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### Experiment 3

## IMPLEMENTATION OF MINIMAX algorithm

#### Aim:

To implement the MINIMAX algorithm.

**Scenario:** AI vs. Human Player – Winning Move Situation

**Context:** The AI is playing as Player X and the human is playing as Player O. It's AI's turn, and there is a possible winning move.

Given Board State (Before AI's Move):

```
X O X
O X .
. O X
```

Expected AI Move (Best Move using Minimax):

```
X O X
O X X
. O X
```

#### Procedure:

1. Define constants:  $\text{PLAYER\_X} = 1$ ,  $\text{PLAYER\_O} = -1$ ,  $\text{EMPTY} = 0$ .
2. Create `evaluate(board)` to check for a winner by scanning rows, columns, and diagonals. Return 1 if AI wins, -1 if human wins, or 0 if no winner.
3. Create `isMovesLeft(board)` to check for empty spaces; return True if moves are available, otherwise False.
4. Implement `minimax(board, isMax)`:
  - If `evaluate(board)` returns a winner, return the corresponding score. ■ If no moves are left, return 0.
  - If `isMax` is True (AI's turn), initialize  $\text{best} = -\infty$ , loop through empty cells, place X, call `minimax(board, False)`, undo move, update best with maximum value, and return best.
  - If `isMax` is False (Human's turn), initialize  $\text{best} = +\infty$ , loop through empty cells, place O, call `minimax(board, True)`, undo move, update best with minimum value, and return best.
5. Implement `findBestMove(board)`:

- Initialize bestVal =  $-\infty$  and bestMove = (-1, -1).
- Loop through empty cells, place X, call minimax(board, False), undo move, update bestMove if a better move is found.
- Return bestMove.

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6. Implement printBoard(board) to display board state using "X", "O", and "." for empty spaces.

7. Initialize a sample board, print its state, call findBestMove(board), update the board with AI's move, and print the final state.

#### **Program:**

# Constants for players

PLAYER\_X = 1

PLAYER\_O = -1

EMPTY = 0

# Evaluate the board

def evaluate(board):

    for row in range(3):

        if board[row][0] == board[row][1] == board[row][2] !=

EMPTY: return board[row][0]

    for col in range(3):

        if board[0][col] == board[1][col] == board[2][col] != EMPTY:

        return board[0][col]

    if board[0][0] == board[1][1] == board[2][2] != EMPTY:

        return board[0][0]

    if board[0][2] == board[1][1] == board[2][0] != EMPTY:

        return board[0][2]

    return 0

# Check if moves are left

def isMovesLeft(board):

    for row in range(3):

        for col in range(3):

```

if board[row][col] == EMPTY:
    return True
    return False
# Minimax function
def minimax(board, isMax):
    score = evaluate(board)

    if score == PLAYER_X: return score
    if score == PLAYER_O: return score
    if not isMovesLeft(board): return 0
    if isMax:
        best = -float('inf')
        for row in range(3):
            for col in range(3):
                if board[row][col] == EMPTY:
                    board[row][col] = PLAYER_X
                    best = max(best, minimax(board, not isMax))
                    board[row][col] = EMPTY
            return best
        else:
            best = float('inf')
            for row in range(3):
                for col in range(3):
                    if board[row][col] == EMPTY:
                        board[row][col] = PLAYER_O
                        best = min(best, minimax(board, not isMax))
                        board[row][col] = EMPTY
            return best
# Find the best move for PLAYER_X
def findBestMove(board):
    bestVal = -float('inf')
    bestMove = (-1, -1)

