Adversarial Game Playing agent Heuristic analysis

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In this paper I would like to present the results of analysis of heuristics for adversarial game playing agent. For solving a search problem for game agent we use two different algorithms such as Minimax algorithm and Alpha-beta pruning algorithms.

For the purpose of this paper the next heuristics have been chosen:

1) The first one is depends on the current players available moves and the distance from the center of the board

```
def custom_score(game, player):
   w, h = game.width / 2., game.height / 2.
   y, x = game.get_player_location(player)
   d = float((h - y) ** 2 + (w - x) ** 2)
   my_moves = len(game.get_legal_moves(player))
   return my_moves * math.fabs(1 - math.sqrt(d))
```

2) The second one relies on the number of moves of each player

```
def custom_score_2(game, player):
   opponent_moves = len(game.get_legal_moves(game.get_opponent(player)))
   my_moves = len(game.get_legal_moves(player))
   all_moves = my_moves + opponent_moves + 0.00001
   return float(0.3 * math.fabs(my_moves - opponent_moves) / all_moves)
```

3) A third one is a custom function with some dependencies of current position of the players

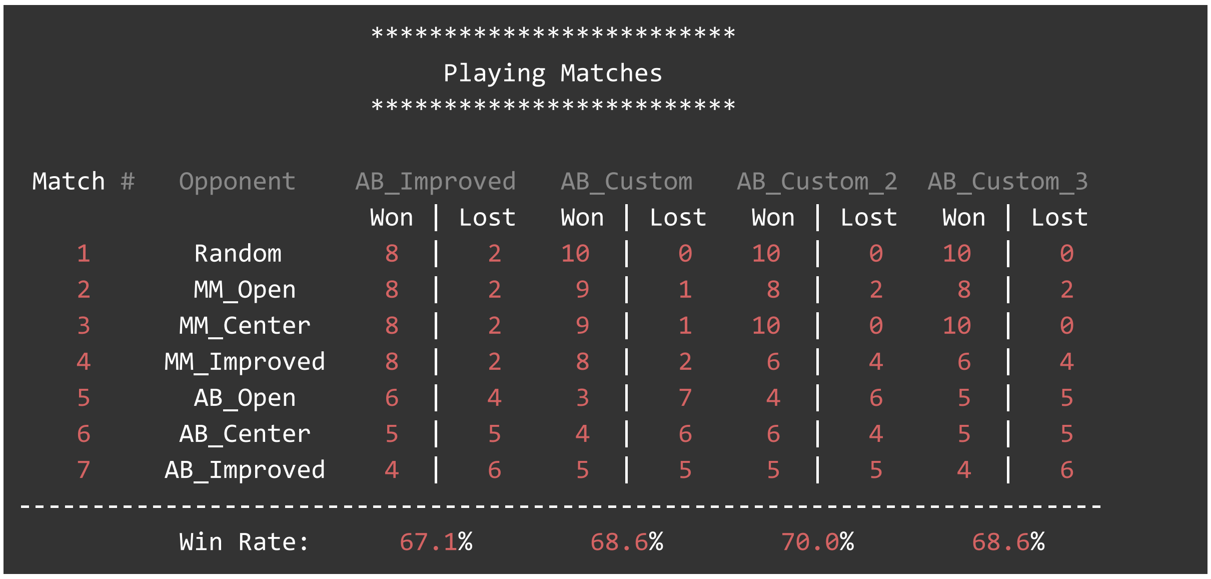
```
def custom_score_3(game, player):
   w, h = game.width / 2., game.height / 2.
   y, x = game.get_player_location(player)
   d = float((h - y) ** 2 + (w - x) ** 2)

   y_, x_ = game.get_player_location(game.get_opponent(player))
   d_ = float((h - y_) ** 2 + (w - x_) ** 2)
   return float(0.1 * (math.sqrt((math.fabs(d - d_)**2 / (d + d_)))))
```

To measure the performance of chosen heuristics we are going to compare the results of our 3 custom heuristics against the score of *AB_Improved* agent which uses alpha-beta pruning with iterative deepening and improved_score heuristics which was discussed in the lecture, and outputs score equal to the difference in the number of moves available to the two players. It is worth mention that our custom heuristics are going to be evaluated with the same configuration as *AB_improved*.

