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XIE ID	201901030	Experiment No	05
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Aim: To implement a game playing algorithm

Theory:

- Mini-max algorithm is a recursive or backtracking algorithm which is used in decision-making and game theory. It provides an optimal move for the player assuming that opponent is also playing optimally.
- Mini-Max algorithm uses recursion to search through the game-tree.
- Min-Max algorithm is mostly used for game playing in AI. Such as Chess, Checkers, tic-tac-toe, go, and various tow-players game. This Algorithm computes the minimax decision for the current state.
- In this algorithm two players play the game, one is called MAX and other is called MIN.
- Both the players fight it as the opponent player gets the minimum benefit while they get the maximum benefit.
- Both Players of the game are opponent of each other, where MAX will select the maximized value and MIN will select the minimized value.
- The minimax algorithm performs a depth-first search algorithm for the exploration of the complete game tree.
- The minimax algorithm proceeds all the way down to the terminal node of the tree, then backtrack the tree as the recursion.

- **Complete-** Min-Max algorithm is Complete. It will definitely find a solution (if exist), in the finite search tree.
- **Optimal-** Min-Max algorithm is optimal if both opponents are playing optimally.
- **Time complexity-** As it performs DFS for the game-tree, so the time complexity of Min-Max algorithm is **$O(b^m)$**, where b is branching factor of the game-tree, and m is the maximum depth of the tree.
- **Space Complexity-** Space complexity of Mini-max algorithm is also similar to DFS which is **O(bm)**.

Code:

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

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")

#printBoard(board)

# if the space is empty we can input 'X' or 'O'
def spaceIsFree(position):
    if board[position] == ' ':
        return True
```

```
    else:
        return False

#print(spaceIsFree(1)) -> returns true if position
1 is free

def insertLetter(letter, position):
    if spaceIsFree(position):
        board[position] = letter
        printBoard(board)
        if (checkDraw()):
            print("Draw!")
            exit()
        if checkForWin():
            if letter == 'X':
                print("Bot wins!")
                exit()
            else:
                print("Player wins!")
                exit()

        return


    else:
        print("Can't insert there!")
        position = int(input("Please enter new
position:  "))
        insertLetter(letter, position)
        return

#insertLetter(x, 1)

def checkDraw():
    for key in board.keys():
```

```
        if (board[key] == ' '): #if there are empty
spaces we can still play & not a draw
            return False
    return


def checkForWin():
    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[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
    elif (board[1] == board[5] and board[1] ==
board[9] and board[1] != ' '):
        return True
    elif (board[7] == board[5] and board[7] ==
board[3] and board[7] != ' '):
        return True
    else:
        return False

def checkWhichMarkWon(mark):
```

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

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


def compMove():
    bestScore = -800
```

```
    bestMove = 0
    for key in board.keys():
        if (board[key] == ' '):
            board[key] = bot #bot will play if the
space is empty
            score = minimax(board, 0, False)
            board[key] = ' '
            if (score > bestScore):
                bestScore = score
                bestMove = key

    insertLetter(bot, bestMove)
    return

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

    if (isMaximizing):
        bestScore = -800
        for key in board.keys():
            if (board[key] == ' '):
                board[key] = bot
                score = minimax(board, depth + 1,
False)
                board[key] = ' '
                if (score > bestScore):
                    bestScore = score
        return bestScore

    else:
```

