

# Isolation Heuristic Analysis

## Custom Score 1: (My Moves – Opponent Moves) \*\* 2.

This scoring places strong bias on maximising the number of player moves versus the opponent. This is simply the squared value of the improved heuristic which in hindsight could lead to suboptimal play, especially on nodes where the number of legal moves for the opponent far exceeds that of the player. Some iterations of the tournament did lead to this heuristic outperforming the improved one, but in general performed worse than the improved methodology.

## Custom Score 2: (My Moves – Opponent Moves) + (Opponents Distance to Centre – My Distance to Centre)

This method favours increasing the number of moves and getting closer to the centre of the board than the opponent, while penalising branches which take the player further away from the centre. Balancing the number of immediate options 1 depth down and in the long term (being near the centre would typically allow this) is a compromise that does not place too much bias on one aspect of the game.

## Custom Score 3: Negative Euclidean Distance to the Opponent

This method encourages picking moves that play closer to the opponent. The notion that chasing the opponent could narrow down the number of options for the opponent is plausible, but faces the issue that this gives the opponent initiative, and the fact that the Euclidean distance is not representative of the (2, 1) jump sizes, i.e. both players could be near each other but have an entirely different set of legal moves.

## Tournament Summaries

With the inclusions of ties, using a metric that incorporates centre play and widening the gap between the player and opponents moves achieved the highest win rate on tournaments. The overall margin to which this occurs is minor, having run only on 12 iterations of tournaments gives no clearer picture as to whether one heuristic consistently outperforms another.

All of the Alpha Beta iterations outperformed their Minimax counterparts as expected; the latter being set a maximum depth of 3. The optimisations Alpha Beta make in pruning redundant branches allow the player to search greater depths for fruitful options that lead to certain victory. The Improved heuristic is consistently better than its other counterparts in the Minimax implementation, where more losses were made by all 4 Alpha Beta implementations.

Custom 2 outperformed the improved methodology against most of the weaker heuristics by a small margin. While in direct competition the **AB\_Improved** implementation wins more games, **AB\_Custom\_2** was better at maximising win rates against weaker agents. By having the extra term in the scoring could suggest there are longer term benefits towards playing the centre, ironically all Alpha Beta players had no trouble against the **MM\_Center**; yielding at least 80%–win rates across all observed tournaments. The other custom implementations do not offer any significant benefits over the second, with **AB\_Custom** having the worst performance, owing to ignoring the sign change between the number of player moves and opponent moves.

Tournament	AB_Improved	AB_Custom	AB_Custom_2	AB_Custom_3
1	65.7%	64.3%	75.7%	71.4%
2	68.6%	61.4%	72.9%	62.9%
3	65.7%	80.0%	70.0%	65.7%
4	74.3%	67.1%	74.3%	71.4%
5	68.6%	71.4%	61.4%	72.9%
6	70.0%	61.4%	61.4%	67.1%
7	81.4%	67.1%	65.7%	67.1%
8	58.6%	57.1%	64.3%	70.0%
9	68.6%	67.1%	67.1%	74.3%
10	70.0%	65.7%	70.0%	60.0%
11	65.7%	67.1%	72.9%	61.4%
12	65.7%	62.9%	71.4%	71.4%
Average	68.6%	66.1%	68.9%	68.0%

# Isolation Heuristic Analysis

## Tournament Details

### Tournament 1

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	10	0
2	MM_Open	8	2	7	3	8	2	10	0
3	MM_Center	8	2	9	1	8	2	10	0
4	MM_Improved	7	3	5	5	9	1	5	5
5	AB_Open	6	4	5	5	7	3	5	5
6	AB_Center	4	6	4	6	6	4	5	5
7	AB_Improved	4	6	4	4	5	5	5	5
Win Rate:		65.7%		64.3%		75.7%		71.4%	

### Tournament 2

Match #	Opponent	AB_Improved		AB_Custom		AB_Custom_2		AB_Custom_3	
		Won	Lost	Won	Lost	Won	Lost	Won	Lost
1	Random	10	0	9	1	10	0	9	1
2	MM_Open	7	3	6	4	8	2	8	2
3	MM_Center	10	0	9	1	10	0	10	0
4	MM_Improved	7	3	6	4	8	2	4	6
5	AB_Open	7	3	2	8	5	5	5	5
6	AB_Center	5	5	7	3	7	3	3	7
7	AB_Improved	2	8	4	6	3	7	5	5
Win Rate:		68.6%		61.4%		72.9%		62.9%	

### Tournament 3

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	10	0	9	1
2	MM_Open	6	4	7	3	8	2	8	2
3	MM_Center	8	2	10	0	9	1	8	2
4	MM_Improved	7	3	9	1	7	3	6	4
5	AB_Open	6	4	7	3	4	6	6	4
6	AB_Center	6	4	7	3	7	3	5	5
7	AB_Improved	3	7	6	4	4	6	4	6
Win Rate:		65.7%		80.0%		70.0%		65.7%	

