Heuristic Analysis of AIND-Isolation Project

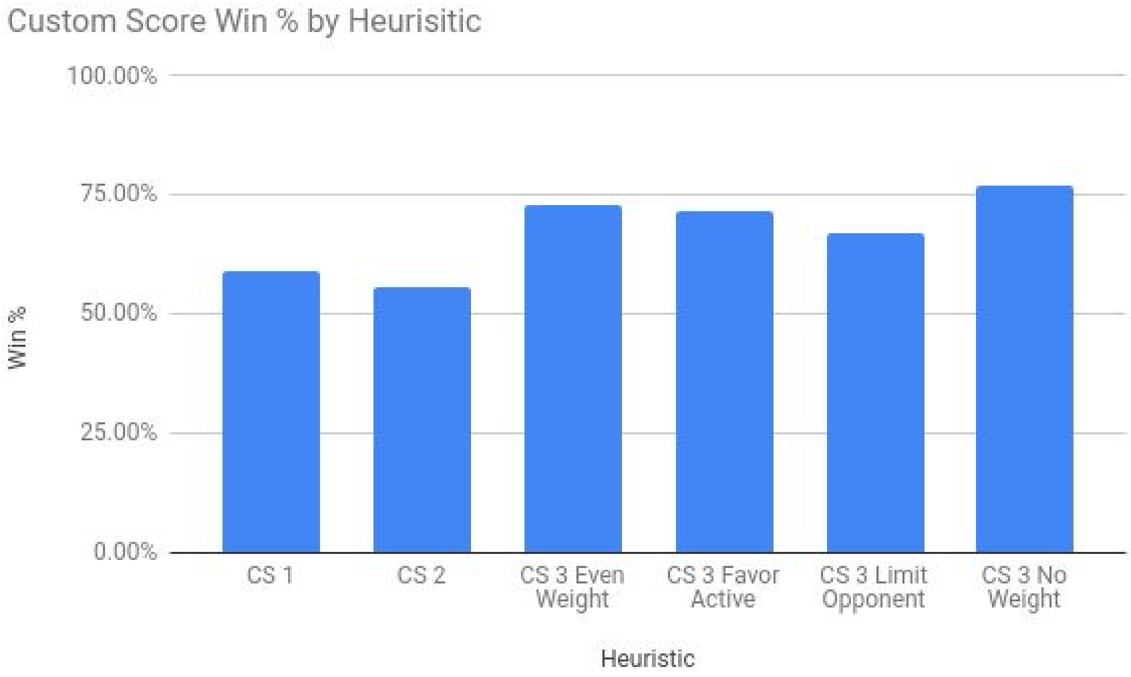
Heuristics

For the isolation project, I created the three custom heuristics below. They are ordered by hypothesized worst to best performance.

1. (active_available_moves) # of legal moves for active player. Because your opponent is trying to limit your moves, more open moves are desirable.
2. (op_available_moves) Negative # of legal opponent moves. This puts emphasis on limiting opponent moves. The ultimate goal is to bring this number to zero, so this heuristic seems to move that direction
3. (weighted_difference) # of legal moves minus # of legal opponent moves. This heuristic seeks to combine and balance the features of custom_score_1 and custom_score_2. This also allows for weighting at various points of the game.

Results

Figure 1. Win % of Custom Scores (CS) for all runs of tournament.py



Before running tournament.py, I assumed that my custom_score_1 function would be the least effective and that custom_score_3 would be the most effective and that all would be better than random.

Figure 2 show that all three heuristics are almost always better than random and that they all won more than 50% of games against other opponent bots. This tournament used even weighting for the 3rd custom heuristic. My assumption about limiting the number of opponents moves being more effective than maximizing active player open moves was incorrect. However, combining these in custom_score_3 was the most effective. This combination also allows more flexibility to change the heuristic as the game progresses.

For the weighted difference heuristic, I tested a weight that favor active player moves (figure 3) vs one that favors opponent player moves (figure 4). Favoring active player available moves shows little change versus even weighting. Reducing opponent player available moves seemed to perform worse, which is not surprising considering purely considering opponent moves was the least effective heuristic.

