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Practical-1

AIM: Write a program to implement simple Chat bot using Python (without using any libraries or packages of python).

- **It should accept any case like lower case and upper case**
- **It should accept any symbol like !,?. etc. by entering user**
- **It should have at least 20 questions.**

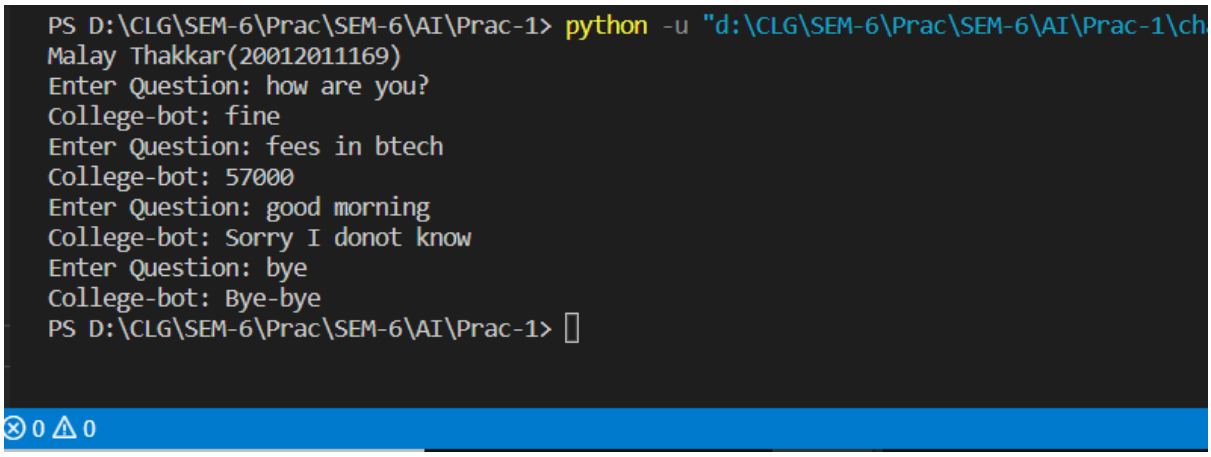
➢ **Program:**

```
print("Malay Thakkar(20012011169)")
question = {"how are you": "fine",
        "name of your college": "uvpce",
        "which type of course available": "btech,bsc,bba,etc",
        "fees in btech": "57000",
        "how many semester in btech": "8",
        "fees in bsc": "25000",
        "how many semester in bsc
        "how many department in btech": "ce,it,mechanical,etc",
        "is it good college": "yes",
        "what is university name": "guni",
        "is bsc available": "yes",
        "is bba available": "yes",
        "is bpharm available": "no",
        "what is bpharm fees": "40000",
        "which is last date for admission": "30 june",
        "how far from ahmedabad": "60km",
        "is ce good": "yes depend on interest",
        "is ce hard": "depend on interest",
        "course duration of btech": "4 years",
        "course duration of bsc": "3 years",
        }

def chatbot():
   while True:
```

```
    qs = input("Enter Question: ").lower()
    symbols = {'?','!', '@', '#', '$', '%', '^', '&', '*', '(', ')', '-'}
    message = ""
    for i in qs:
        if i not in symbols:
            message = message+i
    if message in ["quit",'bye']:
        print("College-bot: Bye-bye")
        break;
    elif message in question:
        print("College-bot: "+question[message])
    else:
        print("College-bot: Sorry I donot know")
chatbot()
```

- **Output:**



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Practical-2

AIM: Write a program to implement Breadth first search Traversal on Tree using Python (without using any libraries or packages of python)

- **Use class concept of python (Tree Class, Node Class)**
- **Use class to implement Data structure to be used in program**
- **Tree & Output should look like below:**

➢ **Program:**

```
class Node:
    def __init__(self, data, parent, childlist):
        self.data = data
        self.parent = parent
        self.childlist = childlist
        self.level = 0
        if self.parent != None:
            self.level = self.parent.level + 1

    def add_child(self, child):
        self.childlist.append(child)

    def space_count(self):
        str_parent = ""
        if self.parent == None:
            str_parent = str(self.parent)
        else:
            str_parent = "None"
            temp = self.parent
            while temp != None:
                str_parent += "->" + temp.data
                temp = temp.parent
        return len(str_parent)

    def __repr__(self):
        str_parent = ""
        if self.parent == None:
            str_parent = str(self.parent)
        else:
            str_parent = str(self.parent.data)
        str_return = "\n"
        str_return += " " * self.space_count()
        str_return += "->" + str(self.data) + " " + \
```

```
            ' '.join(map(str, self.childlist))
        return str_return
class Tree:
    def __init__(self, root):
        self.root = root
    def insert_node(self, data, parent):
        node = Node(data, parent, [])
        parent.add_child(node)
        return node
    def __repr__(self):
        return str(self.root)
def bfs(tree, search_string):
    queue = []
    queue.append(tree.root)
    node = None
    while queue:
        temp = queue.pop(0)
        if temp.data == search_string:
            node = temp
            break
        queue.extend(temp.childlist)
    return node
def draw_path(node):
    list = []
    temp = node
    while temp != None:
        list.append(temp.data)
        temp = temp.parent
        if temp == None:
            break
    list.reverse()
    print("Path: ")
    print(*list, sep="->")
    print("Path Cost = " + str(len(list)-1))
tree = Tree(Node("India", None, []))
gujarat = tree.insert_node("Gujarat", tree.root)
ahmedabad = tree.insert_node("Ahmedabad", gujarat)
mehsana = tree.insert_node("Mehsana", gujarat)
gandhinagar = tree.insert_node("Gandhinagar", gujarat)
rajasthan = tree.insert_node("Rajasthan", tree.root)
jaipur = tree.insert_node("Jaipur", rajasthan)
jodhpur = tree.insert_node("Jodhpur", rajasthan)
ajmer = tree.insert_node("Ajmer", rajasthan)
```

```
kota = tree.insert_node("Kota", rajasthan)
maharashtra = tree.insert_node("Maharashtra", tree.root)
mumbai = tree.insert_node("Mumbai", maharashtra)
bandra = tree.insert_node("Bandra", mumbai)
juhu = tree.insert_node("Juhu", mumbai)
nashik = tree.insert_node("Nashik", maharashtra)
pune = tree.insert_node("Pune", maharashtra)
nagpur = tree.insert_node("Nagpur", maharashtra)
thane = tree.insert_node("Thane", maharashtra)

print("Malay Thakkar (20012011169)")
print(tree)
search_string = "Bandra"
print("Search String = " + search_string)
node = bfs(tree, search_string)
if node == None:
    print(search_string + "String can't be found in tree")
else:
    draw_path(node)
```