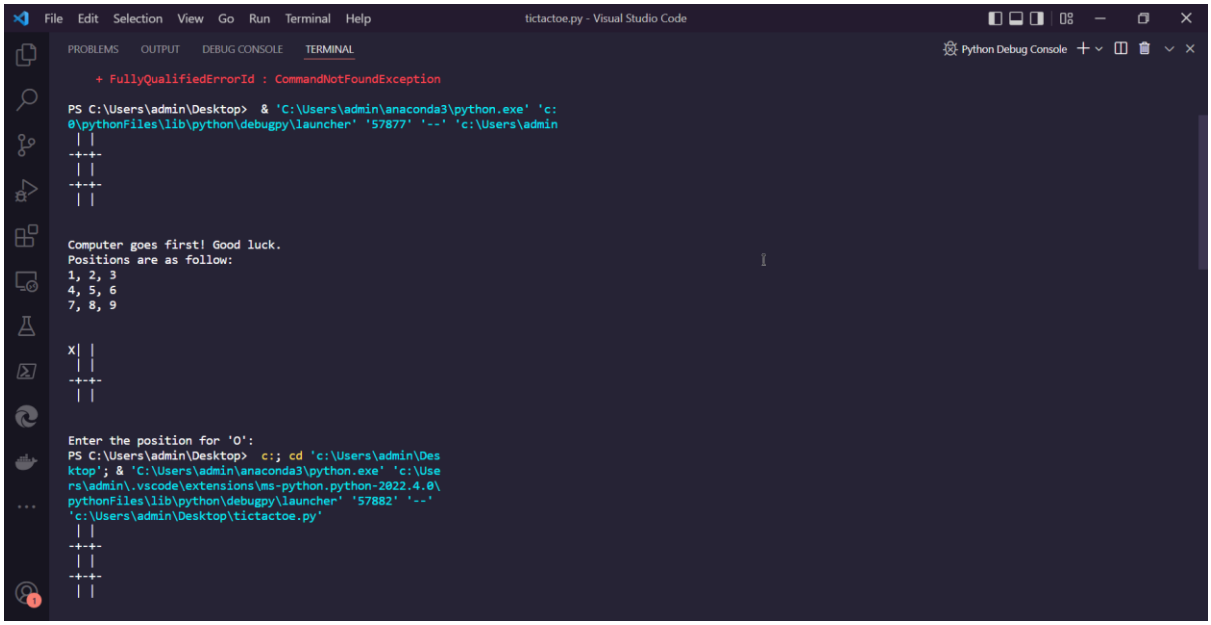
```
        bestScore = 800
        for key in board.keys():
            if (board[key] == ' '):
                board[key] = player
                score = minimax(board, depth + 1,
True)
                board[key] = ' '
                if (score < bestScore):
                    bestScore = score
        return bestScore


printBoard(board)
print("Computer goes first! Good luck.")
print("Positions are as follow:")
print("1, 2, 3 ")
print("4, 5, 6 ")
print("7, 8, 9 ")
print("\n")
player = 'O'
bot = 'X'


global firstComputerMove
firstComputerMove = True

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

Output:


File Edit Selection View Go Run Terminal Help
tictactoe.py - Visual Studio Code
PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL
Python Debug Console
