**Analysis**

Since there is a huge randomness, I have followed the first advice from the re-view and increased the number of matches to 50

*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\**

*Playing Matches*

*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\**

*Match # Opponent AB\_Improved AB\_Custom AB\_Custom\_2 AB\_Custom\_3*

*Won| Lost Won | Lost Won | Lost Won | Lost*

*1 Random 45 | 5 46 | 4 45 | 5 47 | 3*

*2 MM\_Open 39 | 11 31 | 19 34 | 16 33 | 17*

*3 MM\_Center 46 | 4 48 | 2 44 | 6 44 | 6*

*4 MM\_Improved 38 | 12 34 | 16 28 | 22 29 | 21*

*5 AB\_Open 30 | 20 26 | 24 24 | 26 25 | 25*

*6 AB\_Center 31 | 19 26 | 24 27 | 23 26 | 24*

*7 AB\_Improved 28 | 22 25 | 25 24 | 26 19 | 31*

*--------------------------------------------------------------------------*

*Win Rate: 73.4% 66.7% 64.6% 63.3%*

Custome\_score:

Here I used the same logic as the improved score function in sample\_player.py, but also subtracted the distance from the center of the board to keep my moves away from the edges, so that I can have more moves in the future

Logic is to get the nearest move to the center that limits my opponent’s future moves and increases my future moves

Equation: number of my available moves – number of opponent’s moves – distance to the center of the board “using Pythagoras theorem”

**Results:**

Agent Won | Lost

Random 46 | 4

MM\_Open 31 | 19

MM\_Center 48 | 2

MM\_Improved 34 | 16

AB\_Open 26 | 24

AB\_Center 26 | 24

AB\_Improved 25 | 25

In this heuristic, the winning rate is higher than the other heuristics as it has two conditions: difference between the player’s and his opponent’s moves and the distance from the center, but the winning rate isn’t bigger than the other heuristics which indicate that the distance from the center isn’t actually significant when playing the game, this is appearing clearly when compared to the agents using alpha-beta pruning where the difference between the matches won and lost isn’t big. In summary, considering the distance from the center isn’t decisive, it depends on the state of the game.

Custome\_score\_2:

Using the heuristic in the nano-degree to subtract the opponent’s available moves from mine, I added it here to compare it to Custome\_score and make sure that subtracting the distance from the center did improve this heuristic.

**Results:**

Agent Won | Lost

Random 45 | 5

MM\_Open 34 | 16

MM\_Center 44 | 6

MM\_Improved 28 | 22

AB\_Open 24 | 26

AB\_Center 27 | 23

AB\_Improved 24 | 26

In this heuristic we aim to go for the move that increase the number of our next moves while decreasing our opponents moves, as we see it didn’t give good results with alpha-beta agents as alpha-beta agents can visit more nodes than mini-max agents so they can go deeper and perform better.

Custome\_score\_3:

Here I used the open\_move heuristic where only the move that produces more future moves for our player is chosen.

**Results:**

Agent Won | Lost

Random 47 | 3

MM\_Open 33 | 17

MM\_Center 44 | 6

MM\_Improved 29 | 21

AB\_Open 25 | 25

AB\_Center 26 | 24

AB\_Improved 19 | 31

In this heuristic we aim to go for the move that increase the number of our next moves only. Since there is a wide variety of moves that can be chosen and we choose the moves that come in the for loop first, so the effect is actually random here as we choose the node depending on its order in the loop so sometimes the move is good and sometimes it’s bad, this heuristic is the least from performance point of view, but that is expected specially with alpha-beta agents that go deeper and scan much more nodes in the given time threshold.

My recommendation is to use Custome-score2 because:

1. it’s not as complex as custom\_score\_1 as we don’t calculate distances or use Pythagoras theorem
2. Despite it is simple it gives results that are near to the results of heuristic taking into account the distance from the center of the board, so its gain is high compared to its complexity.
3. It doesn’t consume much time due to its simplicity allowing more time for going deeper into the tree.