- **Output:**

```
PS D:\CLG\SEM-6\Prac\SEM-6\AI\Prac-2> python -u "d:\CLG\SEM-6\Prac\SEM-6\AI\Prac-2\bfs.py"
Malay Thakkar (20012011169)

    ->India
        ->Gujarat
            ->Ahmedabad
            ->Mehsana
            ->Gandhinagar
        ->Rajasthan
            ->Jaipur
            ->Jodhpur
            ->Ajmer
            ->Kota
        ->Maharashtra
            ->Mumbai
                ->Bandra
                ->Juhu
            ->Nashik
            ->Pune
            ->Nagpur
            ->Thane
Search String = Bandra
Path:
India->Maharashtra->Mumbai->Bandra
Path Cost = 3
PS D:\CLG\SEM-6\Prac\SEM-6\AI\Prac-2>
⊗ 0 ⚠ 1
```

❖

Practical-3

AIM: Write a program to implement a Water Jug Problem using Python and to solve a Water Jug Problem by using BFS (without using any libraries or packages of python).

- **CODE:**

```
import time
import random

class node:
    def __init__(self, data):
        self.x = 0
        self.y = 0
        self.parent = data
    def __cmp__(self,other):
      if(other == None):
        return False
      return self.x == other.x and self.y == other.y
    def __eq__(self,other):
      if(other == None):
        return False
      return self.x == other.x and self.y == other.y
    def __repr__(self):
      return "("+str(self.x)+", "+str(self.y)+")"

def operation(cnode, rule):
        x = cnode.x
        y = cnode.y

        if rule == 1:
            if x < maxjug1:
                x = maxjug1
            else:
                return None
        elif rule==2:
            if y < maxjug2:
                y = maxjug2
            else:
                return None
        elif rule==3:
            if x > 0:
                x = 0
            else:
                return None
```

```
        elif rule==4:
            if y > 0:
                y = 0
            else:
                return None
        elif rule==5:
            if x+y >= maxjug1:
                y=y-(maxjug1-x)
                x = maxjug1
            else:
                return None
        elif rule==6:
            if x+y >= maxjug2:
                x = x-(maxjug2-y)
                y = maxjug2
            else:
                 return None
        elif rule==7:
            if x+y < maxjug1:
                x = x+y
                y = 0
            else:
                return None
        elif rule==8:
            if x+y < maxjug2:
                y = x+y
                x = 0
            else:
                return None
        if(x==cnode.x and y==cnode.y):
            return None
        nextnode=node(cnode)
        nextnode.x=x
        nextnode.y=y
        nextnode.parent=cnode
        return nextnode
class BFS:
  def __init__(self,initNode,goalNode):
    self.initNode = initNode
    self.goalNode = goalNode
    self.q = []
    self.q.append(initNode)
  def pushList(self,list1):
    self.q.extend(list1)
  def popNode(self):
    return self.q.pop(0)
  def isNotEmpty(self):
```

```
    return len(self.q)>0
  def generateAllSuccessor(self,cnode):
    list1 = []
    for i in range(1,9):
      nextNode = operation(cnode,i)
      if(nextNode != None):
        list1.append(nextNode)
    return list1
  def execution(self):
    while self.isNotEmpty():
      cnode = self.popNode()
      #print("Pop Node:"+str(cnode))
      if cnode.x == self.goalNode.x:
        return cnode
      list1 = self.generateAllSuccessor(cnode)
      self.pushList(list1)
    return None
class DFS:
  def __init__(self,initNode,goalNode):
    self.initNode = initNode
    self.goalNode = goalNode
    self.q = []
    self.q.append(initNode)
    self.popList = []
  def pushList(self,list1):
    self.q.extend(list1)
  def popNode(self):
    return self.q.pop()
  def isNotEmpty(self):
    return len(self.q)>0
  def generateAllSuccessor(self,cnode):
    list1 = []
    for i in range(1,9):
      nextNode = operation(cnode,i)
      if(nextNode != None):
        list1.append(nextNode)
    return list1
  def generateAllSuccessorByRandom(self,cnode):
    list1 = []
    ruleList = []
    while(len(ruleList)!= 8):
      i = random.randint(1,8)
      if(i not in ruleList):
        ruleList.append(i)
    for i in ruleList:
      nextNode = operation(cnode,i)
      if(nextNode != None):
```

```
        list1.append(nextNode)
    return list1
  def generateAllSuccessorByRandomPopList(self,cnode):
    list1 = []
    ruleList = []
    while(len(ruleList)!= 8):
      i = random.randint(1,8)
      if(i not in ruleList):
        ruleList.append(i)
    for i in ruleList:
      nextNode = operation(cnode,i)
      if(nextNode != None and nextNode not in self.popList):
        list1.append(nextNode)
    return list1
  def execution(self):
    while self.isNotEmpty():
      cnode = self.popNode()
      self.popList.append(cnode)
      #print("Pop Node:"+str(cnode))
      if cnode.x == self.goalNode.x:
        return cnode
      list1 = self.generateAllSuccessorByRandomPopList(cnode)
      self.pushList(list1)
    return None
def printPath(cnode):
  temp = cnode
  retStr = ""
  pathCost = 0
  while(temp!=None):
    retStr = str(temp)+"\n"+retStr
    temp = temp.parent
    pathCost += 1
  print(retStr)
  print("Path Cost="+str(pathCost-1))

print("Malay Thakkar-20012011169")
maxjug1=int(input("Enter value of maxjug1:"))
maxjug2=int(input("Enter value of maxjug2:"))
initialNode=node(None)
initialNode.x=0
initialNode.y=0
initialNode.parent=None
GoalNode=node(None)
GoalNode.x=int(input("Enter value of goal in jug1:"))
GoalNode.y=0
GoalNode.parent=None
print("BFS Algorithm")
```

```
startTime = time.time()
bfsSolNode = BFS(initialNode,GoalNode).execution()
endTime = time.time()
diffTime = endTime - startTime
if(bfsSolNode != None):
  print("Got Solution:")
  printPath(bfsSolNode)
  print("Execution Time="+str(diffTime*1000)+"ms")
else:
  print("No Solution")
print("DFS Algorithm")
startTime = time.time()
dfsSolNode = DFS(initialNode,GoalNode).execution()
endTime = time.time()
diffTime = endTime - startTime
if(dfsSolNode != None):
  print("Got Solution:")
  printPath(dfsSolNode)
  print("Execution Time="+str(diffTime*1000)+"ms")
else:
  print("No Solution")
```

