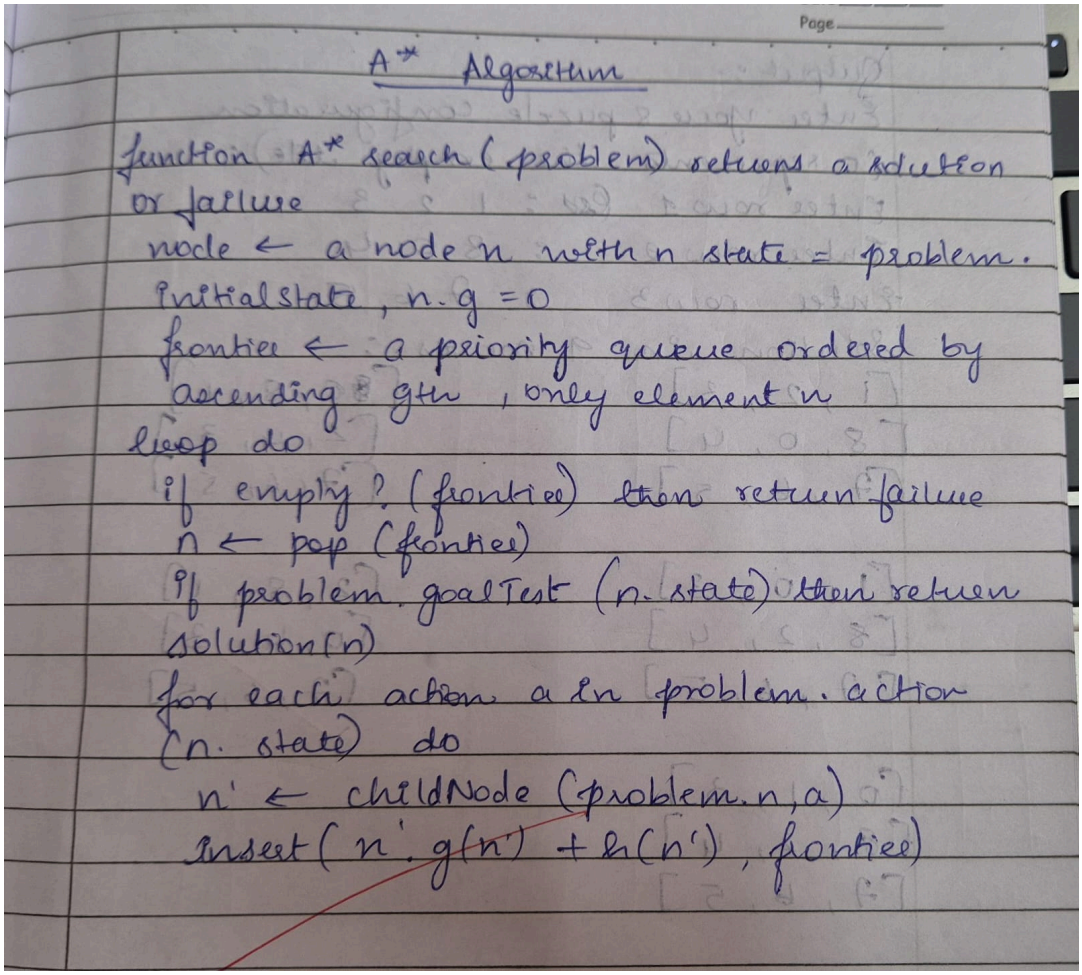
```
    solution = a_star(start_state)

    # Print the solution steps
    if solution:
        print("Solution found in", len(solution) - 1, "moves:")
        for step in solution:
            for row in step:
                print(row)
            print()
    else:
        print("No solution found.")

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

Output:

```
Sonal,1BM22CS286
Enter your 8-puzzle configuration (0 represents the empty tile):
Enter row 1 (space-separated numbers between 0 and 8): 1 2 3
Enter row 2 (space-separated numbers between 0 and 8): 8 0 4
Enter row 3 (space-separated numbers between 0 and 8): 7 6 5
Solution found in 9 moves:
[1, 2, 3]
[8, 0, 4]
[7, 6, 5]

