

# EXTREME TIC TAC TOE BOT

## Final Report

### Team Members - The Sentinels(Team 23):

Rutwik Reddy - 20171125

Charan Chinni - 20171121

### Game Board

The BigBoard is the entire (9x9) game board. There are a total of 2 BigBoards. A SmallBoard is a 3x3 subgrid that contains 9 cells. A cell is a single (1x1) cell.

### Search Strategy

- Our bot uses **Minimax** algorithm along with **alpha beta pruning**.
- We used **Iterative Deepening Search(IDS)** that increases the search space over time. It starts with depth 4. After completing one complete iteration of IDS, the best move is updated, so that we can return the current best move, in case search is cut off abruptly. Also, we have not used deepcopy.
- The search is cutoff after 23 seconds.

### Heuristic

#### Pattern Heuristic

- Each small board is evaluated and given a score and using these small board scores we find a pattern that is suitable in the big board and give an appropriate score for it.
- For the pattern heuristic, we store the list of all patterns that are possible on the board, into a matrix.
- Since a pattern that has one or two tiles, we must give it more weightage to it so that the bot can use those moves for winning.
  - If there are two symbols in the pattern, then we return 20.
  - If there is an opponent symbol in the pattern, that pattern is rejected.

- ## Winning Patterns Matrix

- |   |   |   |
|---|---|---|
| 3 | 2 | 3 |
| 2 | 4 | 2 |
| 3 | 2 | 3 |

- Team 13 vs Team 23:(Opponent = 'X', Us = 'O')-WE WON

- [illegible]



- We have two tiles in the bottom left and bottom right corners, but the bot chooses to place the next tile in the center rather than placing it in the bottom center to win the smallboard. This can be taken care of by adjusting the weight when pattern has two tiles.(Line 832)

|                   |                   |
|-------------------|-------------------|
| X O - X X O X X X | O O O X - - X X - |
| O O O O O - - -   | - - - - - - - -   |
| - - - O - - - -   | - - - O - O - -   |
| X X O X - - X - - | - - - - - - - -   |
| - - - - - - - -   | - - - - - - - -   |
| - - - O O O - - - | - - - - - - - -   |
| O X - X - - X X - | - O - - - - - -   |
| - - - - - - - -   | - - - - - - - -   |
| - - - - - - - -   | - - - - - - - -   |

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|                   |                   |
|-------------------|-------------------|
| X O - X X O X X X | O O O X - - X X - |
| O O O O O - - -   | - - - - O - - -   |
| - - - O - - - -   | - - - O - O - -   |
| X X O X - - X - - | - - - - - - - -   |
| - - - - - - - -   | - - - - - - - -   |
| - - - O O O - - - | - - - - - - - -   |
| O X - X - - X X - | - O - - - - - -   |
| - - - - - - - -   | - - - - - - - -   |
| - - - - - - - -   | - - - - - - - -   |

- The bot places the top right tile when we have one tile in top left and opponent has one tile in top center. This can be taken care of if increase weights of pattern. (Line 1014)

|                   |                   |
|-------------------|-------------------|
| X O - X X O X X X | O O O X - - X X - |
| O O O O O - - -   | - - - - O - - -   |
| - - - O - - - -   | - - - O O O - -   |
| X X O X - - X - - | - - - X X - - -   |
| X O - - - - - -   | - - - - - - - -   |
| O - - O O O - - - | - - - - - - - -   |

|       |             |                   |
|-------|-------------|-------------------|
| O X - | X - - X X - | - O - - - - -     |
| - - - | O - - - -   | - - - - -         |
| - - - | - - - - -   | - - - - -         |
| X O - | X X O X X X | O O O X - - X X - |
| O O O | O O - - -   | - - - O - - -     |
| - - - | O - - - -   | - - - O O O - - - |
| X X O | X - - X - - | - - - X X - - -   |
| X O - | - - - - -   | - - - - -         |
| O - - | O O O - -   | - - - - -         |
| O X O | X - - X X - | - O - - - - -     |
| - - - | O - - - -   | - - - - -         |
| - - - | - - - - -   | - - - - -         |