➢ OUTPUT:

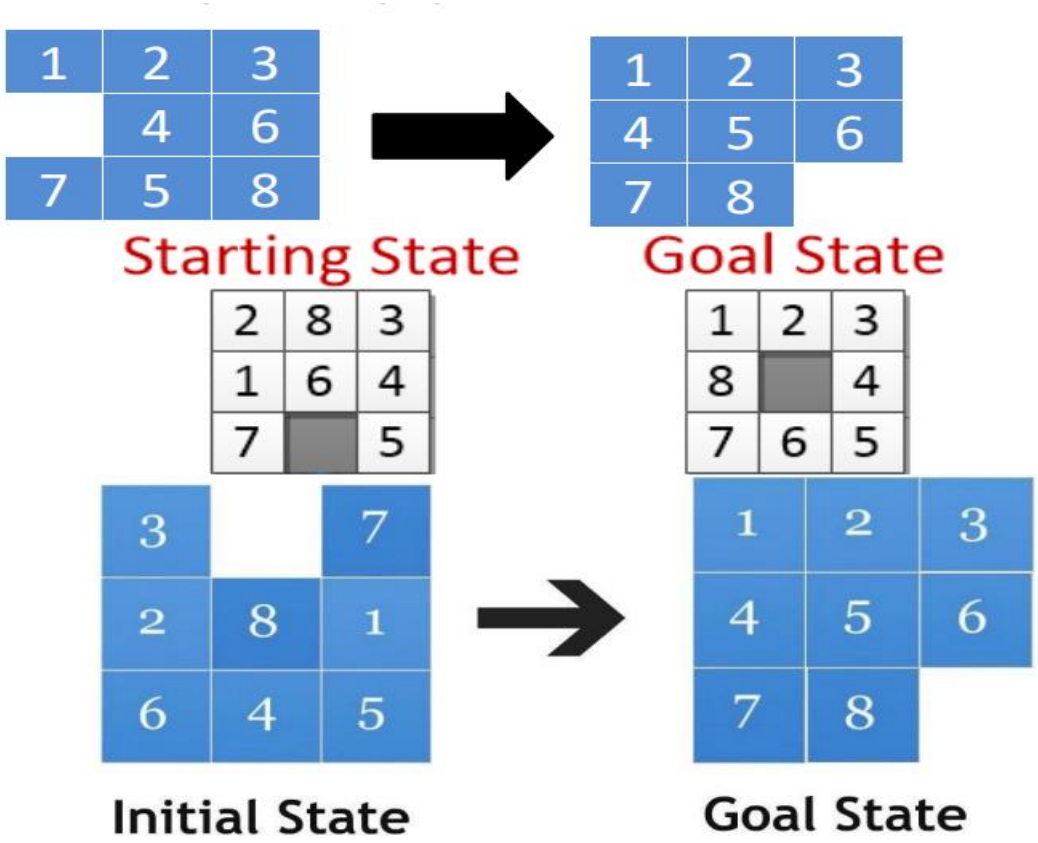
```
Malay Thakkar-20012011169
Enter value of maxjug1:4
Enter value of maxjug2:3
Enter value of goal in jug1:2
BFS Algorithm
Got Solution:
(0, 0)
(4, 0)
(1, 3)
(1, 0)
(0, 1)
(4, 1)
(2, 3)

Path Cost=6
Execution Time=3.9904117584228516ms
DFS Algorithm
Got Solution:
(0, 0)
(0, 3)
(3, 0)
(3, 3)
(4, 2)
(0, 2)
(2, 0)

Path Cost=6
Execution Time=0.0ms
PS D:\CLG\SEM-6\Prac\SEM-6\AI\Prac-3>
```

Practical-4

AIM: Write a program to solve 8 puzzle problem using the Best First search algorithm and also find Execution time, completeness of algorithm, etc.

Consider following steps to create a program in python:

1. Create Enum named "Action" for this problem
2. Create Node class with support of compare node & sort node
3. Choose appropriate heuristic function to solve this problem and create in Node class
4. Create BestFirstSearch class with "execution" method
5. Output should be according to given image
6. Print execution time & number of steps needed to reach goal state
7. Don't use any libraries or packages of python
8. Test Program according to given below test cases