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

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

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

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

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

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

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

Observation book screenshots:



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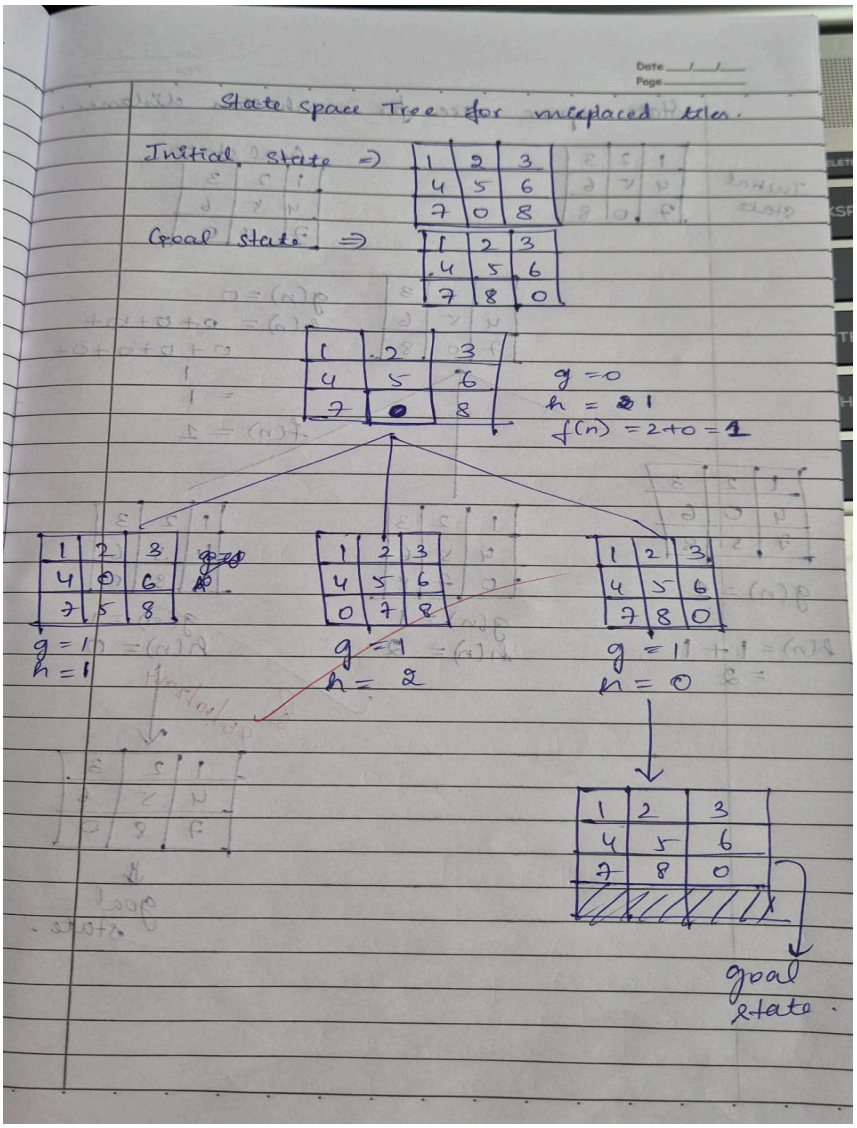
A* Algorithm

function A* search (problem) returns a solution or failure
node ← a node n with n state = problem.
initialstate, n.g = 0
frontier ← a priority queue ordered by ascending g(n), only element n
loop do
if empty? (frontier) then return failure
n ← pop (frontier)
if problem.goalTest (n.state) then return solution(n)
for each action a in problem.action (n.state) do
n' ← childNode (problem.n, a)
insert (n'.g(n') + h(n'), frontier)



Using Manhattan distance:

Code:

```
# manhattan distance
import heapq
print("Sonal,1BM22CS286")

# Define the goal state for the 8-puzzle
GOAL_STATE = [
    [2, 8, 1],
    [0, 4, 3],
```

```
    [7, 6, 5]

]

# Define the position moves (up, down, left, right)
MOVES = [
    (-1, 0),  # Up
    (1, 0),   # Down
    (0, -1),  # Left
    (0, 1)    # Right
]

class PuzzleNode:
    def __init__(self, state, parent=None, g=0, h=0):
        self.state = state
        self.parent = parent
        self.g = g  # Cost from start to current node
        self.h = h  # Heuristic cost to goal (Manhattan distance)
        self.f = g + h  # Total cost

    def __lt__(self, other):
        return self.f < other.f

def manhattan_distance(state):
    """Heuristic function that calculates the Manhattan distance for each tile."""
    distance = 0
    for i in range(3):
        for j in range(3):
            value = state[i][j]
            if value != 0:  # Skip the empty tile
                # Calculate goal position for this value
                goal_x, goal_y = (value - 1) // 3, (value - 1) % 3
                # Add the Manhattan distance for this tile
                distance += abs(i - goal_x) + abs(j - goal_y)
    return distance

def get_zero_position(state):
    """Find the position of the zero (empty tile) in the puzzle."""
    for i in range(3):
        for j in range(3):
            if state[i][j] == 0:
                return i, j
    return None

def generate_successors(node):
```

```
    """Generate successors by moving the empty tile in all possible directions."""
    successors = []
    zero_x, zero_y = get_zero_position(node.state)

    for move_x, move_y in MOVES:
        new_x, new_y = zero_x + move_x, zero_y + move_y
        if 0 <= new_x < 3 and 0 <= new_y < 3:
            new_state = [row[:] for row in node.state]
            new_state[zero_x][zero_y], new_state[new_x][new_y] = new_state[new_x][new_y],
new_state[zero_x][zero_y]
            h = manhattan_distance(new_state)
            successors.append(PuzzleNode(new_state, parent=node, g=node.g + 1, h=h))
    return successors

def is_goal(state):
    """Check if the current state is the goal state."""
    return state == GOAL_STATE

def reconstruct_path(node):
    """Reconstruct the path from the start state to the goal state."""
    path = []
    while node:
        path.append(node.state)
        node = node.parent
    return path[::-1]

def a_star(start_state):
    """A* algorithm to solve the 8-puzzle problem."""
    start_node = PuzzleNode(start_state, g=0, h=manhattan_distance(start_state))
    open_list = []
    closed_set = set()

    heapq.heappush(open_list, start_node)

    while open_list:
        current_node = heapq.heappop(open_list)

        if is_goal(current_node.state):
            return reconstruct_path(current_node)

        closed_set.add(tuple(map(tuple, current_node.state)))

        for successor in generate_successors(current_node):
            if tuple(map(tuple, successor.state)) in closed_set:
                continue
```