● **Team 14 vs Team 23:(Opponent = 'X', Us = 'O')-WE LOST**

- The tile is placed in another bigboard, even though there is one tile in the current bigboard. This can be adjusting the weights of pattern. (Line 204)
- The tile should be placed in BigBoard2 to make a pattern, but it places a tile in BigBoard1. This can be taken care by adjusting weights of pattern values. (Line 512)
- The tile was placed in top center instead of bottom center. This can be adjusted by giving the right weights to pattern heuristic. (Line 556)

● **Team 23 vs Team 13:(Opponent = 'O', Us = 'X')-WE LOST**

- The tile was placed in bottom left corner even though one tile is placed in the top center tile. This can be adjusted by adjusting the values for the pattern heuristic. (Line 236)
- The tile was placed in left centre corner even though one tile is placed in the top center tile. This can be adjusted by adjusting the values for the pattern heuristic. (Line 650)
- The tile should be placed in BigBoard1 but instead it is placed in BigBoard2. This can by adjusting the values for pattern heuristic. (Line 788)
- The tile is placed in such a position that it cannot form a pattern. It should instead be placed in the center tile. (Line 950)

● **Team 23 vs Team 14:(Opponent = 'O', Us = 'X')-WE WON**

- The tile is placed in top right corner even though we have two tiles in top left and bottom right corner. It should instead be placed in the center tile. (Line 358)
- The smallboard is already full such that pattern cannot be formed, but still it places it in that smallboard. Instead, it should place the tile in another small board. (Line 600)
- The tile is placed in such a location that it cannot form a pattern. Instead the tile should be placed in the center for better results. (Line 842)
- The tile should be placed in the center instead of being placed in the top center. This can be taken care of by adjusting the values of pattern heuristic. (Line 886)
- The tile is placed in the right center rather than the bottom center to form a pattern. This is due to the incorrect pattern heuristic. (Line 1018)
- The tile should be placed in the bottom right rather than top center. (Line 1062)
- The tile should be placed in the bottom center to form a pattern rather than top right corner. This can be done by adjusting the values of the pattern heuristic. (Line 1172)
- The smallboard is already full such that pattern cannot be formed, but still it places it in that smallboard. Instead, it should place the tile in another small board. (Line 1238)
- The tile is placed in such a position that it cannot form a pattern. It should instead be placed in the bottom center tile to have a higher chance of forming a pattern. (Line 1282)
- The tile is placed in such a position that it cannot form a pattern. It should instead be placed in the bottom center/left/right tile to have a higher chance of forming a pattern. (Line 1546)
- The tile should be placed in the center to form a pattern, but it places it in the top right corner. (Line 1634)
- The tile is placed in such a position that it cannot form a pattern. It should instead be placed in the center tile to have a higher chance of forming a pattern. (Line 1700)
- The tile should be placed in the center to form a pattern, but it places it in the left center. (Line 1744)
- The tile should be placed in the bottom left to form a pattern, but it places it in the top center. (Line 1942)
- The tile should be placed in the top left to form a pattern, but it places it in the bottom center. (Line 2228)

- **Team 23 vs Team 24:(Opponent = 'O', Us = 'X')-WE WON**

- The tile is placed in such a position that it cannot form a pattern. It should instead be placed in the center tile to have a higher chance of forming a pattern. (Line 94)
- The tile is placed in such a position that it cannot form a pattern. It should instead be placed in the left center tile to have a higher chance of forming a pattern. (Line 468)
- The tile should be placed in the center to win the small board, but instead it places it in left center tile. (Line 996)
- The tile should be placed in the center to win the small board, but instead it places it in right center tile. (Line 1040)
- The pattern can be completed by placing it in the bottom right tile, but instead it is placed in the right center tile. (Line 1084)
- The tile is placed in such a position that it cannot form a pattern. It should instead be placed in the bottom right corner to have a higher chance of forming a pattern. (Line 1194)
- The tile should be placed in the center to win the small board, but instead it places it in bottom right tile. (Line 1238)
- The tile should be placed in the bottom right to win the small board, but instead it places it in top left tile. (Line 1282)
- The tile should be placed in the bottom left to win the small board, but instead it places it in top center tile. (Line 1436)
- The tile should be placed in the center to form a pattern. (Line 1502)
- The tile is placed in such a position that it cannot form a pattern. (Line 1590)