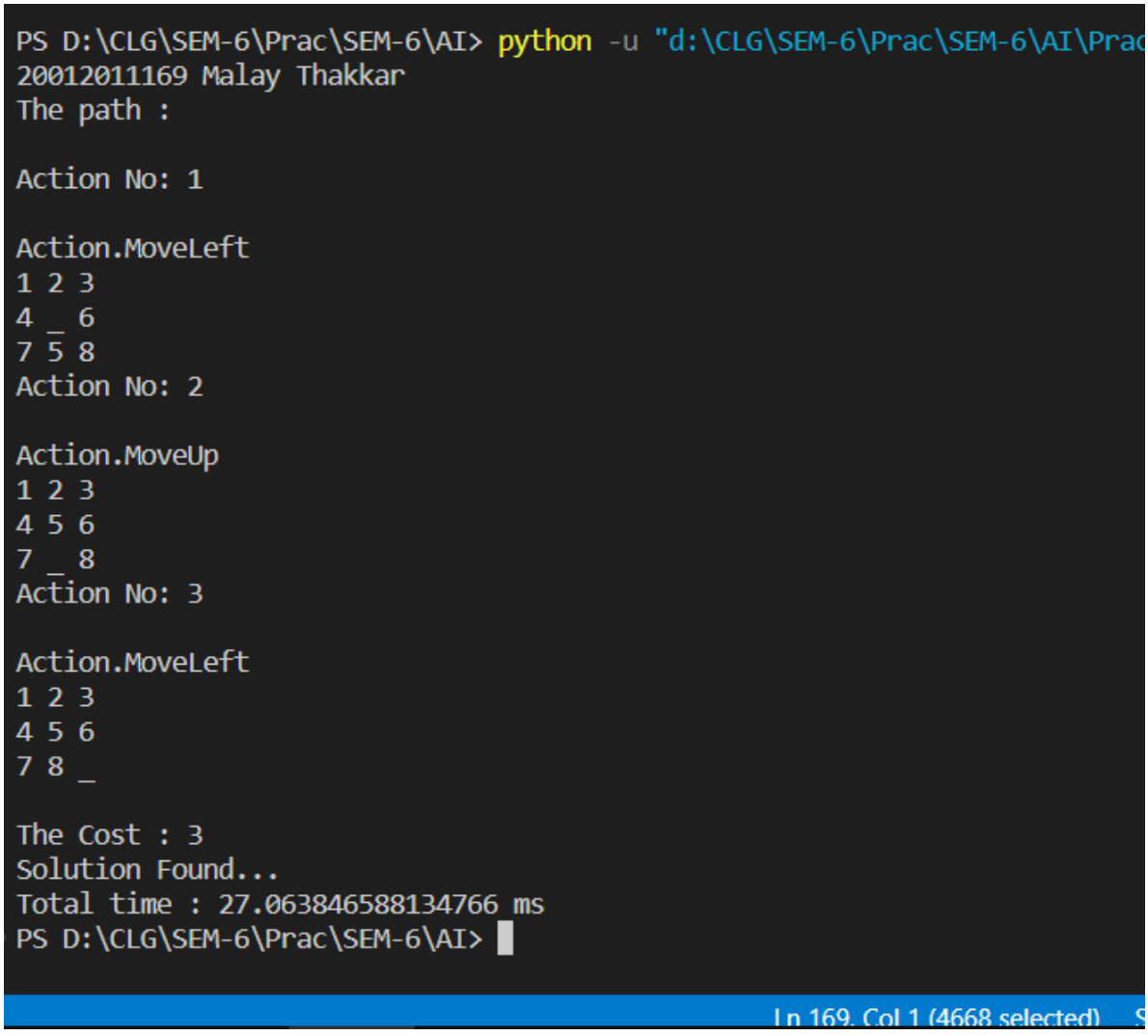
```
import enum
import time

class Action(enum.Enum):
    MoveDown = 0
    MoveUp = 1
    MoveLeft = 2
    MoveRight = 3
    noAction = 4

class Node:

    def __init__(self, position, action=Action.noAction, parent=None):
        self.position = position
        self.action = action
        self.parent = parent
        self.h = 0
        self.f = 0

    def printNode(self):
        print("Position : ", self.position, "\n", "Action : ", self.action, "\n", "Parent : ", self.parent,
"\n", )

    def __eq__(self, other):
        return self.position == other.position

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

    def __gt__(self, other):
        return self.f > other.f

    def __repr__(self):
        return '\n'.join(
            ['\n', str(self.action), str(self.position[:3]), str(self.position[3:6]),
str(self.position[6:])]).replace(
            '[', '').replace(']', '').replace(',', '').replace('0', '_')

    # heuristic value
    def _h(self, goal):
        return sum([1 if self.position[i] != goal[i] else 0 for i in range(9)])

    def generateValue(self, goal):
        self.h = self._h(goal)
        self.f = self.h

    # Possible Moves
```

```
    def possibleMoves(self):
        successor = []
        i = self.position.index(0)

        # MoveDown
        if i in [3, 4, 5, 6, 7, 8]:
            newValue = self.position[:]
            newValue[i], newValue[i - 3] = newValue[i - 3], newValue[i]

            successor.append(Node(position=newValue, parent=self, action=Action.MoveDown))

        # MoveUp
        if i in [0, 1, 2, 3, 4, 5]:
            newValue = self.position[:]
            newValue[i], newValue[i + 3] = newValue[i + 3], newValue[i]

            successor.append(Node(position=newValue, parent=self, action=Action.MoveUp))

        # MoveLeft
        if i in [0, 1, 3, 4, 6, 7]:
            newValue = self.position[:]
            newValue[i], newValue[i + 1] = newValue[i + 1], newValue[i]

            successor.append(Node(position=newValue, parent=self, action=Action.MoveLeft))

        # MoveRight
        if i in [1, 2, 4, 5, 7, 8]:
            newValue = self.position[:]
            newValue[i], newValue[i - 1] = newValue[i - 1], newValue[i]

            #           successor.append(Node(newValue,self,Action.MoveDown))
            successor.append(Node(position=newValue, parent=self, action=Action.MoveRight))

        return successor

def push(list1, node):
    list1.append(node)

def pop(list1):
    a = list1[0]
    del list1[0]
    return a

def not_empty(list1):
    if len(list1) != 0:
        return True
```

```
    else:
        return False
# PrintPath
def printpath(node, iniState):
    list3 = []
    while (node != iniState):
        list3.append(node)
        node = node.parent
    reversed_list = [list3[-(i + 1)] for i in range(len(list3))]

    print('The path :\n ')
    for i in range(len(reversed_list)):
        print('Action No:', i + 1, reversed_list[i])

    print('\nThe Cost :', len(reversed_list))
def can_add_to_openlist(openList, successor):
    for node in openList:
        if successor == node and successor.f >= node.f:
            return False
    return True
def EightPuzzle(initialState, goalState):
    iniState = Node(initialState)
    iniState.generateValue(goalState)

    openList = []
    closedList = []
    find = 1

    openList.append(iniState)
    while (not_empty(openList)):
        openList.sort()
        currentNode = pop(openList)
        #         print(type(currentNode))
        closedList.append(currentNode)
        if currentNode.position == goalState:
            find = 1
            printpath(currentNode, iniState)
            break
        else:
            successors = currentNode.possibleMoves()
        for succ in successors:
            if succ in closedList:
                continue
            else:
                succ.generateValue(goalState)
                if can_add_to_openlist(openList, succ):
                    openList.append(succ)
```

```
    if find == 1:
        print("Solution Found...")
    else:
        print("Solution UnFound....")
if __name__ == '__main__':
    print("20012011169 Malay Thakkar")
    initialState = [1, 2, 3, 0, 4, 6, 7, 5, 8]
    goalState = [1, 2, 3, 4, 5, 6, 7, 8, 0]
    startTime = time.time()
    EightPuzzle(initialState, goalState)
    endTime = time.time()
    print("Total time :", (endTime - startTime) * 1000, "ms")
```

OUTPUT:



Practical-5

Aim: Write a program to solve N-Queen problem using the A* search algorithm with Priority Queue and also find Execution time, completeness of algorithm, etc.

