Heuristic Analysis

Heuristic Descriptions

I will start by going through the three heuristics I created, and describing how they work from a high level:

- Custom_Score is a copy cat strategy, trying as hard as it can to do what the other player did their previous move
- Custom_Score_2 can be described as an extended AB_improved
- Custom_Score_3 can be described as a modified AB_improved

Custom_Score Description

Custom_Score is a copy cat strategy:

It is incredibly simple: it will try to place pieces as close to where the other player placed their piece last turn.

Custom_Score_2 Description

Custom_Score_2 can be described as an extended AB_improved:

- Custom_Score_2 calculates the difference between it's moves, and its opponents moves the same way that AB_Improved does,
    - If Custom_Score_2 is ahead of the opponent, it will try to place pieces as close to the bottom right corner as possible
    - Otherwise, if Custom_Score_2 is behind, it will play the same AB_Improved
- The thinking behind Custom_Score_2's strategy, is that if placing pieces in the bottom right corner is outperforming AB_Improved, then it will continue to keep placing pieces in the bottom right corner, which should lead to it winning,
    - If placing pieces in the bottom right, isn't working, then it will revert to the same strategy as AB_Improved, which should give it a chance to win a game it is falling behind in

Custom_Score_3 Description

Custom_Score_3 can be described as a modified AB_Improved:

- It uses two parts to calculate utility:
    - Part 1: the difference between players and the opponents moves
    - Part 2: the distance between the player and the opponent, the player is incentivized to try to get away from the other player
- These two parts are added together and returned to drive the agents behaviour
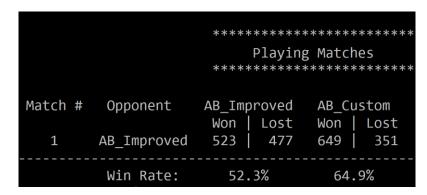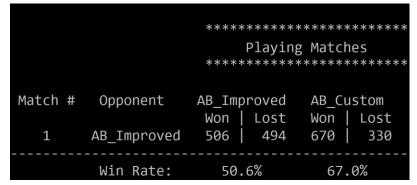
Heuristic Performance

Custom_Score Performance

        Each table was created running tournament.py with 500 matches (1000 games total). The Custom_Score heuristic doesn't tend to do very well against the majority of example opponents.

```
                          ************************
                              Playing Matches
                          ************************

Match #     Opponent       AB_Improved      AB_Custom
                           Won |  Lost      Won |  Lost
   1         Random        311 |  689       417 |  583
   2         MM_Open       341 |  659       447 |  553
   3         MM_Center     348 |  652       449 |  551
   4         MM_Improved   514 |  486       663 |  337
   5         AB_Open       341 |  659       423 |  577
   6         AB_Center     356 |  644       434 |  566
   7         AB_Improved   484 |  516       683 |  317
-------------------------------------------------------
           Win Rate:       38.5%            50.2%
```

        However, Custom_Score does well against AB_Improved, winning roughly 2/3's of the games when it plays 500 matches against AB_Improved. For this reason, **I choose Custom_Score as the best heuristic of the three I created**.

```
                          ************************
                              Playing Matches
                          ************************

Match #     Opponent       AB_Improved      AB_Custom
                           Won |  Lost      Won |  Lost
   1         AB_Improved   523 |  477       649 |  351
-------------------------------------------------------
           Win Rate:       52.3%            64.9%
```

```
                          ************************
                              Playing Matches
                          ************************

Match #     Opponent       AB_Improved      AB_Custom
                           Won |  Lost      Won |  Lost
   1         AB_Improved   506 |  494       670 |  330
-------------------------------------------------------
           Win Rate:       50.6%            67.0%
```

Why does Custom_Score do so well against AB_Improved:
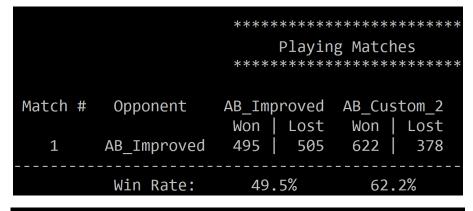
        (I DON'T KNOW)

For these reason I think Custom_Score is the heuristic that should be choosen.
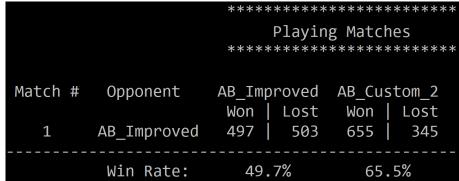
Custom_Score_2 Performance

From all my tests, it looks as though Custom_Score_2 is always close to having a 50%-win rate against the 7 example agents, but never manages to get above 50%.

```
*************************
        Playing Matches
*************************

Match #    Opponent    AB_Improved    AB_Custom_2
                       Won | Lost     Won | Lost
   1        Random     307 | 693      404 | 596
   2        MM_Open    330 | 670      436 | 564
   3       MM_Center   364 | 636      431 | 569
   4      MM_Improved  500 | 500      655 | 345
   5        AB_Open    337 | 663      416 | 584
   6       AB_Center   357 | 643      440 | 560
   7      AB_Improved  506 | 494      656 | 344
-------------------------------------------------
         Win Rate:      38.6%          49.1%
```

Custom_Score_2 performs similarly against AB_Improved, winning roughly 2/3 of games. However it does perform slightly worse than Custom_Score.

```
*************************
        Playing Matches
*************************

Match #    Opponent    AB_Improved    AB_Custom_2
                       Won | Lost     Won | Lost
   1      AB_Improved  495 | 505      622 | 378
-------------------------------------------------
         Win Rate:      49.5%          62.2%
```

```
*************************
        Playing Matches
*************************

Match #    Opponent    AB_Improved    AB_Custom_2
                       Won | Lost     Won | Lost
   1      AB_Improved  497 | 503      655 | 345
-------------------------------------------------
         Win Rate:      49.7%          65.5%
```

Custom_Score_3 Performance

Custom_Score_3 does the worst against the other 7 test agents.

```
             **********************
                  Playing Matches
             **********************

Match #    Opponent    AB_Improved   AB_Custom_3
                       Won | Lost    Won | Lost
   1        Random     294 |  706    324 |  676
   2       MM_Open     335 |  665    338 |  662
   3      MM_Center    359 |  641    348 |  652
   4     MM_Improved   489 |  511    577 |  423
   5       AB_Open     279 |  721    334 |  666
   6      AB_Center    338 |  662    352 |  648
   7     AB_Improved   484 |  516    638 |  362
------------------------------------------------
          Win Rate:       36.8%        41.6%
```

Custom_Score_3 wins roughly 60% of it's games against AB_Improved, which is a little worse than the roughly 66% that Custom_Score and Custom_Score_2 win.

```
             **************************
                  Playing Matches
             **************************

Match #    Opponent    AB_Improved   AB_Custom_3
                       Won | Lost    Won | Lost
   1      AB_Improved  469 |  531    599 |  401
------------------------------------------------
          Win Rate:       46.9%        59.9%
```

```
             **************************
                  Playing Matches
             **************************

Match #    Opponent    AB_Improved   AB_Custom_3
                       Won | Lost    Won | Lost
   1      AB_Improved  501 |  499    587 |  413
------------------------------------------------
          Win Rate:       50.1%        58.7%
```