

Match #	Opponent	AB_Improved		AB_Custom		AB_Custom_2		AB_Custom_3	
		Won	Lost	Won	Lost	Won	Lost	Won	Lost
1	Random	9	1	7	3	8	2	8	2
2	MM_Open	6	4	6	4	7	3	6	4
3	MM_Center	7	3	5	5	8	2	9	1
4	MM_Improved	7	3	7	3	7	3	6	4
5	AB_Open	6	4	6	4	6	4	6	4
6	AB_Center	5	5	5	5	5	5	6	4
7	AB_Improved	6	4	5	5	6	4	6	4

Win Rate:		65.7%		58.6%		67.1%		67.1%	

- **Heuristic 1 (AB_Custom)**

This heuristic calculates the Manhattan distance from the player to the opponent. I'd like to think the further the distance the player is from the opponent the better, since in most situations it's unlikely to be trapped when the distance is great, so the higher the score returned the better. The win rate of 58.6% was the worst of the three heuristics I added. The highest number of wins against the opponents was seven, against the random opponent and the Mini/Max improved opponent. The lowest number of wins was a three-way tie with five wins against the Mini/Max center, alpha/beta center, and alpha/beta improved opponents. For this heuristic the total number of lowest number of wins was worse than any of the other competition heuristics. The only other heuristic that suffered five losses against a single opponent happened one time for the 2nd heuristic, as opposed to three times for this heuristic. This is also the only heuristic I created that doesn't have a higher number of games won against an opponent when compared to the alpha/beta improved heuristic.

- **Heuristic 2 (AB_Custom2)**

For this heuristic I chose to calculate the number of legal moves for the player as well as the opponent and then taking the difference. If the number of legal moves for the opponent is higher than for the player, this would result in a negative score, so anytime there's less room for the player to move around than the opponent the score will always be negative, and positive when the player has more room than the opponent. This simple calculation produced a win rate, tying with the 3rd heuristic for the best results, with a value of 67.1%. There were two cases where eight games were won against the opponent, the random opponent and the Mini/Max center opponent. The games against the alpha/beta center opponent resulted in only 5 wins, the lowest number of wins against any of the opponents, but this was the opponent that all other heuristics had a tough time against. There were two times where this heuristic had a higher number of games won against an opponent when compared to the alpha/beta improved heuristic (Mini/Max open and Mini/Max center).

- **Heuristic 3 (AB_Custom3)**

For the last heuristic I first calculated the Manhattan distances that the player and the opponent are from the center of the board, then I took the difference in the Manhattan calculations between the player and the opponent. I chose to use the center based on an assumption that the center of the board is the optimal position, since it should have the most places to move from, so both players would like to be most near. Because the difference is taken

with respect to the closeness to the center, the opponents distance will work as a penalty for the score, where, if the opponent is closer to the center than the player, the score will always be negative, but if the player is closer to the center than the opponent the difference will be positive. I first attempted to use the sum of the distances from the four corners, but the results weren't that much different. The results from this heuristic were tied for the best with the 2nd heuristic at a win rate of 67.1%. This was the only heuristic I created that reached a win count of nine against an opponent (against Mini/Max center). The second-best number of wins was against the random opponent, with eight wins, and all the other five matches resulted in six wins. Comparing the games won against each opponent to the alpha/beta improved heuristic, this heuristic abled a higher number of wins against the Mini/Max center opponent and the Alpha/Beta center opponent.

- **Conclusion**

The win rate of the 2nd heuristic that used the difference in legal moves between the player and the opponent was tied with the 3rd heuristic that used the difference in distance between the player and opponent distances from the center (67.1%). Both heuristics were able to outperform the alpha/beta improved win rate of 65.7%. This difference is only slight (1.4%) and could likely be reversed by running the tournament again. Also, both heuristics performed well against the random and Mini/Max center opponents. For a pick of the "best" heuristic, here are a few reasons why I would choose the 3rd heuristic over the 2nd heuristic:

1. The overall win rate was higher than the alpha/beta improved heuristic.
2. Games against all ten opponents resulted in win numbers greater than, or equal to, six. It was also the only heuristic I created that had nine games won against an opponent.
3. The third heuristic was the only heuristic able to pull off more than five wins against the alpha/beta center opponent (six games won), this includes the alpha/beta improved heuristic.