- **Team 23 vs Team 39:(Opponent = 'O', Us = 'X')-WE LOST**

- The tile should be placed in BigBoard2 and not in BigBoard1, as it is close to forming a pattern in BigBoard2. (Line 468)
- The tile is placed in such a position that it cannot form a pattern. It should instead be placed in the left center / center tile to have a higher chance of forming a pattern. (Line 644)
- The tile should be placed in bottom left corner to form a pattern, but instead it is placed in the top left corner. (Line 754)
- The tile should be placed in bottom left corner to form a pattern, but instead it is placed in the center right tile. (Line 864)
- The tile is placed in such a position that it cannot form a pattern. It should instead be placed in the top right corner to have a higher chance of forming a pattern. (Line 966)

- The tile is placed in such a position that it cannot form a pattern. It should instead be placed in the bottom right corner to have a higher chance of forming a pattern. (Line 1194)
- **Team 23 vs Team 40:(Opponent = 'O', Us = 'X')-WE LOST**
  - The tile should be placed in BigBoard2 and not in BigBoard1, as it is close to forming a pattern in BigBoard2. (Line 358)
  - The tile is placed in such a position that it cannot form a pattern. It should instead be placed in the center to have a higher chance of forming a pattern. (Line 556)
  - The tile should be placed in left center to have a chance of forming a pattern, rather than bottom left. (Line 732)
  - The tile should be placed in BigBoard2 and not in BigBoard1, as it is close to forming a pattern in BigBoard2. (Line 864)
  - The tile should be placed in top/bottom left to have a chance of forming a pattern, rather than top right. (Line 908)
- **Team 23 vs Team 65:(Opponent = 'O', Us = 'X')-WE WON**
  - The tile should be placed in center to have a chance of forming a pattern, rather than top right. (Line 314)
  - The tile is placed in such a position that it cannot form a pattern. It should instead be placed in the center to have a higher chance of forming a pattern. (Line 578)
  - The tile is placed in such a position that it cannot form a pattern. It should instead be placed in the bottom center/right to have a higher chance of forming a pattern. (Line 820)
  - The tile should be placed in center to have a chance of forming a pattern, rather than top center. (Line 930)
- **Team 24 vs Team 23:(Opponent = 'X', Us = 'O')-WE WON**
  - The tile should be placed in the center to form the pattern instead of top center. (Line 116)
  - The tile should be placed in the center to form the pattern instead of left center. (Line 160)
  - The tile is placed in such a position that it cannot form a pattern. It should instead be placed in the center to have a higher chance of forming a pattern. (Line 358)
  - The tile should be placed in BigBoard2 and not in BigBoard1, as it is close to forming a pattern in BigBoard2. (Line 490) (Line 732)



- **Team 39 vs Team 23:(Opponent = 'X', Us = 'O')-WE LOST**
  - The tile should be placed in top/bottom left to have a chance of forming a pattern, rather than right center. (Line 248)
  - The tile should be placed in left center to have a chance of forming a pattern, rather than top right. (Line 424)
  - The tile should be placed in the center/top center to have a chance of forming a pattern rather than top left. (Line 468)
- **Team 40 vs Team 23:(Opponent = 'X', Us = 'O')-WE LOST**
  - The tile should be placed in the center to have more chance of forming a pattern rather than top center. (Line 732)
- **Team 65 vs Team 23:(Opponent = 'X', Us = 'O')-WE WON**
  - No improvements can be found as opponent had gotten a timeout.

## Improvements

- The pattern heuristic for the big board and the small board must be changed to make the bot perform at its optimum level. This has occurred the most number of times, so if we correct this heuristic, we can improve our bot by a large amount.
- The bot should start its game from the centre position if the board is empty as it will give us more chance for success.
- There were a lot of chances where the bot could have used the open move to my advantage, to complete a pattern in any part of the small board or big board.