

Project : Build a game-playing agent

Heuristic Analysis

Heuristic 1:

$$\text{score} = \# \text{my_moves} - \# \text{opponent_moves} + 2 * (\# \text{my_player_move_directions} - \# \text{opponent_player_move_directions})$$

The heuristic tries to consider the mobility of the player by calculating the possible moving directions. The idea is that the more directions the player can move the less possible it will be blocked by the opponent's future move.

Heuristic 2:

$$\text{score} = \# \text{my_moves} - \# \text{opponent_moves}^2$$

This heuristic function tries to minimize opponent moves as much as possible when considering own moves at the same time. For example, the state where $\# \text{my_moves} = 6$ and $\# \text{opponent_moves} = 2$ is preferred than $\# \text{my_moves} = 8$ and $\# \text{opponent_moves} = 3$

Heuristic 3:

$$\text{score} = \# \text{my_player_move_directions} - \# \text{opponent_player_move_directions}$$

This heuristic function tries to maximize player's own move directions minus opponent's move directions. This evaluation function puts all focus on the mobility of the player.

Analysis of all heuristic functions

The chart A in the next page shows the performance overview on the 4 heuristic functions playing against 3 AB_* players based on 3 tournaments (See Appendix A for the raw results of these tournaments). The Y axis stands for the winning percentage. The results of playing against minimax players are excluded from this analysis because alphabeta player is an enhanced version of it and by doing that we also move the impact of the alphabeta pruning algorithm out of the equation and can, therefore, study the performance and goodness of the heuristic functions.

The three heuristic functions mentioned above are computationally more complicated than the open move heuristic function (my player's number of available moves) and the improved heuristic function (using the difference between my player's and opponent's open moves) with a factor of constant time. The center score heuristic is a bit more complicated, but the heuristic 1 and 3 need to compute the available moving directions and requires more time and thus they also run slower than the center score function. Giving a specified time for the agent to search the tree, a more complex heuristic would spend more time to run and therefore it probably goes less deep in the tree. With that, I would believe the heuristic 2 out of my three heuristic functions would go deepest in the search tree.

If you look at the below results of the yellow columns which show the average winning percentage against all three AB players, the performance ranks from top to bottom are heuristic function 2 (AB_Custom2), heuristic function 1 and 3 (AB_Custom tied with AB_Custom_3), and the improved function (AB_Improved). The heuristic function 2 works best probably because it attacks really aggressively to minimize the open moves of the opponent meanwhile still trying to maintain some open moves for itself.