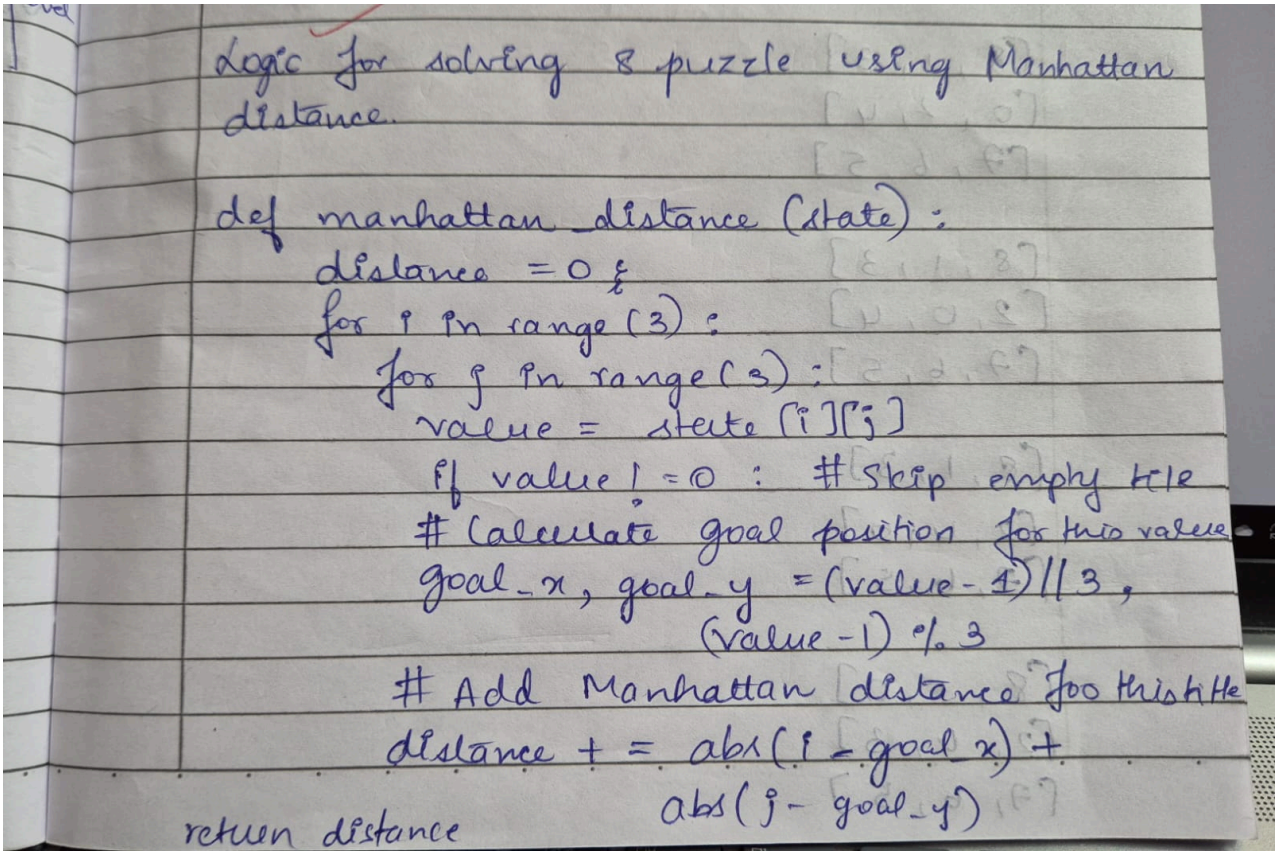
```
            heapq.heappush(open_list, successor)

    return None

def get_user_input():
    """Get a valid 8-puzzle input state from the user."""
    print("Enter your 8-puzzle configuration (0 represents the empty tile):")
    state = []
    values = set()

    for i in range(3):
        row = input(f"Enter row {i+1} (space-separated numbers between 0 and 8): ").split()
        if len(row) != 3:
            print("Each row must have exactly 3 numbers. Please try again.")
            return None

        row = [int(x) for x in row]

        if not all(0 <= x <= 8 for x in row):
            print("Values must be between 0 and 8. Please try again.")
            return None

        state.append(row)
        values.update(row)

    if values != set(range(9)):
        print("All numbers from 0 to 8 must be present exactly once. Please try again.")
        return None

    return state

# Main function
def main():
    start_state = None
    while start_state is None:
        start_state = get_user_input()

    solution = a_star(start_state)

    # Print the solution steps
    if solution:
        print("Solution found in", len(solution) - 1, "moves:")
        for step in solution:
            for row in step:
                print(row)
```

```
            print()
    else:
        print("No solution found.")

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

Output:

```
Sonal,1BM22CS286
Enter your 8-puzzle configuration (0 represents the empty tile):
Enter row 1 (space-separated numbers between 0 and 8): 1 2 3
Enter row 2 (space-separated numbers between 0 and 8): 8 0 4
Enter row 3 (space-separated numbers between 0 and 8): 7 6 5
Solution found in 9 moves:
[1, 2, 3]
[8, 0, 4]
[7, 6, 5]

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

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

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

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

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

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

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

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

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

Observation book screenshots:



Logic for solving 8 puzzle using Manhattan distance.

```
def manhattan_distance (state):
    distance = 0 &
    for i in range (3):
        for j in range (3):
            value = state [i][j]
            if value != 0 : # skip empty tile
            # Calculate goal position for this value
            goal_x, goal_y = (value - 1) // 3,
                             (value - 1) % 3
            # Add Manhattan distance for this tile
            distance += abs(i - goal_x) +
                        abs(j - goal_y)
return distance
```

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State space tree for manhattan distance

