ARTIFICIAL INTELLIGENCE

EXPERIMENT NO: 6

IMPLEMENTATION OF MINIMAX ALGORITHM FOR AN APPLICATION

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AIM:

To implement minimax algorithm for an application using python

ALGORITHM:

1. 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.
2. 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.
3. In this algorithm two players play the game; one is called MAX and other is called MIN.
4. Both Players of the game are opponent of each other, where MAX will select the maximized value and MIN will select the minimized value.
5. The minimax algorithm performs a depth-first search algorithm for the exploration of the complete game tree.

SOURCE CODE:

```
import sys
import random

# This class represent a tic tac to game
class TicTacToeGame:
  def __init__(self, rows:int, columns:int, goal:int, max_depth:int=4):
    # Create the game state
    self.state = []
    self.tiles = {}
    self.inverted_tiles = {}
    tile = 0
    for y in range(rows):
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```
        row = []
        for x in range(columns):
            row += '.'
            tile += 1
            self.tiles[tile] = (y, x)
            self.inverted_tiles[(y, x)] = tile
        self.state.append(row)
    # Set the number of noughts and crosses in a row that is needed to win the game
    self.goal = goal
    # Create vectors
    self.vectors = [(1,0), (0,1), (1,1), (-1,1)]
    # Set lengths
    self.rows = rows
    self.columns = columns
    self.max_row_index = rows - 1
    self.max_columns_index = columns - 1
    self.max_depth = max_depth
    # Heuristics for cutoff
    self.winning_positions = []
    self.get_winning_positions()
    # Set the starting player at random
    #self.player = 'O'
    self.player = random.choice(['X', 'O'])
# Get winning positions
def get_winning_positions(self):
# Loop the board
    for y in range(self.rows):
        for x in range(self.columns):
            # Loop vectors
            for vector in self.vectors:
```

```
            # Get the start position
            sy, sx = (y, x)
            # Get vector deltas
            dy, dx = vector
            # Create a counter
            counter = 0
            # Loop until we are outside the board
            positions = []
            while True:
                # Add the position
                positions.append(self.inverted_tiles.get((sy, sx)))
                # Check if we have a winning position
                if (len(positions) == self.goal):
                    # Add winning positions
                    self.winning_positions.append(positions)
                    # Break out from the loop
                    break
                # Update the position
                sy += dy
                sx += dx
                # Check if the loop should terminate
                if(sy < 0 or abs(sy) > self.max_row_index or sx < 0 or abs(sx) > self.max_columns_index):
                    break
        # Play the game
def play(self):
    # Variables
    result = None
    # Create an infinite loop
    print('Starting board')
    while True:
```

```
# Draw the state
self.print_state()
# Get a move from a player
if (self.player == 'X'):
    # Print AI move
    print('Player X moving (AI) ...')
    # Get the best move
    max, py, px, depth = self.max(-sys.maxsize, sys.maxsize)
    # Get a heuristic move at cutoff
    print('Depth: {0}'.format(depth))
    if(depth > self.max_depth):
        py, px = self.get_best_move()
    # Make a move
    self.state[py][px] = 'X'
    # Check if the game has ended, break out from the loop in that case
    result = self.game_ended()
    if(result != None):
        break
    # Change turn
    self.player = 'O'
elif (self.player == 'O'): # Human player
    # Print turn
    print('Player O moving (Human) ...')
    # Get a recommended move
    min, py, px, depth = self.min(-sys.maxsize, sys.maxsize)
    # Get a heuristic move at cutoff
    print('Depth: {0}'.format(depth))
    if(depth > self.max_depth):
        py, px = self.get_best_move()
    # Print a recommendation
```

```
