

# ULTIMATE TIC-TAC-TOE BOT

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## Algorithms used:

- [MTDF](#) algorithm with iterative deepening search is used. It is more efficient than normal minimax search algorithms.
  - Bot searches 6 level deep in starting and upto 7-8 in the end.
  - Bonus move is also considered. Whenever during search, if bot wins a block, if it is at a max node, it consider its child node also as max nodes instead of min nodes. Similarly, if bot wins a block at a min node, it consider its child nodes as a min nodes instead of max nodes.
  - Transposition table is used for making the pruning faster. It is implemented using zobrist hashing
  - The time limit used is 14.5 seconds.
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## Heuristic:

The board is the entire 16x16 game board. A block is a 4x4 subgrid. A cell is a single 1x1 cell.

Heuristic score depends on two parts: one is the sum of all block scores and the other is the game status.

$$heuristicScore = \sum_{i=1}^{i=4} \sum_{j=1}^{j=4} blockScore_{ij} + gameStatus$$

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## Block Score:

Block score represents how the bot is performing in a particular block. If block is already won, block score is blockWon. Otherwise, we calculated the total number of rows, columns and diagonals in which we occupied one cell, two cells and three cells. Let these values be  $cellCount_1$ ,  $cellCount_2$  and  $cellCount_3$  respectively. We ignore those rows, columns or diagonals in which opponent's marker is present. Now,

$$ourScore = \sum_{i=1}^3 cellWeight_i * cellCount_i^2$$

Similarly opponent's score is calculated. Finally,

$$blockScore = ourScore - opponentScore$$


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### **Game Status:**

The game status is computed in a manner similar to the block score. In this, we calculate the total number of rows, columns or diagonals in the board, in which we won one block, two blocks and three blocks. Let these values be  $blockCount_1$ ,  $blockCount_2$  and  $blockCount_3$  respectively. Then,

$$ourGameScore = \sum_{i=1}^3 blockWeight_i * blockCount_i^2$$

Similarly opponent's gamescore is calculated. Finally,

$$gameStatus = ourGameScore - opponentGameScore$$


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### **Values of Variables:**

We gave values to the variables used according to the following order:

$$cellWeight1 \ll cellWeight2 \ll cellWeight3 \ll blockWon < blockWeight1 \ll blockWeight2 \ll blockWeight3$$


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