**NATIONAL UNIVERSITY OF COMPUTER AND EMERGING SCIENCES**

**FAST KARACHI**



**Course:** Artificial Intelligence

**Topic:** Ultimate Tic Tac Toe

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**Introduction**

Ultimate Tic Tac Toe is an advanced variation of the classic Tic Tac Toe game. It consists of a 3x3 grid of smaller Tic Tac Toe boards, making it a more strategic and challenging game. This project aims to implement Ultimate Tic Tac Toe with an AI opponent using the Minimax algorithm with alpha-beta pruning for optimal move selection **(AI Approach & Methodology).** The game will be implemented in python using Numpy, and tkinter/pygame for GUI **(Implementation)** .

**Game Rules**

1. The game consists of nine 3x3 boards, arranged to form a larger 3x3 grid (the main board).

2. Each cell of the main board contains its own 3x3 board, referred to as a small board.

3. A player must win three small boards in a row (horizontally, vertically, or diagonally) to win the game.

4. The AI opponent will make decisions using the Minimax algorithm with alpha-beta pruning to optimize move selection and reduce computation time.

5. When a player wins a small board, that cell on the main board is marked permanently with the winner's symbol (X or O), and the small board becomes inactive.

6. When a player wins a small board, they get the next turn, breaking the regular alternating pattern.

7. The game starts by randomly selecting which player (human or AI) plays first.

As we continue coding the game, some rules may be adjusted, added, or removed to introduce new challenges and make the gameplay more engaging and enjoyable.

**Heuristics for Game State Evaluation**

To efficiently implement the Minimax algorithm with alpha-beta pruning in the context of Ultimate Tic Tac Toe, a heuristic evaluation function will be used. The goal of the heuristic will be to guide the AI in selecting moves that maximize its chance of winning while minimizing the opponent's chances.

The following heuristic components will be considered:

**1. Mini Board Control**

Assign a score for each small 3x3 board based on which player currently controls it:

- +100 points if the board is won by the AI.
- -100 points if the board is won by the opponent.
- 0 points if the board is still undecided.

**2. Win Potential Within Mini Boards**

Reward near-winning conditions within individual small boards:

- +10 points for each 2-in-a-row by the AI with the third cell empty.
- -10 points for each 2-in-a-row by the opponent with the third cell empty.
- +1 or -1 for favorable single-move advantages.

**3. Main Board Win Opportunities**

Assign additional weight to situations where the AI or opponent is close to forming three in a row on the main board:

- +300 points for two AI-controlled mini boards aligned with a third potential win.
- -300 points for the opponent in a similar situation.

**4. Center Control**

Prioritize control of center positions:

- +15 points if the AI controls the center cell of a mini board.
- +25 points if the AI controls the center of the main board.

The final evaluation function will be a weighted sum of these factors. The weights will be adjusted and tested during development to optimize AI performance.