            print('Recommendation: {0}'.format(self.inverted_tiles.get((py, px))))
            # Get input
            number = int(input('Make a move (tile number): '))
            tile = self.tiles.get(number)
            # Check if the move is legal
            if(tile != None):
                # Make a move
                py, px = tile
                self.state[py][px] = 'O'
                # Check if the game has ended, break out from the loop in that case
                result = self.game_ended()
                if(result != None):
                    break
                # Change turn
                self.player = 'X'
            else:
                print('Move is not legal, try again.')
        # Print result
    self.print_state()
    print('Winner is player: {0}'.format(result))
    # An evaluation function to get the best move based on heuristics
def get_best_move(self):
    # Create an heuristic dictionary
    heuristics = {}
    # Get all empty cells
    empty_cells = []
    for y in range(self.rows):
        for x in range(self.columns):
            if (self.state[y][x] == '.'):
                empty_cells.append((y, x))
```

```
# Loop empty positions
for empty in empty_cells:
    # Get numbered position
    number = self.inverted_tiles.get(empty)
    # Loop winning positions
    for win in self.winning_positions:
        # Check if number is in a winning position
        if(number in win):
        # Calculate the number of X:s and O:s in the winning position
            player_x = 0
            player_o = 0
            start_score = 1
            for box in win:
            # Get the position
                y, x = self.tiles[box]
                # Count X:s and O:s
                if(self.state[y][x] == 'X'):
                    player_x += start_score if self.player == 'X' else start_score * 2
                    start_score *= 10
                elif (self.state[y][x] == 'O'):
                    player_o += start_score if self.player == 'O' else start_score * 2
                start_score *= 10
                # Save heuristic
            if(player_x == 0 or player_o == 0):
                # Calculate a score
                score = max(player_x, player_o) + start_score
                # Update the score
            if(heuristics.get(number) != None):
                heuristics[number] += score
            else:
```

```
                heuristics[number] = score
            # Get the best move from the heuristic dictionary
        best_move = random.choice(empty_cells)
        best_count = -sys.maxsize
        for key, value in heuristics.items():
            if(value > best_count):
                best_move = self.tiles.get(key)
                best_count = value
        # Return the best move
        return best_move
    # Check if the game has ended
    def game_ended(self) -> str:
        # Check if a player has won
        result = self.player_has_won()
        if(result != None):
            return result
        # Check if the board is full
        for y in range(self.rows):
            for x in range(self.columns):
                if (self.state[y][x] == '.'):
                    return None
        # Return a tie
        return 'It is a tie!'

    # Check if a player has won
    def player_has_won(self) -> str:
        # Loop the board
        for y in range(self.rows):
            for x in range(self.columns):
                # Loop vectors
```

```
        for vector in self.vectors:
          # Get the start position
          sy, sx = (y, x)
          # Get vector deltas
          dy, dx = vector
          # Create counters
          steps = 0
          player_x = 0
          player_o = 0
          # Loop until we are outside the board or have moved the number of steps in the goal
          while steps < self.goal:
            # Add steps
            steps += 1
            # Check if a player has a piece in the tile
            if(self.state[sy][sx] == 'X'):
              player_x += 1
            elif(self.state[sy][sx] == 'O'):
              player_o += 1
              # Update the position
            sy += dy