```

```

for row in range(3):
    for col in range(3):
        if board[row][col] == EMPTY:
            board[row][col] = PLAYER_X
            moveVal = minimax(board,
False)  board[row][col] =
EMPTY
            if moveVal > bestVal:

                bestMove = (row, col)
                bestVal = moveVal
            return bestMove
# Print the board
def printBoard(board):
    for row in board:
        print(" ".join(["X" if x == PLAYER_X else "O" if x == PLAYER_O else "."
for x in  row]))
# Example game
board = [
    [PLAYER_X, PLAYER_O, PLAYER_X],
    [PLAYER_O, PLAYER_X, EMPTY],
    [EMPTY, PLAYER_O, PLAYER_X]
]
print("Current Board:")
printBoard(board)
move = findBestMove(board)
print(f"Best Move: {move}")
board[move[0]][move[1]] = PLAYER_X
print("\nBoard after best move:")
printBoard(board)

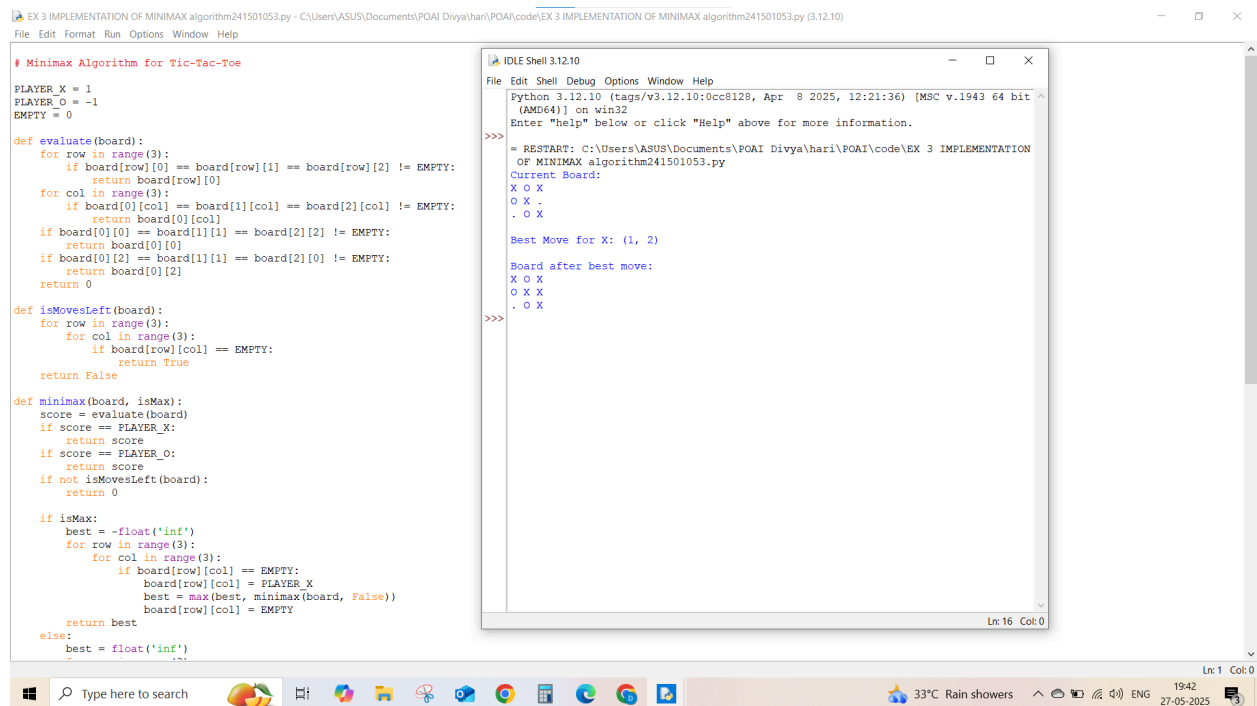
```

## Output:

```
Current Board:
X O X
O X .
. O X

Best Move: (2, 0)

Board after best move:
X O X
O X .
X O X
```



```
# Minimax Algorithm for Tic-Tac-Toe
PLAYER_X = 1
PLAYER_O = -1
EMPTY = 0

def evaluate(board):
    for row in range(3):
        if board[row][0] == board[row][1] == board[row][2] != EMPTY:
            return board[row][0]
    for col in range(3):
        if board[0][col] == board[1][col] == board[2][col] != EMPTY:
            return board[0][col]
    if board[0][0] == board[1][1] == board[2][2] != EMPTY:
        return board[0][0]
    if board[0][2] == board[1][1] == board[2][0] != EMPTY:
        return board[0][2]
    return 0

def isMovesLeft(board):
    for row in range(3):
        for col in range(3):
            if board[row][col] == EMPTY:
                return True
    return False

def minimax(board, isMax):
    score = evaluate(board)
    if score == PLAYER_X:
        return score
    if score == PLAYER_O:
        return score
    if not isMovesLeft(board):
        return 0

    if isMax:
        best = -float('inf')
        for row in range(3):
            for col in range(3):
                if board[row][col] == EMPTY:
                    board[row][col] = PLAYER_X
                    best = max(best, minimax(board, False))
                    board[row][col] = EMPTY
        return best
    else:
        best = float('inf')
        for row in range(3):
            for col in range(3):
                if board[row][col] == EMPTY:
                    board[row][col] = PLAYER_O
                    best = min(best, minimax(board, True))
                    board[row][col] = EMPTY
        return best

# Test the algorithm
board = [[1, 0, 1], [0, 1, 0], [0, 0, 1]]
bestMove = minimax(board, True)
print("Best Move for X: ", bestMove)
```

```
Python 3.12.10 (tags/v3.12.10:0cc8128, Apr 8 2025, 12:21:36) [MSC v.1943 64 bit (AMD64)] on win32
Enter "help" below or click "Help" above for more information.

>>> = RESTART: C:\Users\ASUS\Documents\POAI Divya\hari\POAI\code\EX 3 IMPLEMENTATION OF MINIMAX algorithm241501053.py
Current Board:
X O X
O X .
. O X

Best Move for X: (1, 2)

Board after best move:
X O X
O X .
. O X

>>>
```