CODE:

```
import time
import queue
import random
import numpy as np
import matplotlib.pyplot as plt
from heapq import heappush, heappop, heapify

N = int(input("Enter the number of Queen You want to place: "))
a = queue.Queue()
class PriorityQueue:

    def __init__(self):
        self.pq = []

    def add(self, item):
        heappush(self.pq, item)

    def poll(self):
        return heappop(self.pq)

    def peek(self):
        return self.pq[0]

    def remove(self, item):
        value = self.pq.remove(item)
        heapify(self.pq)
        return value is not None

    def __len__(self):
        return len(self.pq)

class queen:
    def __init__(self):
        self.row = -1
        self.col = -1
    def __cmp__(self, other):
        return self.row == other.row and self.cok == other.col

    def __eq__(self, other):
```

```
        return self.__cmp__(other)

    def __hash__(self):
        return hash(str(self.list_()))
    def list_(self):
        return [self.row,self.col]

class state:
    def __init__(self, data):
        self.nQueen = [queen() for i in range(N)]
        if(data != None):
            self.moves = data.moves + 1
            self.heuristicVal = data.heuristicVal
            for i in range(N):
                self.nQueen[i].row = data.nQueen[i].row
                self.nQueen[i].col = data.nQueen[i].col
        else:
            self.moves = 0
            self.initQueens()
        self.parent = data

    def getConflictCount(self,row,col):
        count = 0
        conflictCount = 0
        ConflictSet = []
        for i in range(N):
            if(self.nQueen[i].row == row):
                count+=1
                ConflictSet.append(self.nQueen[i])
        for i in range(N):
            if(self.nQueen[i].col == col):
                count+=1
                ConflictSet.append(self.nQueen[i])
        for i in range(N):
            if(abs(self.nQueen[i].row - row) == abs(self.nQueen[i].col -col)):
                count+=1
                ConflictSet.append(self.nQueen[i])
        for obj in ConflictSet:
            if(not(obj.row == row and obj.col == col)):
                conflictCount+=1
        return conflictCount

    def placeQueen(self,row,col):
        if(row >= N or col >= N):
            return
        if(self.nQueen[col].row == row and self.nQueen[col].col == col):
            return
```

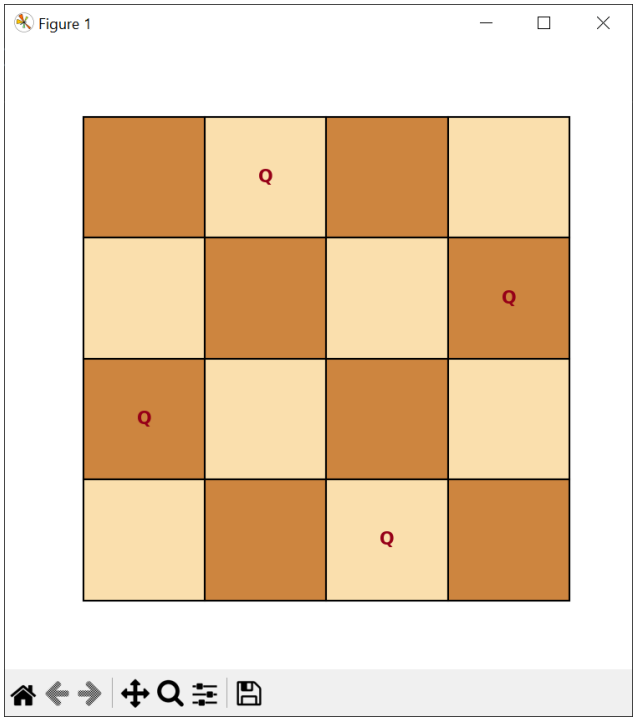
```
        self.nQueen[col].row = row
        self.nQueen[col].col = col
        self.heuristicVal = self.getHeuristicCost()

    def printQueen(self):
        for i in range(N):
            for j in range(N):
                if(self.nQueen[j].row == i):
                    print("1", end=" ")
                else:
                    print("0", end=" ")
            print()
        print()

    def drawQueens(self):
        board = self.getMatrix()
        matrix = np.zeros ((N, N))
        matrix = matrix.astype(str)

        for i in range(N):
            for j in range (N):
                if board[i][j] == 1:
                    matrix[i][j] = 'Q'
                else:
                    matrix[i][j] =' '

        w = 5
        h = 5
        plt.figure(1, figsize=(w, h))
        tb = plt.table(cellText=matrix, loc=(0, 0), cellLoc='center')

        for i in range(N):
            for j in range(N):
                if board[i][j] ==1:
                    tb._cells[(i, j)]._text.set_color('#960018')
                    tb._cells[(i, j)]._text.set_weight('extra bold')
                if ((i + j) % 2) == 0:
                    tb._cells[(i, j)].set_facecolor('#CD853F')
                else:
                    tb._cells[(i, j)].set_facecolor('#FADFAD')
                tb._cells[(i, j)].set_height(1.0 / N)
                tb._cells[(i, j)].set_width(1.0 / N)
        ax = plt.gca()
        ax.set_xticks([])
        ax.set_yticks([])
        plt.show()
```

```
def getMatrix(self):
    board = np.zeros((N, N))
    board.astype(int)
    for j in range(N):
        for i in range(N):
            if(self.nQueen[i].row == j):
                board[i][j] = 1
            else:
                board[i][j] = 0
    return board

def initQueens(self):
    for col in range(N):
        row = random.randint(0,N-1)
        self.placeQueen(row, col)
    self.moves = 0
    self.heuristicVal = self.getHeuristicCost()

def getHeuristicCost(self):
    count = 0
    for i in range(N):
        count = count + self.getConflictCount(self.nQueen[i].row, self.nQueen[i].col)
    return count

def score(self):
    return self._h() + self._g()

def _h(self):
    return self.heuristicVal

def _g(self):
    return self.moves

def __cmp__(self, other):
    if(other == None):
        return False
    return self.nQueen == other.nQueen

def __eq__(self, other):
    return self.__cmp__(other)

def __hash__(self):
    return hash(str(self.nQueen))

def __lt__(self, other):
    return self.score() < other.score()
```

```
    def nextAllState(self):
        list1 = []
        row = self.moves
        for i in range(N):
            if(not(self.nQueen[i].row == row and self.nQueen[i].col == i)):
                nextState = state(self)
                nextState.placeQueen(row, i)
                list1.append(nextState)
        return list1

def solve(initial_state):
    openset = PriorityQueue()
    openset.add(initial_state)
    closed = set()
    moves = 0
    print("Trying to solve:")
    print(openset.peek().printQueen(),'\n\n')
    start = time.time()
    while openset:
        current = openset.poll()
        if current.heuristicVal == 0:
            end = time.time()
            print('I found a solution')
            current.printQueen()
            current.drawQueens()
            print('I found the solution in %2.f milliseconds'% float((end - start)*1000))
            break
        moves += 1
        for state in current.nextAllState():
            if state not in closed:
                openset.add(state)
        closed.add(current)
    else:
        print('I couldn"t solve it!')

def main():
    initial_state = state(None)
    solve(initial_state)

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

OUTPUT:

```
PS C:\Users\Malay Thakkar> python -u "d:\CLG\SEM-6\Prac\SEM-6\AI\Prac-5\N-Queen.py"
Enter the number of Queen You want to place: 4
Trying to solve:
0 0 0 0
0 0 0 0
0 1 0 0
1 0 1 1

None


I found a solution
0 0 1 0
1 0 0 0
0 0 0 1
0 1 0 0

I found the solution in  2 milliseconds
PS C:\Users\Malay Thakkar>
```



Practical-6

AIM: Write a program to create tic-tac-toe game using the alpha-beta algorithm.

- **CODE:**

```
from math import inf as infinity
from random import choice
import platform
import time
from os import system
import numpy as np
import matplotlib.pyplot as plt
from matplotlib.colors import ListedColormap

player = -1
computer = +1
steps = 1
turn = ""
status = "RUNNING..."

class stateNode:
    def __init__(self):
        self.board = [
            [0, 0, 0],
            [0, 0, 0],
            [0, 0, 0],
        ]

    def evaluate(self):
        if self.wins(computer):
            score = +1
        elif self.wins(player):
            score = -1
        else:
            score = 0
        return score

    def game_over(self):
        return self.wins(player) or self.wins(computer)

    def empty_cells(self):
        cells = []
        for x, row in enumerate(self.board):
            for y, cell in enumerate(row):
                if cell == 0:
```

```
                cells.append([x, y])
        return cells

    def valid_move(self, x, y):
        if [x, y] in self.empty_cells():
            return True
        else:
            return False

    def set_move(self, x, y, player):
        if self.valid_move(x, y):
            self.board[x][y] = player
            return True
        else:
            return False

    def wins(self, player):
        state = self.board
        win_state = [
            [state[0][0], state[0][1], state[0][2]],
            [state[1][0], state[1][1], state[1][2]],
            [state[2][0], state[2][1], state[2][2]],
            [state[0][0], state[1][0], state[2][0]],
            [state[0][1], state[1][1], state[2][1]],
            [state[0][2], state[1][2], state[2][2]],
            [state[0][0], state[1][1], state[2][2]],
            [state[2][0], state[1][1], state[0][2]],
        ]
        if [player, player, player] in win_state:
            return True
        else:
            return False

    def render(self, computer_choice, player_choice):
        global steps, turn, status
        chars = {-1: player_choice, +1: computer_choice, 0: ""}
        str_line = "---------------"

        print("\n" + str_line)

        for row in self.board:
            for cell in row:
                symbol = chars[cell]
                print(f"| {symbol} |", end="")
            print("\n" + str_line)

        arr = np.zeros((3, 3), dtype=int)
```

```
        arr[1::2, 0::2] = 1
        arr[0::2, 1::2] = 1
        image = arr.reshape((3, 3))

        colors = ["blue", "yellow", "red", "green", "k", "#550011", "black", "orange"]

        cmap = ListedColormap(colors)
        plt.matshow(image, cmap=cmap)
        i, j = 0, 0

        for row in self.board:
            j = 0
            for cell in row:
                symbol = chars[cell]
                plt.text(
                    j,
                    i,
                    symbol,
                    va="center",
                    ha="center",
                    color="blue" if (i - j) % 2 == 0 else "green",
                    fontsize=30,
                )
                j += 1
            i += 1

        plt.xlabel(
            "step no.:-[{}] Turn:-[{}]\nchoice:- player[{}] computer[{}]".format(
                steps, turn, player_choice, computer_choice
            )
        )
        plt.ylabel("Status:- {}".format(status))
        plt.show()
        steps += 1

def minimax(state, depth, player):
    if player == computer:
        best = [-1, -1, -infinity]
    else:
        best = [-1, -1, +infinity]

    if depth == 0 or state.game_over():
        score = state.evaluate()
        return [-1, -1, score]

    for cell in state.empty_cells():
        x, y = cell[0], cell[1]
```

```
            state.board[x][y] = player
            score = minimax(state, depth - 1, -player)
            state.board[x][y] = 0
            score[0], score[1] = x, y

            if player == computer:
                if score[2] > best[2]:
                    best = score  # max value

            else:
                if score[2] < best[2]:
                    best = score  # min value

        return best

def clean():
    os_name = platform.system().lower()
    if "windows" in os_name:
        system("cls")
    else:
        system("clear")

