Heuristic Analysis

Heuristic score evaluates the board position and assigns a score. The higher the score the better it is for the AI agent, if the score is lower it is better for the opponent. Each level of the tree is called a “ply”, in this analysis of the game tree we cut off at a certain maximum depth.

Analysis:

Custom functions used for heuristic analysis are the following:

AB_Custom: The score is based on AI agents moves - Opponent’s move
AB_Custom2: The score is based on AI agents moves - 3*Opponents move
AB_Custom3: The score is based on AI agents available moves.

I have experimented with different match sizes to analyze timeout and performance of heuristic functions.

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Playing Matches
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Match #	Opponent	AB_Improved		AB_Custom		AB_Custom_2		AB_Custom_3	
		Won	Lost	Won	Lost	Won	Lost	Won	Lost
1	Random	77	3	73	7	73	7	72	8
2	MM_Open	59	21	59	21	64	16	53	27
3	MM_Center	69	11	71	9	64	16	67	13
4	MM_Improved	56	24	57	23	60	20	57	23
5	AB_Open	39	41	44	36	39	41	33	47
6	AB_Center	47	33	45	35	45	35	43	37
7	AB_Improved	42	38	43	37	40	40	35	45
	Win Rate:	69.5%		70.0%		68.8%		64.3%	

There were 21.0 timeouts during the tournament -- make sure your agent handles search timeout

# of matches played : 40

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*************************
     Playing Matches
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  Match #    Opponent     AB_Improved    AB_Custom    AB_Custom_2  AB_Custom_3
                           Won | Lost   Won | Lost   Won | Lost   Won | Lost
     1        Random       36  |   4    38  |   2    39  |   1    37  |   3
     2        MM_Open      29  |  11    26  |  14    29  |  11    30  |  10
     3       MM_Center     38  |   2    35  |   5    35  |   5    35  |   5
     4     MM_Improved     34  |   6    27  |  13    29  |  11    28  |  12
     5        AB_Open      21  |  19    21  |  19    23  |  17    20  |  20
     6       AB_Center     25  |  15    21  |  19    28  |  12    24  |  16
     7     AB_Improved     24  |  16    21  |  19    20  |  20    20  |  20
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           Win Rate:      73.9%        67.5%        72.5%        69.3%

 There were 1.0 timeouts during the tournament -- make sure your agent handles search
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# of matches played : 20

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     Playing Matches
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  Match #    Opponent     AB_Improved    AB_Custom    AB_Custom_2  AB_Custom_3
                           Won | Lost   Won | Lost   Won | Lost   Won | Lost
     1        Random       17  |   3    20  |   0    17  |   3    17  |   3
     2        MM_Open      14  |   6    15  |   5    17  |   3    17  |   3
     3       MM_Center     16  |   4    17  |   3    20  |   0    18  |   2
     4     MM_Improved     14  |   6    14  |   6    12  |   8    10  |  10
     5        AB_Open       9  |  11    11  |   9     9  |  11     8  |  12
     6       AB_Center     12  |   8     6  |  14    13  |   7     8  |  12
     7     AB_Improved      9  |  11     9  |  11    11  |   9    10  |  10
 ----------------------------------------------------------------------------
           Win Rate:      65.0%        65.7%        70.7%        62.9%

 There were 1.0 timeouts during the tournament -- make sure your agent handles search
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# of matches played : 10

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Playing Matches
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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	9	1	7	3	7	3	7	3
3	MM_Center	8	2	8	2	8	2	9	1
4	MM_Improved	8	2	9	1	7	3	7	3
5	AB_Open	4	6	5	5	5	5	5	5
6	AB_Center	6	4	4	6	8	2	4	6
7	AB_Improved	5	5	5	5	5	5	4	6
	Win Rate:	71.4%		68.6%		70.0%		64.3%	

# of matches played : 5

The best score is AB_Custom2, it is the same as AB_Custom but with a fundamental difference of a factor of 3 multiplied to the opponent's move. When a multiplication factor of 3 is attached to the opponent's move what it means is that, opponent now has 3 times more moves than it really does, thus the AI agent has to choose the right moves to improve the score. The only time it was below AB_Custom was when number of matches played were 40, but I strongly believe it was because of the timeouts.

The next best score is AB_Custom, the reason being it gives the maximum score when AI agents have more possible moves than the opponent and minimum score when opponent's has more possible moves than the AI agent. This heuristic analysis is called "Improved Score"

Finally, the worst is AB_Custom3, here only AI agents available moves are considered and none of opponent's moves are taken into account, thus the AI agent is has a higher probability of a bad move and reducing the score.

Conclusion:

From the above 3 analysis it is clear to use **AB_Custom2** since it the best winning rate, can there be a optimum weighting factor?

Addendum: (02/27/2018)

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                    *************************
                         Playing Matches
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 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     8  |  2
    2       MM_Open      7  |  3     9  |  1     7  |  3     8  |  2
    3      MM_Center     8  |  2     9  |  1     6  |  4     10 |  0
    4     MM_Improved    7  |  3     7  |  3     8  |  2     5  |  5
    5       AB_Open      4  |  6     5  |  5     5  |  5     5  |  5
    6      AB_Center     4  |  6     6  |  4     6  |  4     7  |  3
    7     AB_Improved    5  |  5     6  |  4     7  |  3     6  |  4
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           Win Rate:      62.9%        72.9%        70.0%        70.0%

There were 10.0 timeouts during the tournament -- make sure your agent handles search timeout
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Recommendations:

- **AB_Custom1:**

Used “center based” heuristic calculation.

Agent gets high score if the legal move is close to the center of the board, as it moves further from the center, it earns less score. Similarly, the same process is followed for the opponent but push the opponent more towards the edge.
This is performing a little better than AB_Custom2, that is because maximizing the number of legal moves of the agent closer to the center of the board will have more legal moves than the opponent.

- **AB_Custom2:**

Used “improved score” heuristic calculation.
This heuristic function calculates the difference of agent’s move and opponent’s move with the opponent’s move multiplied by a factor of 3.

- **AB_Custom3:**

Used "manhattan distance" for heuristic calculation.

The more moves the agent has from the evaluated position, it is positive of the agent, if the agent's move and opponent's move are not the same then the function just returns the difference of the agent's move and opponent's move. However, not all starting position between the agent and the opponent are the same, if the agent's position is near the center it has far more likely that the agent will do better than the opponent whose available moves are at the edges.