Initial state

1	2	3
4	5	6
7	0	8

Goal state

1	2	3
4	5	6
7	8	0

1	2	3
4	5	6
7	0	8

$g(n) = 0$

$h(n) = 0+0+0+0+0+0+0+0$

$= 1$

$f(n) = 1$

1

1	2	3
4	0	6
7	5	8

$g(n) = 1$

$h(n) = 1 + 1$

$= 2$

1	2	3
4	5	6
0	7	8

$g(n) = 1$

$h(n) = 2$

1	2	3
4	5	6
7	8	0

$g(n) = 1$

$h(n) = 0$

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1	2	3
4	5	6
7	8	0

goal state.

5. N queens using Hill climbing algorithm

Code:

```
from random import randint

# Function to print the board
def printBoard(board, N):
    for i in range(N):
        print(" ".join(map(str, board[i])))
    print("-" * (2 * N - 1))

# Function to calculate the objective value
def calculateObjective(board, state, N):
    attacking = 0
    for i in range(N):
        row = state[i]

        # Check row conflicts
        col = i - 1
        while col >= 0 and board[row][col] != 1:
            col -= 1
        if col >= 0 and board[row][col] == 1:
            attacking += 1

        col = i + 1
        while col < N and board[row][col] != 1:
            col += 1
        if col < N and board[row][col] == 1:
            attacking += 1

        # Check diagonal conflicts
        for d_row, d_col in [(-1, -1), (1, 1), (1, -1), (-1, 1)]:
            r, c = row + d_row, i + d_col
            while 0 <= r < N and 0 <= c < N and board[r][c] != 1:
                r += d_row
                c += d_col
            if 0 <= r < N and 0 <= c < N and board[r][c] == 1:
                attacking += 1

    return attacking // 2

# Function to generate the board from the state
def generateBoard(board, state, N):
    for i in range(N):
        for j in range(N):
```

```
                board[i][j] = 0
        for i in range(N):
            board[state[i]][i] = 1

    # Function to get the best neighbor
    def getNeighbour(board, state, N):
        opState = state[:]
        opBoard = [[0] * N for _ in range(N)]
        generateBoard(opBoard, opState, N)
        opObjective = calculateObjective(opBoard, opState, N)

        for i in range(N):
            original_row = state[i]
            for new_row in range(N):
                if new_row != original_row:
                    state[i] = new_row
                    generateBoard(board, state, N)
                    tempObjective = calculateObjective(board, state, N)
                    if tempObjective < opObjective:
                        opObjective = tempObjective
                        opState = state[:]
            state[i] = original_row
        generateBoard(board, opState, N)
        return opState, opObjective

    # Hill climbing algorithm
    def hillClimbing(N, initial_state):
        board = [[0] * N for _ in range(N)]
        state = initial_state[:]
        generateBoard(board, state, N)

        iteration = 0
        while True:
            print(f"Iteration {iteration}:")
            print(f"Current State: {state}")
            currentObjective = calculateObjective(board, state, N)
            print(f"Objective Value: {currentObjective}")
            printBoard(board, N)

            nextState, nextObjective = getNeighbour(board, state, N)

            # Break if we reach an optimal solution with objective 0
            if nextObjective == 0:
                print("Final Solution:")
                printBoard(board, N)
                break
```