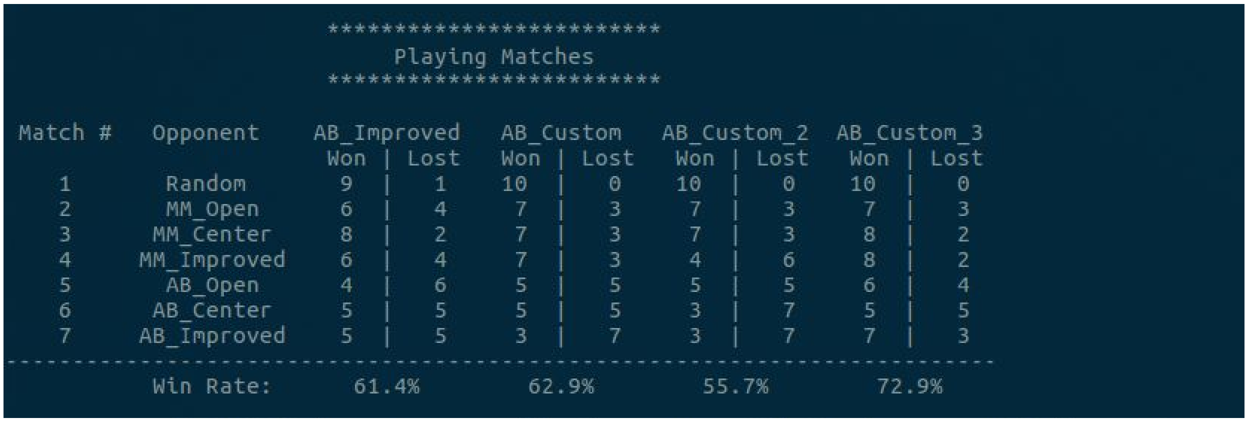
Among these custom heuristic, custom_score_3 should be used with even weights. Since the weights are not contributing to performance, it is better that they are removed during internal tournaments to avoid unnecessary calculation and allow the search to go deeper (figure 5 shows the tournament with weights removed). custom_score_3 has these advantages:

- While the arithmetic to find the difference between active and opponent moves adds to the computation time, the operation is simple and still allows for deep search
- Considering both players' moves gives direction to the search. This heuristic considers the goal of the game (limit opponent moves to 0) and adds more differentiation to the leaves of the search tree.
- This heuristic is as easy to understand and implement as the other two, but gives a noticeable performance boost.

While static weighting did not improve performance, I maintain the hypothesis that updating weights during various stages of play will improve performance. I will explore these options further before submitting to a PvP competition.

Figure 2.

Custom_score_3 with even weights



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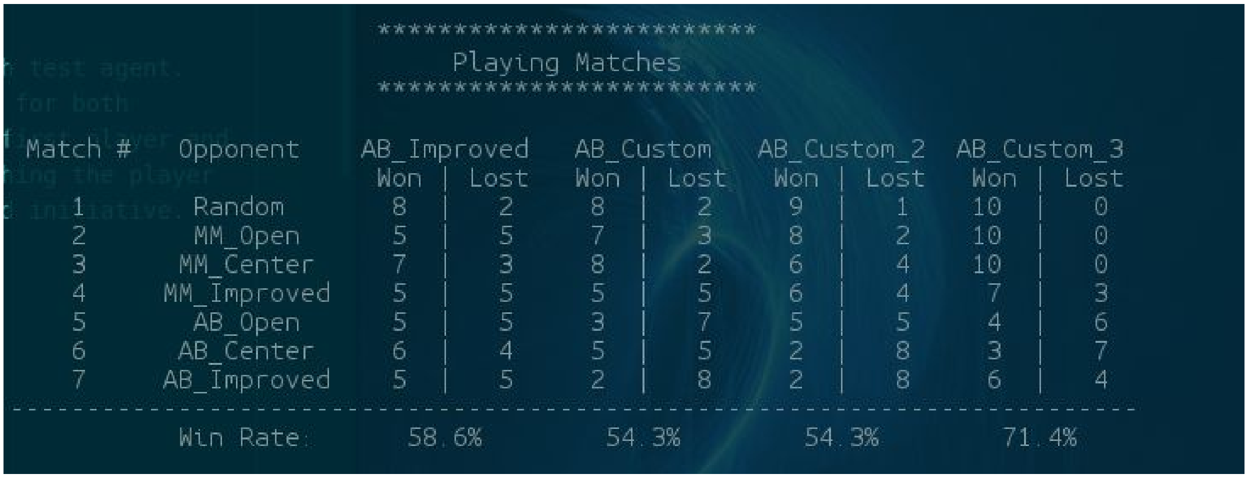
                        *************************
                             Playing Matches
                        *************************

