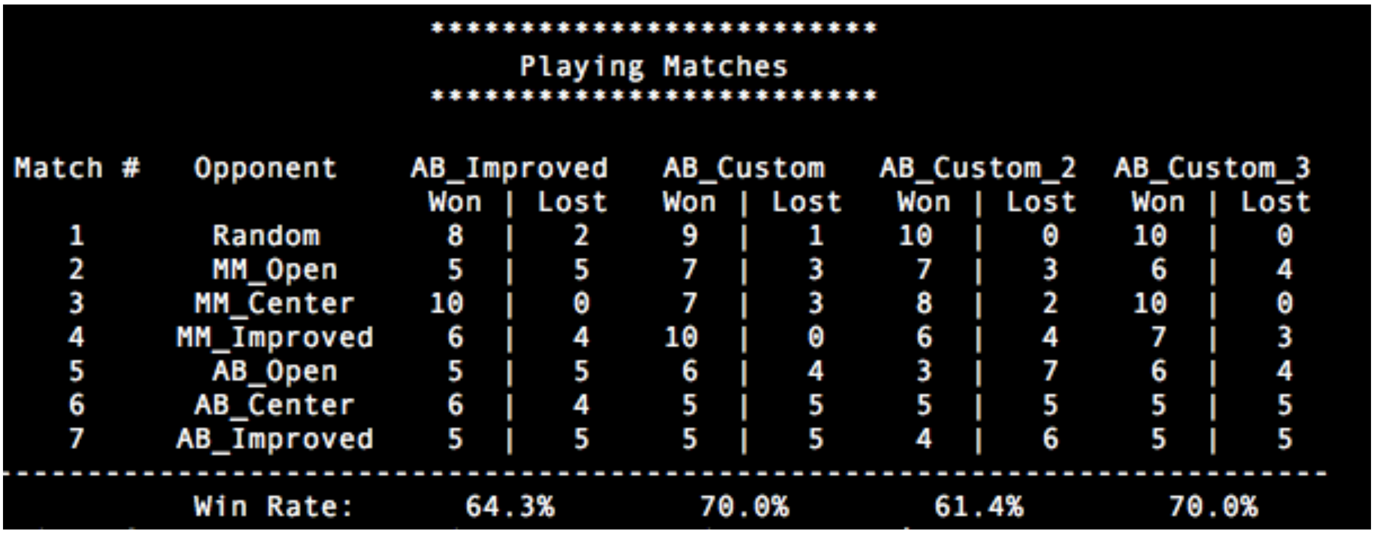
Heuristic Analysis

This is the report for analysis of different heuristic functions used in evaluation of board state.