def computer_turn(state, computer_choice, player_choice):
    global turn
    turn = "COMPUTER"
    depth = len(state.empty_cells())
    if depth == 0 or state.game_over():
        return
    # clean()
    print(f"Computer turn[{computer_choice}]")
    state.render(computer_choice, player_choice)
    if depth == 9:
        x = choice([0, 1, 2])
        y = choice([0, 1, 2])
    else:
        move = minimax(state, depth, computer)
        x, y = move[0], move[1]
    state.set_move(x, y, computer)
    time.sleep(1)

def player_turn(state, computer_choice, player_choice):
    global turn
    turn = "player"
    depth = len(state.empty_cells())

    if depth == 0 or state.game_over():
        return
```

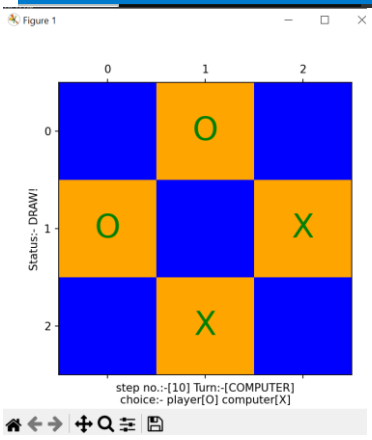
```
    move = -1
    moves = {
        1: [0, 0],
        2: [0, 1],
        3: [0, 2],
        4: [1, 0],
        5: [1, 1],
        6: [1, 2],
        7: [2, 0],
        8: [2, 1],
        9: [2, 2],
    }

    print(f"player turn [{player_choice}]")

    state.render(computer_choice, player_choice)
    while move < 1 or move > 9:
        try:
            move = int(input("Enter Any Number (1..9): "))
            coord = moves[move]
            can_move = state.set_move(coord[0], coord[1], player)
            if not can_move:
                print("Bad move")
                move = -1
        except (EOFError, KeyboardInterrupt):
            print("Bye")
            exit()

        except (KeyError, ValueError):
            print("Bad choice")

def main():

    player_choice = ""
    computer_choice = ""
    first = ""
    state = stateNode()

    while player_choice != "O" and player_choice != "X":
        try:
            player_choice = input("::Choose 'X' or 'O'::\nYour Choice: ").upper()
            print("")
        except (EOFError, KeyboardInterrupt):
            print("Program End")
            exit()
        except (KeyError, ValueError):
```

```
            print("Bad choice")

        if player_choice == "X":
            computer_choice = "O"
        else:
            computer_choice = "X"

    while first != "Y" and first != "N":
        try:
            first = input("Do you want to start first? [Y/N]: ").upper()
        except (EOFError, KeyboardInterrupt):
            print("Program End")
            exit()
        except (KeyError, ValueError):
            print("Bad choice")

    while len(state.empty_cells()) > 0 and not state.game_over():
        if first == "N":
            computer_turn(state, computer_choice, player_choice)
            first = ""
        player_turn(state, computer_choice, player_choice)
        computer_turn(state, computer_choice, player_choice)

    global status
    if state.wins(player):
        print(f"player turn [{player_choice}]")
        status = "player WINS!"
        state.render(computer_choice, player_choice)
        print(status)
    elif state.wins(computer):
        print(f"Computer turn [{computer_choice}]")
        status = "COMPUTER WINS"
        state.render(computer_choice, player_choice)
        print(status)
    else:
        status = "DRAW!"
        state.render(computer_choice, player_choice)
        print(status)
    exit()

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

➢ OUTPUT:

```
PS C:\Users\Malay Thakkar\Downloads> python -u "c:\Users\
::Choose 'X' or 'O'::
Your Choice: O

Do you want to start first? [Y/N]: Y
player turn [O]

--------------
|  ||  ||  |
--------------
|  ||  ||  |
--------------
|  ||  ||  |
--------------
Enter Any Number (1..9): 5
Computer turn[X]

--------------
|  ||  ||  |
--------------
|  || o ||  |
--------------
|  ||  ||  |
--------------
player turn [O]

--------------
| X ||  ||  |
--------------
|  || o ||  |
--------------
|  ||  ||  |
--------------
Enter Any Number (1..9): 9
Computer turn[X]
```

```
| X || o || X |
--------------
|  || o ||  |
--------------
|  || X || o |
--------------
Enter Any Number (1..9): 4
Computer turn[X]

--------------
| X || o || X |
--------------
| o || o ||  |
--------------
|  || X || o |
--------------
player turn [O]

--------------
| X || o || X |
--------------
| o || o || X |
--------------
|  || X || o |
--------------
Enter Any Number (1..9): 7

--------------
| X || o || X |
--------------
| o || o || X |
--------------
| o || X || o |
--------------
DRAW!
PS C:\Users\Malay Thakkar\Downloads>
```



Practical-7

Aim: Write a program to build Multi-layer Perceptron to implement any Boolean functions as mentioned below without using any python packages.