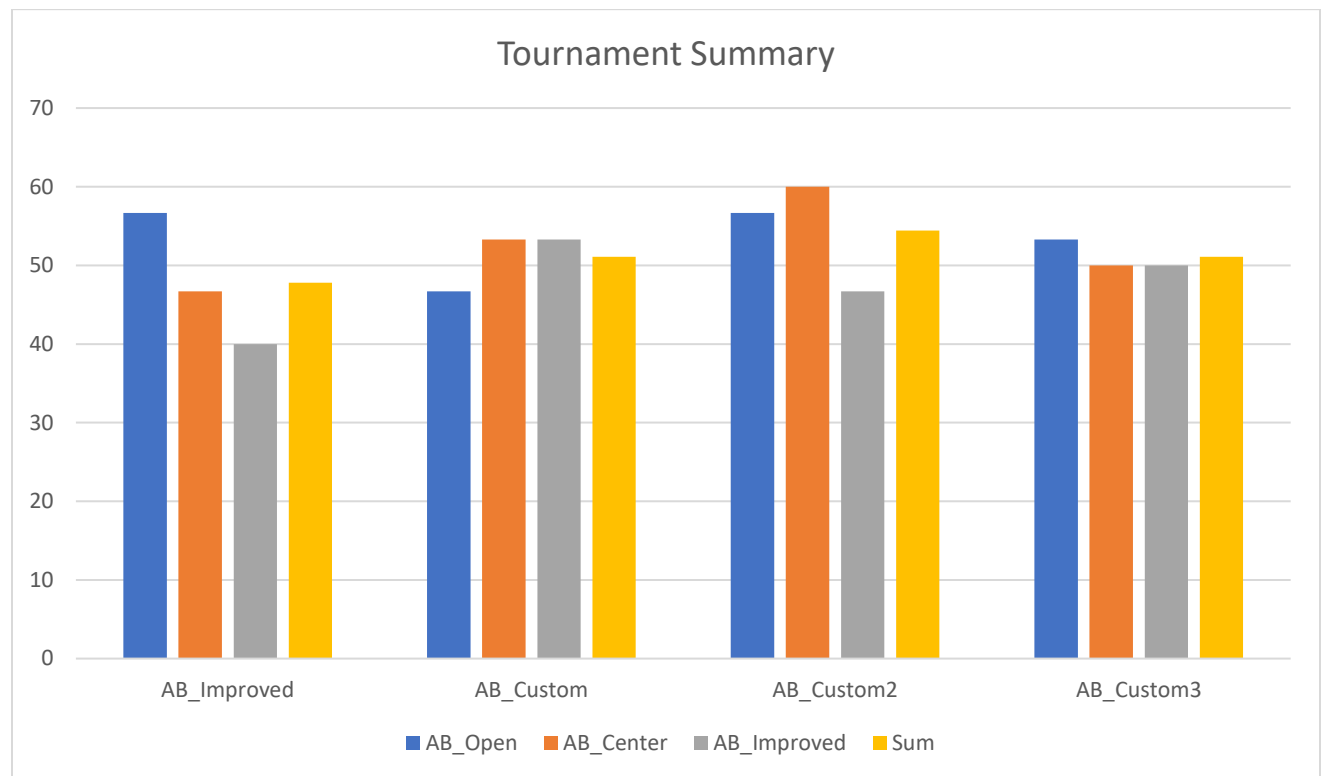


Chart A

To sum up, all three heuristic functions work a bit better than the improved function. The fine tune of the weights of different features, i.e. the open moves and the available moving directions, could potentially improve the agent a bit more.

Appendix A

Tournament Raw Results

| 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 | 9 | 1 | 10 | 0 |
| 2 | MM_Open | 7 | 3 | 8 | 2 | 5 | 5 | 7 | 3 |
| 3 | MM_Center | 6 | 4 | 7 | 3 | 6 | 4 | 8 | 2 |
| 4 | MM_Improved | 6 | 4 | 5 | 5 | 6 | 4 | 8 | 2 |
| 5 | AB_Open | 5 | 5 | 3 | 7 | 6 | 4 | 4 | 6 |
| 6 | AB_Center | 4 | 6 | 5 | 5 | 7 | 3 | 5 | 5 |
| 7 | AB_Improved | 4 | 6 | 4 | 6 | 4 | 6 | 6 | 4 |
| Win Rate: | | 57.1% | | 58.6% | | 61.4% | | 68.6% | |

| 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 | 7 | 3 | 9 | 1 |
| 2 | MM_Open | 7 | 3 | 7 | 3 | 6 | 4 | 6 | 4 |
| 3 | MM_Center | 10 | 0 | 8 | 2 | 9 | 1 | 9 | 1 |
| 4 | MM_Improved | 5 | 5 | 7 | 3 | 6 | 4 | 6 | 4 |
| 5 | AB_Open | 7 | 3 | 5 | 5 | 6 | 4 | 5 | 5 |
| 6 | AB_Center | 4 | 6 | 6 | 4 | 5 | 5 | 6 | 4 |
| 7 | AB_Improved | 5 | 5 | 6 | 4 | 5 | 5 | 4 | 6 |
| Win Rate: | | 68.6% | | 68.6% | | 62.9% | | 64.3% | |

| Match # | Opponent | AB_Improved | | AB_Custom | | AB_Custom_2 | | AB_Custom_3 | |
|-----------|-------------|-------------|------|-----------|------|-------------|------|-------------|------|
| | | Won | Lost | Won | Lost | Won | Lost | Won | Lost |
| 1 | Random | 8 | 2 | 7 | 3 | 7 | 3 | 9 | 1 |
| 2 | MM_Open | 6 | 4 | 8 | 2 | 6 | 4 | 7 | 3 |
| 3 | MM_Center | 8 | 2 | 8 | 2 | 7 | 3 | 6 | 4 |
| 4 | MM_Improved | 8 | 2 | 4 | 6 | 5 | 5 | 8 | 2 |
| 5 | AB_Open | 5 | 5 | 6 | 4 | 5 | 5 | 7 | 3 |
| 6 | AB_Center | 6 | 4 | 5 | 5 | 6 | 4 | 4 | 6 |
| 7 | AB_Improved | 3 | 7 | 6 | 4 | 5 | 5 | 5 | 5 |
| Win Rate: | | 62.9% | | 62.9% | | 58.6% | | 65.7% | |