            sx += dx
            # Check if the loop should terminate
            if(sy < 0 or abs(sy) > self.max_row_index or sx < 0 or abs(sx) > self.max_columns_index):
              break
        # Check if we have a winner
        if(player_x >= self.goal):
          return 'X'
        elif(player_o >= self.goal):
          return 'O'
    # Return None if no winner is found
```

```
    return None
    # Get a min value (O)

def min(self, alpha:int=-sys.maxsize, beta:int=sys.maxsize, depth:int=0):
    # Variables
    min_value = sys.maxsize
    by = None
    bx = None
    # Check if the game has ended
    result = self.game_ended()
    if(result != None):
        if result == 'X':
            return 1, 0, 0, depth
        elif result == 'O':
            return -1, 0, 0, depth
        elif result == 'It is a tie!':
            return 0, 0, 0, depth
    elif(depth > self.max_depth):
        return 0, 0, 0, depth
    # Loop the board
    for y in range(self.rows):
        for x in range(self.columns):
            # Check if the tile is empty
            if (self.state[y][x] == '.'):
                # Make a move
                self.state[y][x] = 'O'
                # Get max value
                max, max_y, max_x, depth = self.max(alpha, beta, depth + 1)
                # Set min value to max value if it is lower than curren min value
                if (max < min_value):
```

```
                min_value = max
                by = y
                bx = x
            # Reset the tile
            self.state[y][x] = '.'
            # Do an alpha test
            if (min_value <= alpha):
                return min_value, bx, by, depth
            # Do a beta test
            if (min_value < beta):
                beta = min_value
    # Return min value
    return min_value, by, bx, depth
    # Get max value (X)

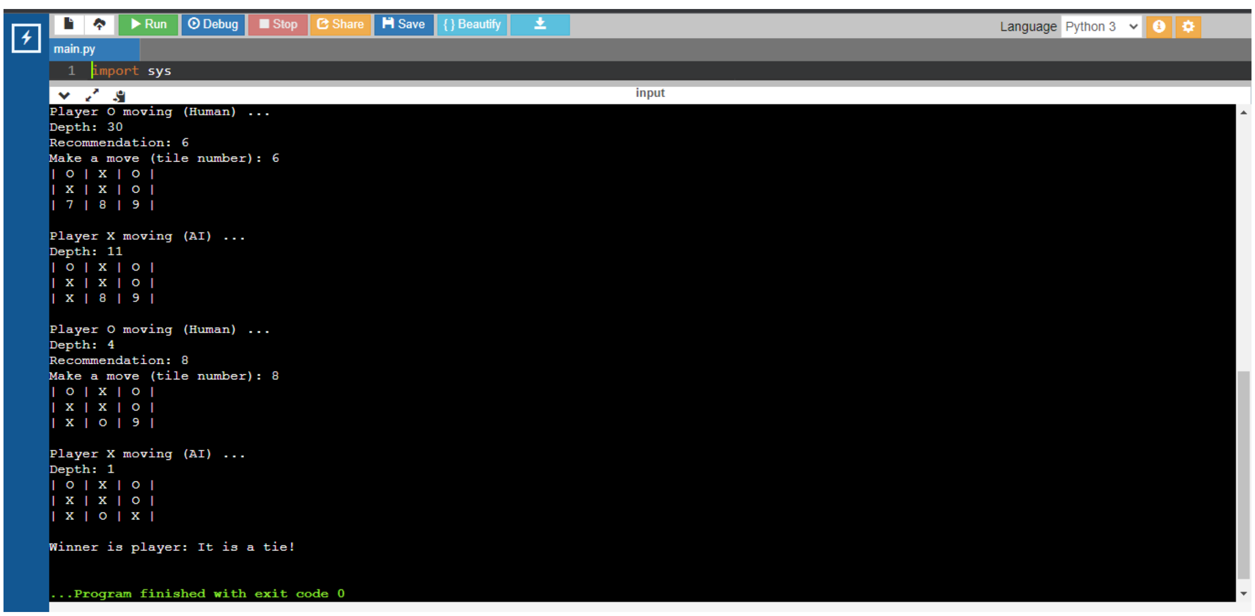
def max(self, alpha:int=-sys.maxsize, beta:int=sys.maxsize, depth:int=0):
# Variables
    max_value = -sys.maxsize
    by = None
    bx = None
    # Check if the game has ended
    result = self.game_ended()
    if(result != None):
        if result == 'X':
            return 1, 0, 0, depth
        elif result == 'O':
            return -1, 0, 0, depth
        elif result == 'It is a tie!':
            return 0, 0, 0, depth
    elif(depth > self.max_depth):
```

```
        return 0, 0, 0, depth
    # Loop the board
    for y in range(self.rows):
        for x in range(self.columns):
            # Check if the current tile is empty
            if (self.state[y][x] == '.'):
                # Add a piece to the board
                self.state[y][x] = 'X'
                # Set max value to min value if min value is greater than current max value
                min, min_y, min_x, depth = self.min(alpha, beta, depth + 1)
                # Adjust the max value
                if (min > max_value):
                    max_value = min
                    by = y
                    bx = x
                # Reset the tile
                self.state[y][x] = '.'
                # Do a beta test
                if (max_value >= beta):
                    return max_value, bx, by, depth
                # Do an alpha test
                if (max_value > alpha):
                    alpha = max_value
        # Return max value
    return max_value, by, bx, depth
    # Print the current game state

def print_state(self):
    for y in range(self.rows):
        print('| ', end='')
```

```
            for x in range(self.columns):
                if (self.state[y][x] != '.'):
                    print('{0} | '.format(self.state[y][x]), end='')
                else:
                    digit = str(self.inverted_tiles.get((y,x))) if len(str(self.inverted_tiles.get((y,x)))) > 1 else
str(self.inverted_tiles.get((y,x)))
                    print('{0} | '.format(digit), end='')
            print()
        print()
def main():
    game = TicTacToeGame(3, 3, 3, 1000)
    game.play()
if __name__ == "__main__":
    main()
```

OUTPUT:



RESULT:

Hence agent programs for real world problems (8-puzzle) using python is developed.