➢ **CODE:**

```
from numpy import dot

class perceptronNeuron:
    def __init__(self, x, w, w0):
        l = [ww for ww in x]
        l.insert(0, 1)
        self.x = l
        self.y = 0
        l = [ww for ww in w]
        l.insert(0, w0)
        self.w = l
        #print("L:"+str(l)+", w:"+str(w)+"self.w:"+str(self.w))

    def __repr__(self):
        return "Input:"+str(self.x)+", Weight:"+str(self.w)

    def activationFunction(self):
        self.y = 1 if dot(self.x, self.w) >= 0 else 0
        return self.y

    def dot(x, W):
        if len(x) != len(W):
            return 0
        return sum(i[0] * i[1] for i in zip(X, W))

class multiLayerPerceptron:
    def __init__(self, a0, a1, dimension, inputBias, weight, functionName, s0, s1):
        self.n = dimension
        self.a0 = a0
        self.a1 = a1
        self.inputBias = inputBias
        self.hidden = []
        self.weight = weight
        self.funcName = functionName
        self.s0 = s0
        self.s1 = s1

    def binaryCombinations(self, a0, a1, n):
        list1 = []
        for i in range(1 << n):
```

```
            s = bin(i)[2:]
            s = '0'*(n-len(s))+s
            l = list(map(int, list(s)))
            l = [a0 if item == 0 else a1 for item in l]
            list1.append(l)
        return list1

    def generateHiddenLayer(self, input):
        allPossibleList = self.binaryCombinations(self.a0, self.a1, self.n)
        self.hidden = [perceptronNeuron(input, weight, self.inputBias)
                       for weight in allPossibleList]
        return self.hidden

    def outputActivationFun(self, hiddenLayer):
        return self.a1 if dot(hiddenLayer, self.weight) >= 0 else self.a0

    def generateOutput(self, xStr):
        allPossibleInputs = self.binaryCombinations(self.a0, self.a1, self.n)
        output = []
        strheader = "\n"+self.funcName+"\n"
        for i in range(self.n):
            strheader += (xStr+str(i+1)+"\t")
        strheader += ("Output")
        print(strheader)
        for input in allPossibleInputs:
            allhiddenOutput = self.generateHiddenLayer(input)
            # print(allhiddenOutput)
            o = [hiddenPerceptron.activationFunction()
                 for hiddenPerceptron in allhiddenOutput]
            o.insert(0, 1)
            # print(str(o))
            o = self.outputActivationFun(o)
            output.append(o)
            print(str([self.s0 if item == self.a0 else self.s1 for item in input]).replace("[",
"").replace(
                "]", "").replace(",", "\t").replace("'", "")+"\t"+str(self.s0 if o == self.a0 else self.s1))

# return output
true = 1
false = -1
initialBias = -2
outputBias = -1
dimension = 2
s0 = "0"
s1 = "1"
xStr = "x"
andMLP = multiLayerPerceptron(false, true, dimension, initialBias, [
```

```
                        outputBias, false, false, false, true], "AND Function", s0, s1)
orMLP = multiLayerPerceptron(false, true, dimension, initialBias, [
                       outputBias, false, true, true, true], "OR Function", s0, s1)
xorMLP = multiLayerPerceptron(false, true, dimension, initialBias, [
                        outputBias, false, true, true, false], "XOR Function", s0, s1)
xnorMLP = multiLayerPerceptron(false, true, dimension, initialBias, [
                         outputBias, true, false, false, true], "XNOR Function", s0, s1)
norMLP = multiLayerPerceptron(false, true, dimension, initialBias, [
                        outputBias, true, false, false, false], "NOR Function", s0, s1)
nandMLP = multiLayerPerceptron(false, true, dimension, initialBias, [
                         outputBias, true, true, true, false], "NAND Function", s0, s1)
notInput1MLP = multiLayerPerceptron(false, true, dimension, initialBias, [
                           outputBias, true, true, false, false], "Not"+xStr+"1 Function", s0, s1)
notInput2MLP = multiLayerPerceptron(false, true, dimension, initialBias, [
                           outputBias, true, false, true, false], "Not"+xStr+"2 Function", s0, s1)
nullMLP = multiLayerPerceptron(false, true, dimension, initialBias, [
                         outputBias, false, false, false, false], "NULL Function", s0, s1)
identityMLP = multiLayerPerceptron(false, true, dimension, initialBias, [
                          outputBias, true, true, true, true], "Identity Function", s0, s1)
inhibition1MLP = multiLayerPerceptron(false, true, dimension, initialBias, [
                            outputBias, false, false, true, false], "Inhibition x1^~x2 Function", s0,
s1)
inhibition2MLP = multiLayerPerceptron(false, true, dimension, initialBias, [
                            outputBias, false, true, false, false], "Inhibition x2^~x1 Function", s0,
s1)
transferX1MLP = multiLayerPerceptron(false, true, dimension, initialBias, [
                           outputBias, false, false, true, true], "Transfer x1 Function", s0, s1)
transferX2MLP = multiLayerPerceptron(false, true, dimension, initialBias, [
                           outputBias, false, true, false, true], "Transfer x2 Function", s0, s1)
implication1MLP = multiLayerPerceptron(false, true, dimension, initialBias, [
                            outputBias, true, false, true, true], "Implication x1V~x2 Function",
s0, s1)
implication2MLP = multiLayerPerceptron(false, true, dimension, initialBias, [
                            outputBias, true, true, false, true], "Implication x2V~x1 Function",
s0, s1)
andMLP.generateOutput(xStr)
orMLP.generateOutput(xStr)
xorMLP.generateOutput(xStr)
norMLP.generateOutput(xStr)
xnorMLP.generateOutput(xStr)
nandMLP.generateOutput(xStr)
notInput1MLP.generateOutput(xStr)
notInput2MLP.generateOutput(xStr)
nullMLP.generateOutput(xStr)
identityMLP.generateOutput(xStr)
inhibition1MLP.generateOutput(xStr)
inhibition2MLP.generateOutput(xStr)
```

transferX1MLP.generateOutput(xStr)
transferX2MLP.generateOutput(xStr)
implication1MLP.generateOutput(xStr)
implication2MLP.generateOutput(xStr)

➢ OUTPUT:

```
PS C:\Users\Malay Thakkar\Down

AND Function
x1      x2      Output
0       0       0
0       1       0
1       0       0
1       1       1

OR Function
x1      x2      Output
0       0       0
0       1       1
1       0       1
1       1       1

XOR Function
x1      x2      Output
0       0       0
0       1       1
1       0       1
1       1       0

NOR Function
x1      x2      Output
0       0       1
0       1       0
1       0       0
1       1       0

XNOR Function
x1      x2      Output
0       0       1
0       1       0
1       0       0
1       1       1
```

```
Inhibition x2^~x1 Function
x1      x2      Output
0       0       0
0       1       1
1       0       0
1       1       0

Transfer x1 Function
x1      x2      Output
0       0       0
0       1       0
1       0       1
1       1       1

Transfer x2 Function
x1      x2      Output
0       0       0
0       1       1
1       0       0
1       1       1

Implication x1V~x2 Function
x1      x2      Output
0       0       1
0       1       0
1       0       1
1       1       1

Implication x2V~x1 Function
x1      x2      Output
0       0       1
0       1       1
1       0       0
1       1       1
PS C:\Users\Malay Thakkar\Downloads>
```

❖