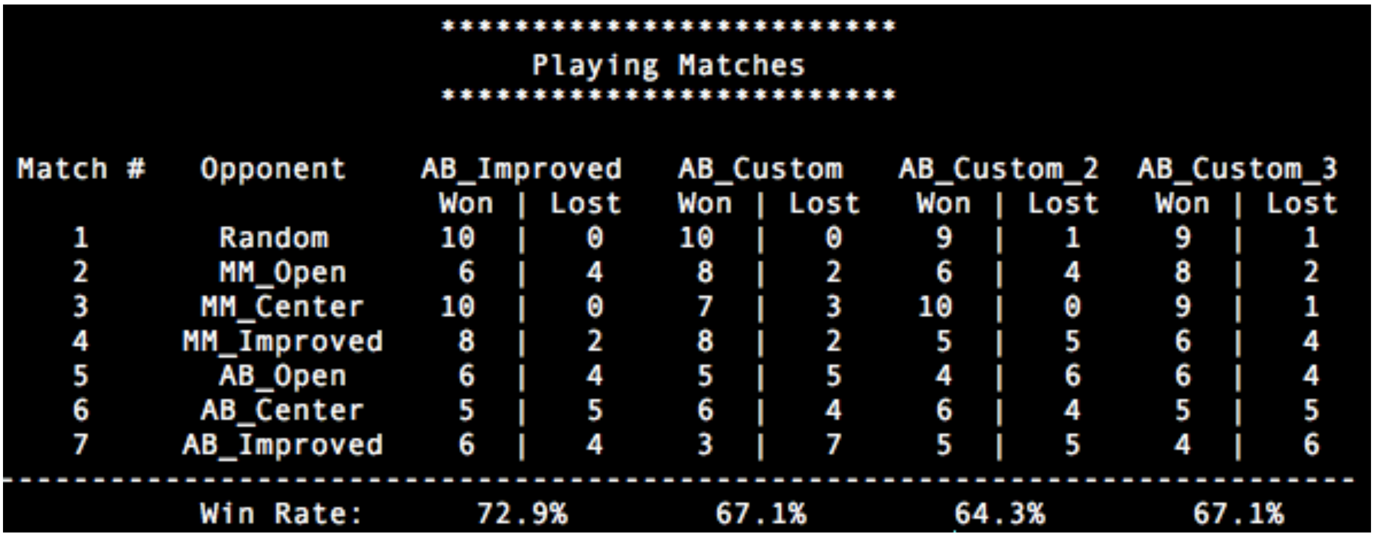
Match 1



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

 Match #     Opponent     AB_Improved    AB_Custom    AB_Custom_2   AB_Custom_3
                           Won | Lost   Won | Lost   Won | Lost   Won | Lost
    1         Random        8  |   2     9  |   1    10  |   0    10  |   0
    2         MM_Open       5  |   5     7  |   3     7  |   3     6  |   4
    3        MM_Center     10  |   0     7  |   3     8  |   2    10  |   0
    4       MM_Improved     6  |   4    10  |   0     6  |   4     7  |   3
    5         AB_Open       5  |   5     6  |   4     3  |   7     6  |   4
    6        AB_Center      6  |   4     5  |   5     5  |   5     5  |   5
    7       AB_Improved     5  |   5     5  |   5     4  |   6     5  |   5
--------------------------------------------------------------------------------
             Win Rate:        64.3%        70.0%        61.4%        70.0%
```

Match 2



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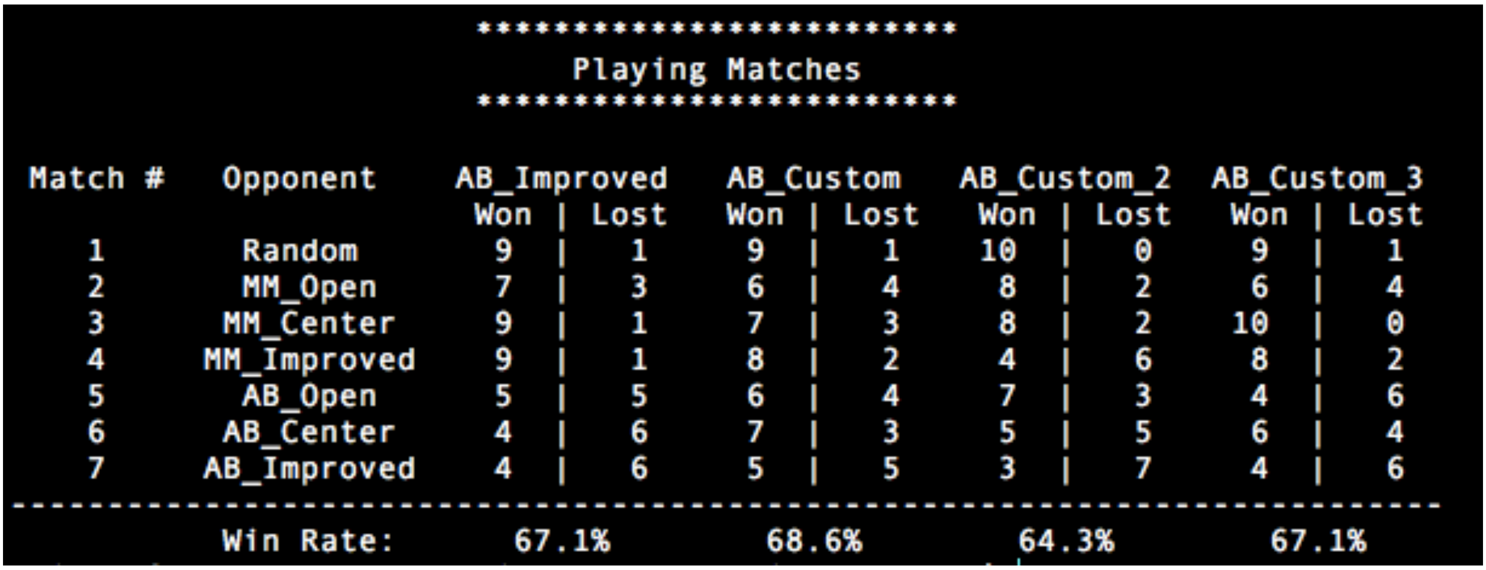
                         **************************
                              Playing Matches
                         **************************

 Match #     Opponent     AB_Improved    AB_Custom    AB_Custom_2   AB_Custom_3
                           Won | Lost   Won | Lost   Won | Lost   Won | Lost
    1         Random       10  |   0    10  |   0     9  |   1     9  |   1
    2         MM_Open       6  |   4     8  |   2     6  |   4     8  |   2
    3        MM_Center     10  |   0     7  |   3    10  |   0     9  |   1
    4       MM_Improved     8  |   2     8  |   2     5  |   5     6  |   4
    5         AB_Open       6  |   4     5  |   5     4  |   6     6  |   4
    6        AB_Center      5  |   5     6  |   4     6  |   4     5  |   5
    7       AB_Improved     6  |   4     3  |   7     5  |   5     4  |   6
--------------------------------------------------------------------------------
             Win Rate:        72.9%        67.1%        64.3%        67.1%
```