 Match #   Opponent    AB_Improved   AB_Custom   AB_Custom_2  AB_Custom_3
                        Won | Lost   Won | Lost   Won | Lost   Won | Lost
    1       Random       9  |   1    10  |   0    10  |   0    10  |   0
    2       MM_Open      6  |   4     7  |   3     7  |   3     7  |   3
    3      MM_Center     8  |   2     7  |   3     7  |   3     8  |   2
    4     MM_Improved    6  |   4     7  |   3     4  |   6     8  |   2
    5       AB_Open      4  |   6     5  |   5     5  |   5     6  |   4
    6      AB_Center     5  |   5     5  |   5     3  |   7     5  |   5
    7     AB_Improved    5  |   5     3  |   7     3  |   7     7  |   3
--------------------------------------------------------------------------
           Win Rate:      61.4%        62.9%        55.7%        72.9%
```

Figure 3.

Custom_score_3 favoring active player open moves



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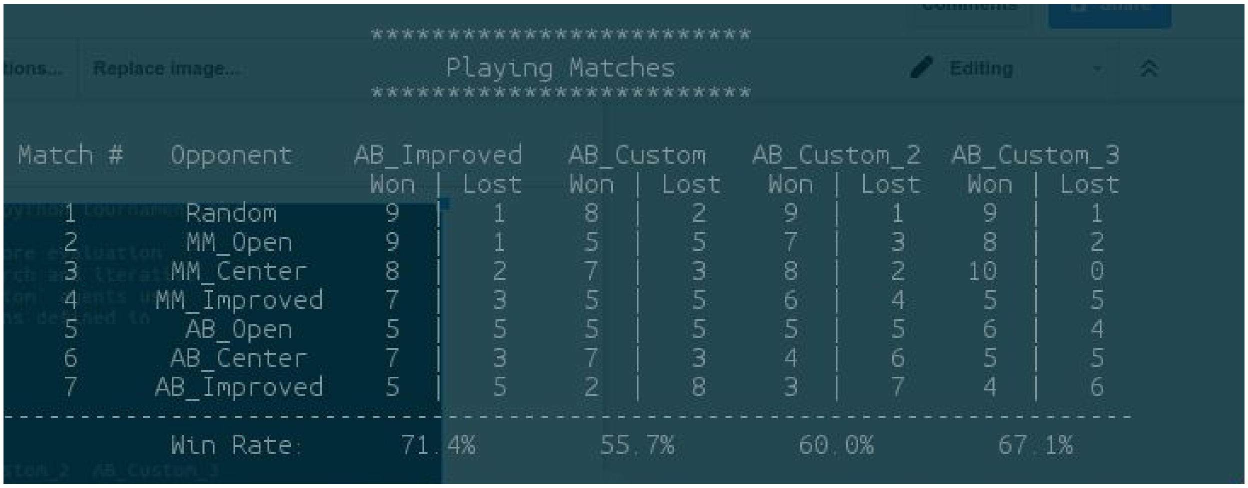
                          *************************
                               Playing Matches
                          *************************

 Match #   Opponent    AB_Improved   AB_Custom   AB_Custom_2  AB_Custom_3
                        Won | Lost   Won | Lost   Won | Lost   Won | Lost
    1       Random       8  |   2     8  |   2     9  |   1    10  |   0
    2       MM_Open      5  |   5     7  |   3     8  |   2    10  |   0
    3      MM_Center     7  |   3     8  |   2     6  |   4    10  |   0
    4     MM_Improved    5  |   5     5  |   5     6  |   4     7  |   3
    5       AB_Open      5  |   5     3  |   7     5  |   5     4  |   6
    6      AB_Center     6  |   4     5  |   5     2  |   8     3  |   7
    7     AB_Improved    5  |   5     2  |   8     2  |   8     6  |   4
--------------------------------------------------------------------------
           Win Rate:      58.6%        54.3%        54.3%        71.4%
```

Figure 4.