+ FullyQualifiedErrorId : CommandNotFoundException
PS C:\Users\admin\Desktop> & 'C:\Users\admin\anaconda3\python.exe' 'c:
0\pythonFiles\lib\python\debugpy\launcher' '57877' '--' 'c:\Users\admin
| |
-+-+-
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| |
Computer goes first! Good luck.
Positions are as follow:
1, 2, 3
4, 5, 6
7, 8, 9
X| |
| |
-+-+-
| |
Enter the position for 'O':
PS C:\Users\admin\Desktop> c:; cd 'c:\Users\admin\Des
ktop'; & 'C:\Users\admin\anaconda3\python.exe' 'c:\Use
rs\admin\.vscode\extensions\ms-python.python-2022.4.0\
pythonFiles\lib\python\debugpy\launcher' '57882' '--'
'c:\Users\admin\Desktop\tictactoe.py'
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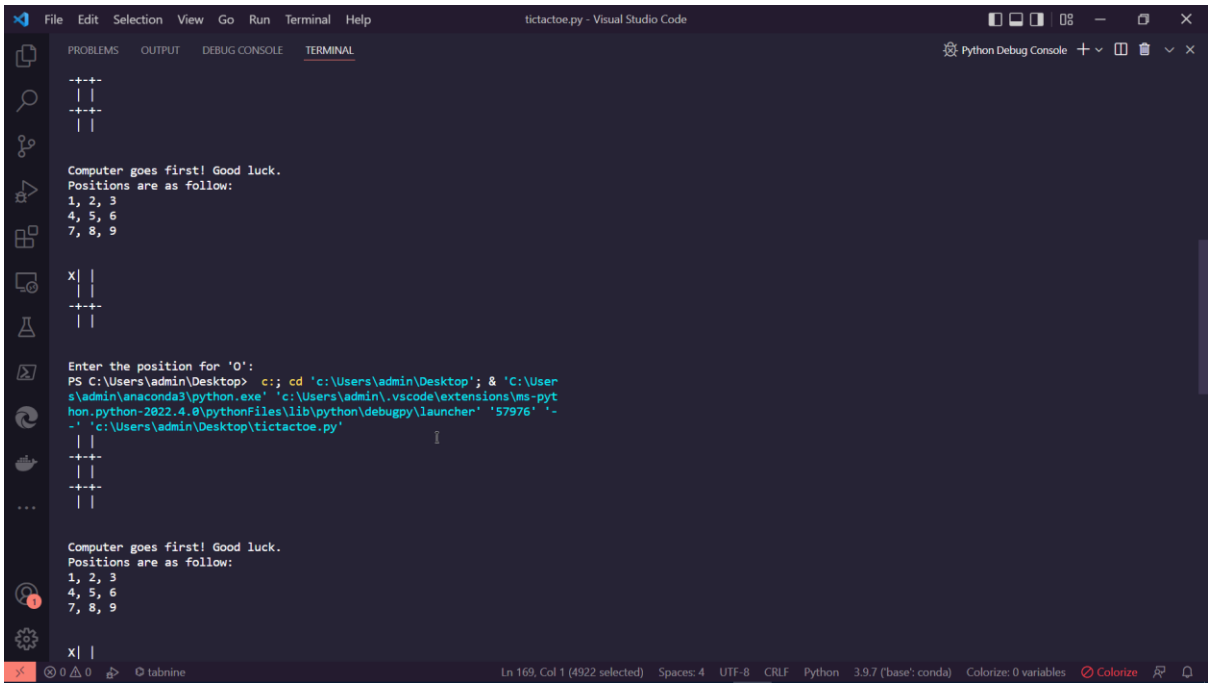
File Edit Selection View Go Run Terminal Help
tictactoe.py - Visual Studio Code
PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL
Python Debug Console
-+-+-
| |
-+-+-
| |
Computer goes first! Good luck.
Positions are as follow:
1, 2, 3
4, 5, 6
7, 8, 9
X| |
| |
-+-+-
| |
Enter the position for 'O':
PS C:\Users\admin\Desktop> c:; cd 'c:\Users\admin\Desktop'; & 'C:\User
s\admin\anaconda3\python.exe' 'c:\Users\admin\.vscode\extensions\ms-pyt
hon.python-2022.4.0\pythonFiles\lib\python\debugpy\launcher' '57976' '-
-' 'c:\Users\admin\Desktop\tictactoe.py'
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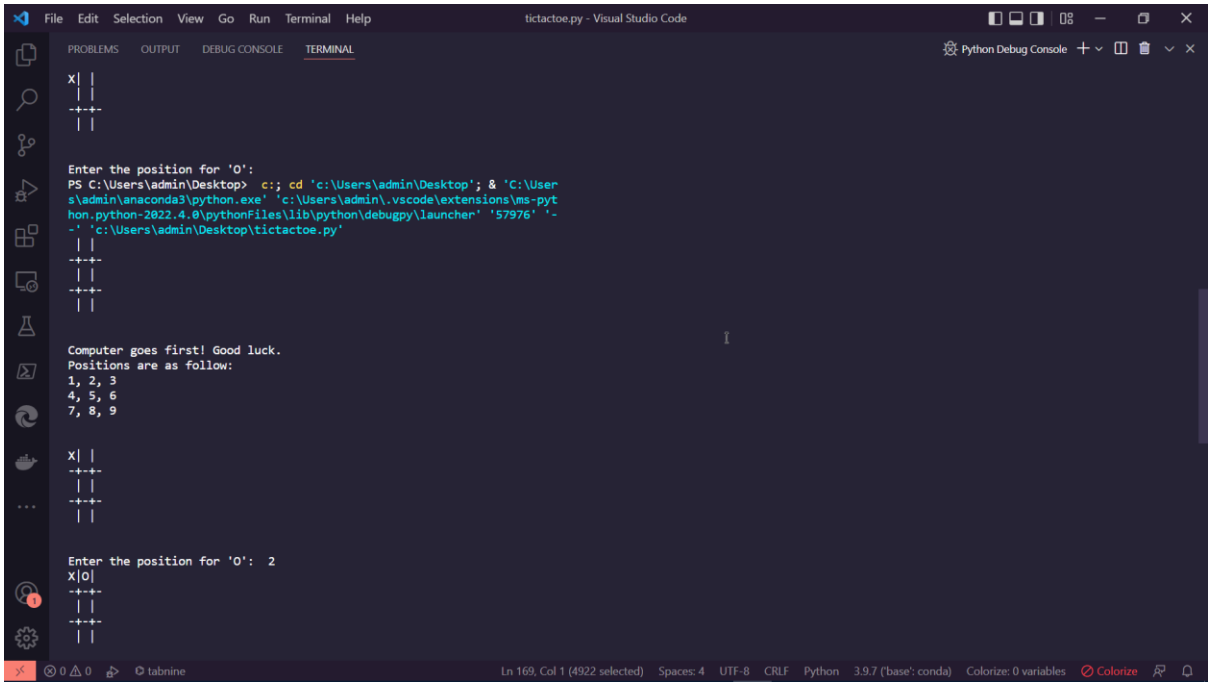
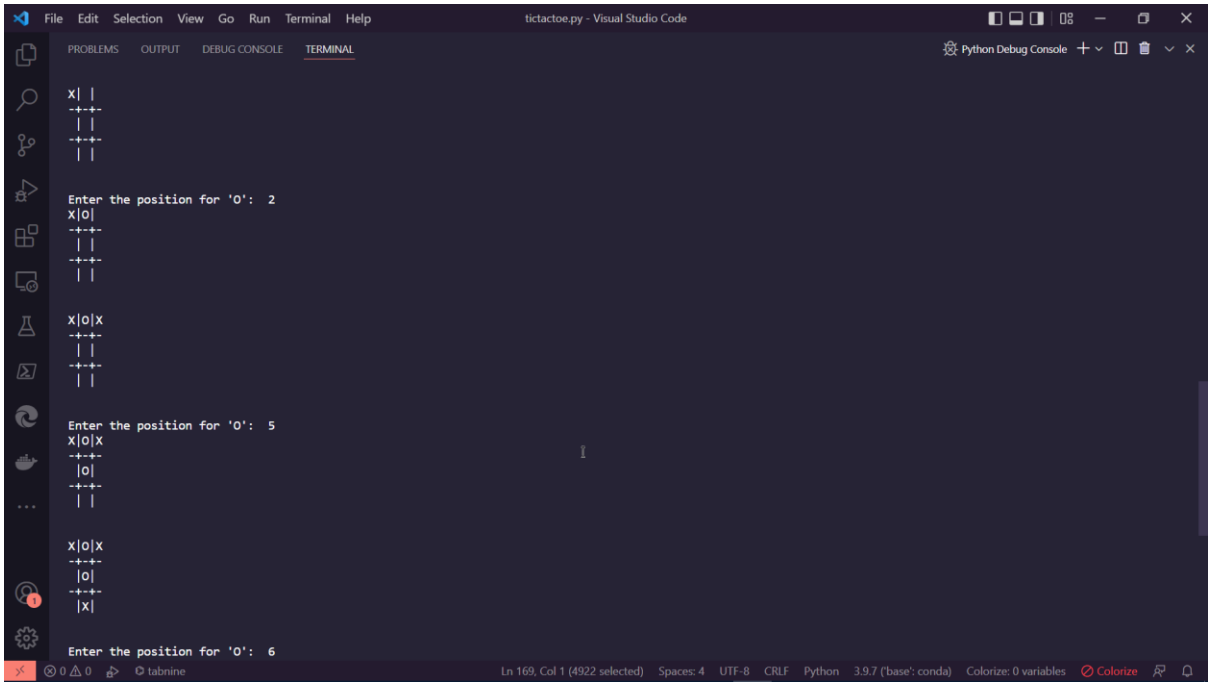
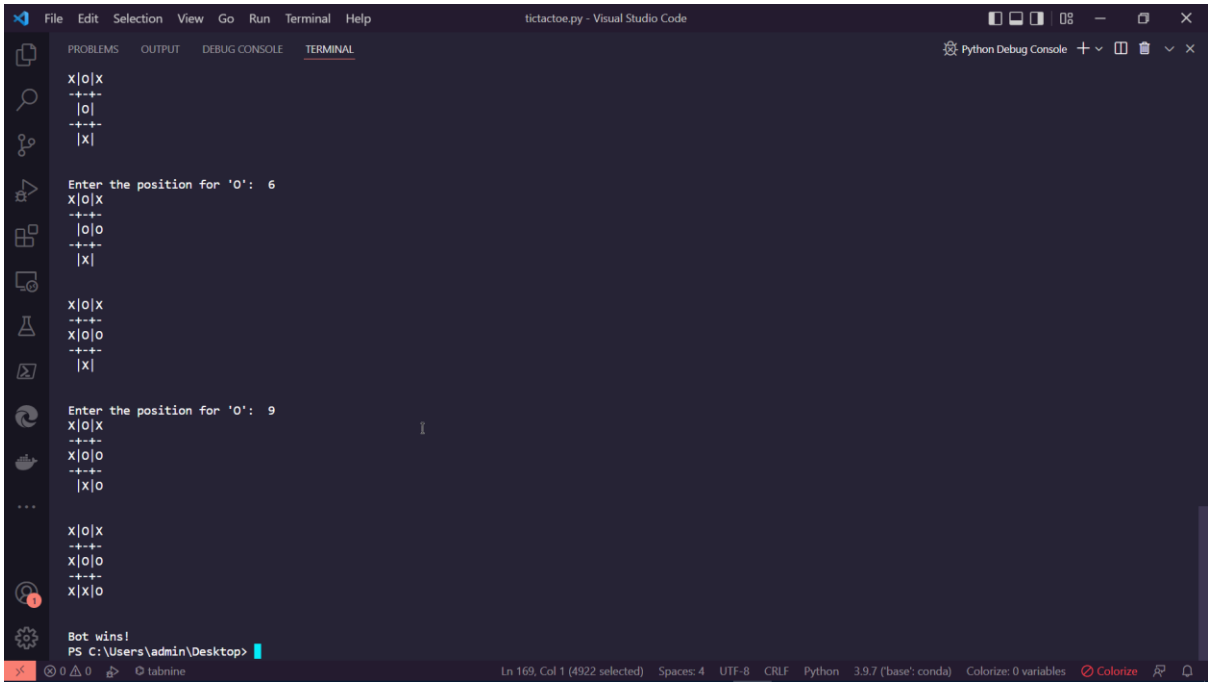
| |
Computer goes first! Good luck.
Positions are as follow:
1, 2, 3
4, 5, 6
7, 8, 9
X| |
tabnine
Ln 169, Col 1 (4922 selected) Spaces: 4 UTF-8 CRLF Python 3.9.7 ('base': conda) Colorize: 0 variables Colorize





Conclusion: Implementation of the game playing algorithm has been successful.


File Edit Selection View Go Run Terminal Help
tictactoe.py - Visual Studio Code
PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL
Python Debug Console
x|o|x
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|o|
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|x|
Enter the position for 'O': 6
x|o|x
-+-+-
|o|o
-+-+-
|x|
x|o|x
-+-+-
x|o|o
-+-+-
|x|
Enter the position for 'O': 9
x|o|x
-+-+-
x|o|o
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|x|o
x|o|x
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x|o|o
-+-+-
x|x|o
Bot wins!
PS C:\Users\admin\Desktop>
tabnine
Ln 169, Col 1 (4922 selected) Spaces: 4 UTF-8 CRLF Python 3.9.7 ('base': conda) Colorize: 0 variables Colorize