Match 3



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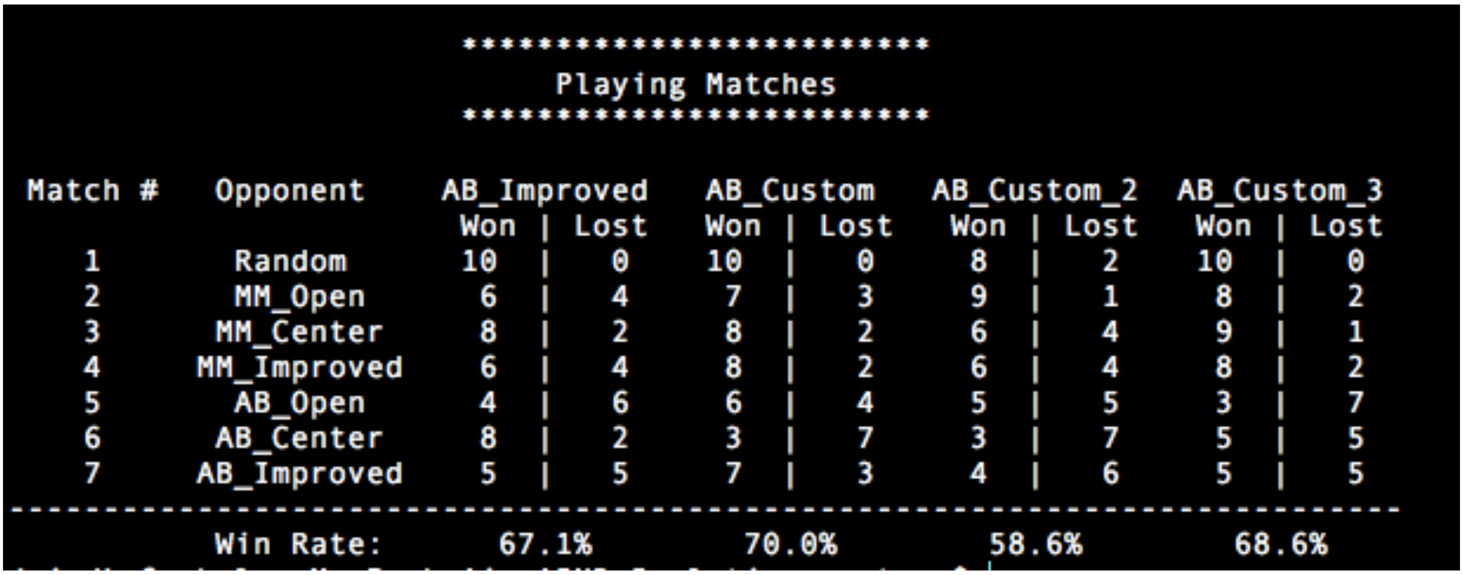
                        *************************
                             Playing Matches
                        *************************