### Tournament 4

Match #	Opponent	AB_Improved		AB_Custom		AB_Custom_2		AB_Custom_3	
		Won	Lost	Won	Lost	Won	Lost	Won	Lost
1	Random	10	0	9	1	10	0	10	0
2	MM_Open	9	1	8	2	8	2	8	2
3	MM_Center	9	1	9	1	8	2	9	1
4	MM_Improved	6	4	6	4	8	2	7	3
5	AB_Open	5	5	6	4	6	4	4	6
6	AB_Center	9	1	5	5	6	4	6	4
7	AB_Improved	4	6	4	6	6	4	6	4
Win Rate:		74.3%		67.1%		74.3%		71.4%	

### Tournament 5

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	8	2	10	0
2	MM_Open	8	2	7	3	7	3	9	1
3	MM_Center	9	1	9	1	9	1	7	3
4	MM_Improved	8	2	8	2	6	4	8	2
5	AB_Open	5	5	5	5	4	6	4	6
6	AB_Center	5	5	5	5	5	5	7	3
7	AB_Improved	4	6	6	4	4	6	6	4
Win Rate:		68.6%		71.4%		61.4%		72.9%	

### Tournament 6

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	10	0	9	1
2	MM_Open	7	3	5	5	6	4	6	4
3	MM_Center	8	2	9	1	9	1	8	2
4	MM_Improved	9	1	7	3	5	5	6	4
5	AB_Open	4	6	5	5	3	7	6	4
6	AB_Center	7	3	6	4	5	5	7	3
7	AB_Improved	6	4	3	7	5	5	5	5
Win Rate:		70.0%		61.4%		61.4%		67.1%	

### Tournament 7

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	7	3	8	2	8	2	6	4
3	MM_Center	9	1	9	1	10	0	8	2
4	MM_Improved	9	1	6	4	8	2	6	4
5	AB_Open	8	2	5	5	4	6	6	4
6	AB_Center	7	3	3	7	6	4	7	3
7	AB_Improved	7	3	6	4	1	9	5	5
Win Rate:		81.4%		67.1%		65.7%		67.1%	

### Tournament 8

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	9	1	8	2
2	MM_Open	5	5	5	5	6	4	7	3
3	MM_Center	8	2	9	1	9	1	9	1
4	MM_Improved	6	4	6	4	7	3	8	2
5	AB_Open	5	5	5	5	5	5	5	5
6	AB_Center	4	6	3	7	5	5	7	3
7	AB_Improved	4	6	2	8	4	6	5	5
Win Rate:		58.6%		57.1%		64.3%		70.0%	

### Tournament 9

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	9	1	9	1
2	MM_Open	6	4	6	4	8	2	8	2
3	MM_Center	10	0	8	2	8	2	9	1
4	MM_Improved	7	3	9	1	7	3	7	3
5	AB_Open	6	4	4	6	5	5	6	4
6	AB_Center	5	5	5	5	5	5	7	3
7	AB_Improved	5	5	6	4	5	5	6	4
Win Rate:		68.6%		67.1%		67.1%		74.3%	

### Tournament 10

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	8	2	9	1
2	MM_Open	6	4	8	2	6	4	6	4
3	MM_Center	8	2	8	2	10	0	10	0
4	MM_Improved	6	4	7	3	8	2	5	5
5	AB_Open	6	4	6	4	7	3	6	4
6	AB_Center	7	3	3	7	5	5	2	8
7	AB_Improved	7	3	4	6	5	5	4	6
Win Rate:		70.0%		65.7%		70.0%		60.0%	

### Tournament 11

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	9	1
2	MM_Open	7	3	8	2	7	3	7	3
3	MM_Center	8	2	9	1	8	2	10	0
4	MM_Improved	5	5	5	5	6	4	6	4
5	AB_Open	5	5	6	4	7	3	3	7
6	AB_Center	9	1	5	5	7	3	5	5
7	AB_Improved	4	6	5	5	6	4	3	7
Win Rate:		65.7%		67.1%		72.9%		61.4%	

### Tournament 12

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	8	2	10	0
2	MM_Open	7	3	6	4	8	2	6	4
3	MM_Center	9	1	8	2	9	1	9	1
4	MM_Improved	6	4	7	3	7	3	7	3
5	AB_Open	6	4	4	6	4	6	7	3
6	AB_Center	6	4	6	4	8	2	5	5
7	AB_Improved	3	7	3	7	6	4	6	4
Win Rate:		65.7%		62.9%		71.4%		71.4%	