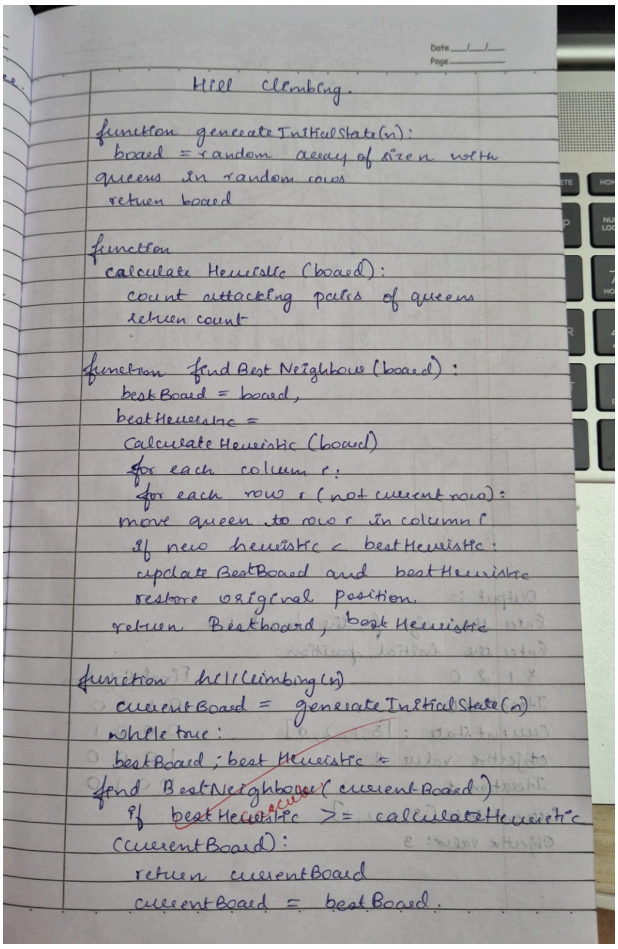
```
            # If stuck in a local optimum, pick a random neighboring state
            if nextObjective >= currentObjective:
                print("Stuck in local optimum. Jumping to a random neighbor...")
                state[randint(0, N - 1)] = randint(0, N - 1)
                generateBoard(board, state, N)
            else:
                state = nextState  # Move to the next better state

            iteration += 1

    # Main code to accept user input
    if __name__ == "__main__":
        N = int(input("Enter the size of the board (e.g., 8 for 8-Queens
problem): "))
        print(f"Enter the initial positions of queens for each column (0 to
{N-1}):")
        initial_state = list(map(int, input().split()))

        if len(initial_state) != N or any(pos < 0 or pos >= N for pos in
initial_state):
            print("Invalid input. Please ensure each queen position is within the
board size.")
        else:
            hillClimbing(N, initial_state)
```

Output:

```
Enter the size of the board (e.g., 8 for 8-Queens problem): 4
Enter the initial positions of queens for each column (0 to 3):
3 1 2 0
Iteration 0:
Current State: [3, 1, 2, 0]
Objective Value: 2
0 0 0 1
0 1 0 0
0 0 1 0
1 0 0 0
-------
Stuck in local optimum. Jumping to a random neighbor...
Iteration 1:
Current State: [3, 1, 2, 1]
Objective Value: 3
0 0 0 0
0 1 0 1
0 0 1 0
1 0 0 0
-------
Iteration 2:
Current State: [3, 0, 2, 1]
Objective Value: 1
0 1 0 0
0 0 0 1
0 0 1 0
1 0 0 0
-------
Stuck in local optimum. Jumping to a random neighbor...
Iteration 3:
Current State: [3, 0, 2, 1]
Objective Value: 1
0 1 0 0
0 0 0 1
0 0 1 0
```