 Match #     Opponent    AB_Improved   AB_Custom   AB_Custom_2  AB_Custom_3
                          Won | Lost  Won | Lost  Won | Lost   Won | Lost
    1        Random        9  |   1    9  |   1   10  |   0     9  |   1
    2        MM_Open       7  |   3    6  |   4    8  |   2     6  |   4
    3       MM_Center      9  |   1    7  |   3    8  |   2    10  |   0
    4      MM_Improved     9  |   1    8  |   2    4  |   6     8  |   2
    5        AB_Open       5  |   5    6  |   4    7  |   3     4  |   6
    6       AB_Center      4  |   6    7  |   3    5  |   5     6  |   4
    7      AB_Improved     4  |   6    5  |   5    3  |   7     4  |   6
--------------------------------------------------------------------------
           Win Rate:      67.1%        68.6%        64.3%        67.1%
```

Match 4



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                        *************************
                             Playing Matches
                        *************************

 Match #     Opponent    AB_Improved   AB_Custom   AB_Custom_2  AB_Custom_3
                          Won | Lost  Won | Lost  Won | Lost   Won | Lost
    1        Random       10  |   0   10  |   0    8  |   2    10  |   0
    2        MM_Open       6  |   4    7  |   3    9  |   1     8  |   2
    3       MM_Center      8  |   2    8  |   2    6  |   4     9  |   1
    4      MM_Improved     6  |   4    8  |   2    6  |   4     8  |   2
    5        AB_Open       4  |   6    6  |   4    5  |   5     3  |   7
    6       AB_Center      8  |   2    3  |   7    3  |   7     5  |   5
    7      AB_Improved     5  |   5    7  |   3    4  |   6     5  |   5
--------------------------------------------------------------------------
           Win Rate:      67.1%        70.0%        58.6%        68.6%
```

Custom Heuristic 1

This heuristic takes into account that the opponent player is trying to make our player lose by eliminating those moves which can be taken by our player.

We compare the legal_moves which are common in both our player and opponent and modify the total_score accordingly. The more common moves there are the less the score as opponent will/might try to move on a common square to reduce our player's number of moves.

This gave the maximum wins rate average of 68.95% which crosses that of AB_Improved which was the baseline for this test.

Custom Heuristic 2

This heuristic divides the board into two parts vertically. The division can also be done horizontally with similar results.

First we take the total number of blank spaces present in the game board. Then we separate the left ones and the right ones. Now depending upon the current position of the player if it is on the left side of the board then the number of blank spaces on that side will be returned as the score. This ensures that our player tries to move to a side where more number of blank spaces are present.

This gave the lowest average win rate of 62.15%.

Custom Heuristic 3

This heuristic simply uses the square of distance from the player's location to the centre of board and returns it after modification.

We first calculate the centre of the board as (width/2, height/2) and then get player's location. Now we have the coordinates so we find the square of distance between them and subtract that from the product of height and width of the board. This is done since as the distance increases from the centre, the player moves towards corners which will limit the number of legal moves in the future.

This gave 68.2% as an average win rate which comes as a close second but still manages to beat AB_Improved.

Conclusion

Now after measuring the performances of all the heuristics I've decided to go with the "Custom Heuristic 1" evaluation function because of these reasons which can be verified by looking at the above tournament.py results:

1. It gives consistent results across various matches against another player and thus it's score does not fluctuate between extremely high and extremely low.
2. It takes into account that the opponent must also be trying to reduce the chances of winning of our current player by moving on squares which might've been used by our player in the next move.
3. It doesn't require much computational power to calculate the score using this function and is also not complex to implement.

The average score of AB_Improved is 67.85% win rate which is crossed by both "Custom Heuristic 1" and "Custom Heuristic 3".

Moreover we should also keep in mind that the performance measuring tournament.py script is hardware dependent thus it might provide better results on better hardware.