For our performance score we are going to use the number of games which will be played against several agents and will be calculated as an overall winning rate (%).

As was mentioned above we are going to use following player to play against and calculate the overall winning rate for each of heuristics:

1) Random Agent - randomly chooses a move each turn
2) MM_Open: MinimaxPlayer agent using the open_move_score heuristic with search depth 3
3) MM_Center: MinimaxPlayer agent using the center_score heuristic with search depth 3
4) MM_Improved: MinimaxPlayer agent using the improved_score heuristic with search depth 3
5) AB_Open: AlphaBetaPlayer using iterative deepening alpha-beta search and the open_move_score heuristic
6) AB_Center: AlphaBetaPlayer using iterative deepening alpha-beta search and the center_score heuristic
7) AB_Improved: AlphaBetaPlayer using iterative deepening alpha-beta search and the improved_score heuristic



```
                         *************************
                              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    10  |   0    10  |   0    10  |   0
    2       MM_Open      8  |   2     9  |   1     8  |   2     8  |   2
    3      MM_Center     8  |   2     9  |   1    10  |   0    10  |   0
    4     MM_Improved    8  |   2     8  |   2     6  |   4     6  |   4
    5       AB_Open      6  |   4     3  |   7     4  |   6     5  |   5
    6      AB_Center     5  |   5     4  |   6     6  |   4     5  |   5
    7     AB_Improved    4  |   6     5  |   5     5  |   5     4  |   6
--------------------------------------------------------------------------
           Win Rate:      67.1%        68.6%        70.0%        68.6%
```

Tab.1 The results of played games

From ***Tab. 1*** we can see that our three custom heuristics show not very bad results especially *AB_Custom_2* heuristic that gives us **70%** winning rate and other two *AB_Custom_3 and AB_Custom_1* heuristics give **68.6%** each.

In addition, comparing the heuristic with best performance *AB_Custom_2* and *AB_Improved* we can conclude that *AB_Custom_2* shows overall a better result and gives us 70.0% winning rate over 67.1% for *AB_Improved.* Although AB_Custom_2 shows a poor performance for *AB_Open* player.

```
 Match #    Opponent    AB_Improved      AB_Custom     AB_Custom_2    AB_Custom_3
                        Won | Lost     Won | Lost     Won | Lost     Won | Lost
5          AB_Open       6  |   4      3  |   7       4  |   6       5  |   5
```

It showed the best results for *Random* and *MM_Center* players as well as AB_Custom_3 heuristic:

```
 Match #    Opponent    AB_Improved      AB_Custom     AB_Custom_2    AB_Custom_3
                           Won | Lost  Won | Lost    Won | Lost    Won | Lost
    1         Random        8  |   2    10 |   0     10 |   0     10 |   0
    3       MM_Center       8  |   2     9 |   1     10 |   0     10 |   0
```

From the result we can conclude that *AB_Improved agent* with improved_score heuristic have roughly the same winning score against all players, have some difficulties again *AB_Open, AB_Centered, and AB_Imroved* thought. Regarding presented custom heuristics we can conclude that they have definitely better performance against *Random, MM_Open, and MM_center* players winning 10 games of 10 , and show better results playing against other players than *AB_Improved.*

Recommendations

AB_Custom_2 showed the best performance over other heuristics and should be used.

- Overall it gives the higher winning rate **70%** over **67.1%** AB_Improved
- It's more flexible due to an introduced coefficient that can be tuned in order to improve overall performance
- It's uncomplicated owing to having a small number of simple arithmetic operations

To sum up, carefully selected heuristics can significantly improve chances of winning from the results above we can see that even very simple heuristics can show very descent results.