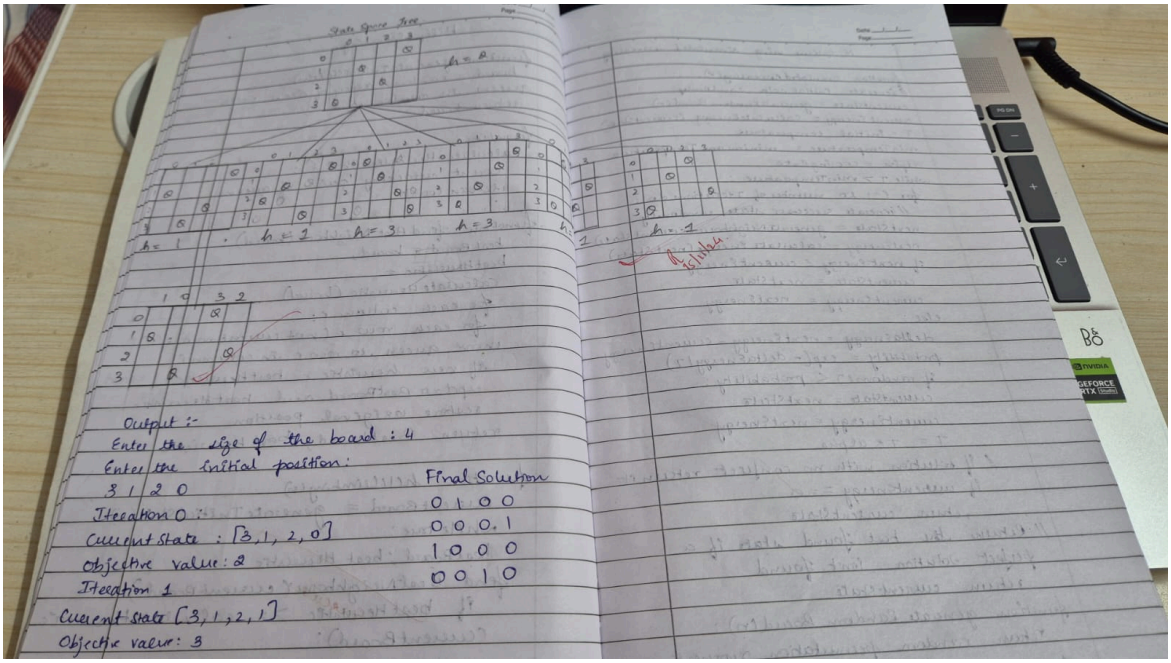
```
Current State: [3, 0, 2, 1]
Objective Value: 1
0 1 0 0
0 0 0 1
0 0 1 0
1 0 0 0
-------
Stuck in local optimum. Jumping to a random neighbor...
Iteration 14:
Current State: [2, 0, 2, 1]
Objective Value: 2
0 1 0 0
0 0 0 1
1 0 1 0
0 0 0 0
-------
Final Solution:
0 1 0 0
0 0 0 1
1 0 0 0
0 0 1 0
-------
```

Observation book screenshots:



Hill Climbing.

```
function generateInitialState(n):
    board = random array of size n with
    queens in random rows
    return board

function
    calculateHeuristic(board):
        count attacking pairs of queens
        return count

function findBestNeighbour(board):
    bestBoard = board,
    bestHeuristic =
    CalculateHeuristic(board)
    for each column c:
        for each row r (not current row):
    move queen to row r in column c
    if new heuristic < bestHeuristic:
    update BestBoard and bestHeuristic
    restore original position.
    return BestBoard, bestHeuristic

function hillClimbing(n)
    currentBoard = generateInitialState(n)
    while true:
    bestBoard, bestHeuristic =
    findBestNeighbour(currentBoard)
    if bestHeuristic >= calculateHeuristic
    (currentBoard):
        return currentBoard
        currentBoard = bestBoard.
```



Output :-
Enter the size of the board : 4
Enter the initial position:
3 1 2 0
Iteration 0:
Current state : [3, 1, 2, 0]
Objective value: 2
Iteration 1
Current state [3, 1, 2, 1]
Objective value: 3

Final Solution
0 1 0 0
0 0 0 1
1 0 0 0
0 0 1 0

6. N queens using Simulated Annealing

Code :

```
import random
import math

def create_board_from_input(n, positions):
    """Create a board based on user input positions for each column."""
    return positions

def calculate_conflicts(board):
    """Calculate the number of conflicts on the board."""
    n = len(board)
    conflicts = 0
    for i in range(n):
        for j in range(i + 1, n):
            if board[i] == board[j] or abs(board[i] - board[j]) == j - i:
                conflicts += 1
    return conflicts

def get_neighbors(board):
    """Generate all neighboring boards by changing the position of one
queen."""
    n = len(board)
    neighbors = []
    for i in range(n):
        for j in range(n):
            if board[i] != j:
                neighbor = list(board)
                neighbor[i] = j
                neighbors.append(neighbor)
    return neighbors

def simulated_annealing(n, initial_temperature, cooling_rate, initial_state):
    """Perform simulated annealing to solve the n-queens problem."""
    current_board = initial_state
    current_conflicts = calculate_conflicts(current_board)
    best_board = list(current_board)
    best_conflicts = current_conflicts
    temperature = initial_temperature
    iterations = 0  # Counter for iterations

    while temperature > 1:
        iterations += 1  # Increment the iteration count
        neighbors = get_neighbors(current_board)
```