Custom_score_3 favoring minimizing opponent moves

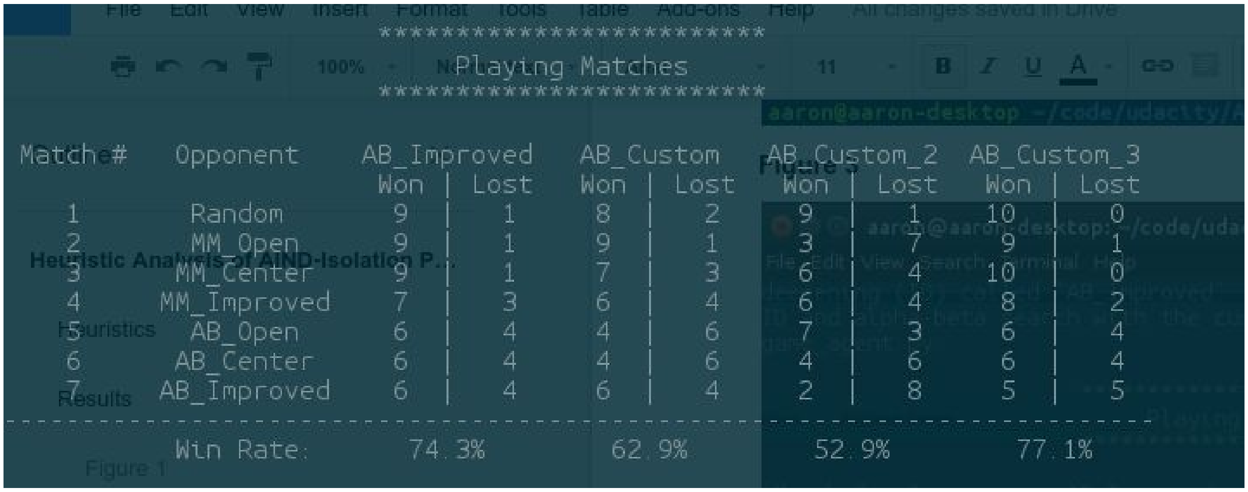


```
                          *************************
                               Playing Matches
                          *************************

 Match #   Opponent    AB_Improved   AB_Custom   AB_Custom_2  AB_Custom_3
                        Won | Lost   Won | Lost   Won | Lost   Won | Lost
    1       Random       9  |   1     8  |   2     9  |   1     9  |   1
    2       MM_Open      9  |   1     5  |   5     7  |   3     8  |   2
    3      MM_Center     8  |   2     7  |   3     8  |   2    10  |   0
    4     MM_Improved    7  |   3     5  |   5     6  |   4     5  |   5
    5       AB_Open      5  |   5     5  |   5     5  |   5     6  |   4
    6      AB_Center     7  |   3     7  |   3     4  |   6     5  |   5
    7     AB_Improved    5  |   5     2  |   8     3  |   7     4  |   6
--------------------------------------------------------------------------
           Win Rate:      71.4%        55.7%        60.0%        67.1%
```

Figure 5.

Custom_score_3 with no weights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Heuristic Analysis of AIND-Isolation P...
Heuristics
Results
Figure 1
Figure 3
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aaron@aaron-desktop: ~/code/uda
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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     8  |   2     9  |   1    10  |   0
   2        MM_Open      9  |   1     9  |   1     3  |   7     9  |   1
   3       MM_Center     9  |   1     7  |   3     6  |   4    10  |   0
   4      MM_Improved    7  |   3     6  |   4     6  |   4     8  |   2
   5        AB_Open      6  |   4     4  |   6     7  |   3     6  |   4
   6       AB_Center     6  |   4     4  |   6     4  |   6     6  |   4
   7      AB_Improved    6  |   4     6  |   4     2  |   8     5  |   5
--------------------------------------------------------------------------
           Win Rate:      74.3%        62.9%        52.9%        77.1%
```