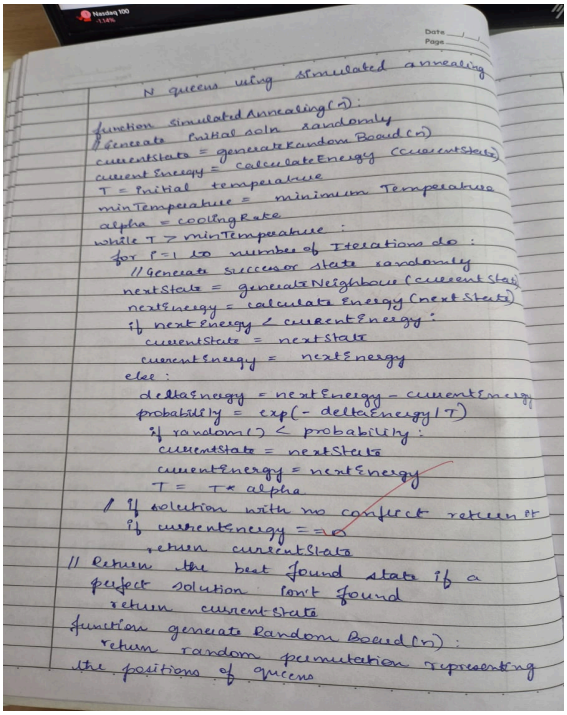
```
            neighbor = random.choice(neighbors)
            neighbor_conflicts = calculate_conflicts(neighbor)

            delta = neighbor_conflicts - current_conflicts

            if delta < 0 or random.random() < math.exp(-delta / temperature):
                current_board = neighbor
                current_conflicts = neighbor_conflicts

            if current_conflicts < best_conflicts:
                best_board = list(current_board)
                best_conflicts = current_conflicts

            temperature *= cooling_rate

        return best_board, best_conflicts, iterations

    # Main code to accept user input
    if __name__ == "__main__":
        n = int(input("Enter the size of the board (number of queens): "))
        initial_temperature = float(input("Enter the initial temperature (e.g.,
100): "))
        cooling_rate = float(input("Enter the cooling rate (e.g., 0.99): "))

        print(f"Enter the initial positions of queens for each column (values
between 0 and {n-1}, one value per column):")
        initial_state = []
        for i in range(n):
            pos = int(input(f"Position for column {i + 1} (0 to {n-1}): "))
            if 0 <= pos < n:
                initial_state.append(pos)
            else:
                print(f"Invalid input for column {i + 1}, please enter a number
between 0 and {n-1}.")
                break
        else:
            solution, conflicts, iterations = simulated_annealing(n,
initial_temperature, cooling_rate, initial_state)

            print("\nSolution:")
            for i in range(n):
                line = ""
                for j in range(n):
                    if j == solution[i]:
                        line += "Q "
                    else:
```

```
                line += ". "
        print(line)

    print("\nConflicts:", conflicts)
    print(f"Iterations: {iterations}")
```

Output:

```
Enter the size of the board (number of queens): 4
Enter the initial temperature (e.g., 100): 50
Enter the cooling rate (e.g., 0.99): 0.22
Enter the initial positions of queens for each column (values between 0 and 3, one value per column):
Position for column 1 (0 to 3): 2
Position for column 2 (0 to 3): 1
Position for column 3 (0 to 3): 3
Position for column 4 (0 to 3): 0

Solution:
. . Q .
. Q . .
. . . Q
Q . . .

Conflicts: 1
Iterations: 3
```

Observation book screenshots:



function generateNeighbour(state):
return modified state with one queen moved to a different row

function calculateEnergy(state):
Conflicts (attacks) between queens
Return count of pairs of queens attacking each other

function exp(value):
return Math.exp(value)

function random():
return Math.random().

Output

Enter the size of the board : 4
Enter the initial temperature : 50
Enter the cooling rate : 0.20
Enter the initial positions of queens for each column
Position for column 1 : 2
Position for column 2 : 1
Position for column 3 : 3
Position for column 4 : 0

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Solution

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

Conflicts : 1
Iterations : 3