

Heuristics Comparison

I choose and implemented 4 heuristics for the project, as well as one control heuristic just for comparison:

Heuristic 1: player's legal moves * 1/blank spaces on board

Heuristic 2: player's legal moves – player's distance to board's center

Heuristic 3: opponent's distance to center – opponent's legal moves

Heuristic 4: player's legal moves – 2 * opponent's legal moves

Heuristic 5: player's legal moves (just included for the sake of comparison)

Below are the comparison of their scores in the tournament:

Method	ID_Improved Score	Student Score
Heuristic 1	70.00%	65.71%
Heuristic 2	72.14%	51.43%
Heuristic 3	67.14%	55.71%
Heuristic 4	74.29%	78.57%
Heuristic 5 (control group)	69.29%	61.43%

I ended up with the **4th heuristic** for 4 main reasons:

- 1) It scored the highest in the tournament compared to the other three heuristics, as can be seen above. In fact, it was the only one that was able to beat the ID_Improved agent.
- 2) It is a lot more consistent against its opponents compared to the other three, as it repeatedly beat its competitors (see the output of the tournaments.py script below)
- 3) It is simple enough to calculate rapidly, but not so simple that it neglects too much information about the state of the board, as it considers both its own moves as well as those of its competitor
- 4) And last but not least, it logically makes the most sense: from the perspective of the player, it knows its options, but it doesn't know what its opponent's strategy is. Therefore, giving its opponent's moves more weight while computing its evaluation function makes a lot of sense. Keep your friends close, but your enemies closer.

It is indeed very interesting that the simplest evaluation function I had (option 5) came third. This validates the point from the lectures that simpler evaluation functions can indeed be a lot better than more complex ones, as they can search deeper in the tree in the same amount of time.

HEURISTIC 1

Evaluating: ID_Improved

Playing Matches:

Match 1: ID_Improved vs Random Result: 16 to 4

Match 2: ID_Improved vs MM_Null Result: 13 to 7

Match 3: ID_Improved vs MM_Open Result: 16 to 4

Match 4: ID_Improved vs MM_Improved Result: 13 to 7

Match 5: ID_Improved vs AB_Null Result: 14 to 6

Match 6: ID_Improved vs AB_Open Result: 12 to 8

Match 7: ID_Improved vs AB_Improved Result: 14 to 6

Results:

ID_Improved 70.00%

Evaluating: Student

Playing Matches:

Match 1: Student vs Random Result: 18 to 2

Match 2: Student vs MM_Null Result: 14 to 6

Match 3: Student vs MM_Open Result: 10 to 10

Match 4: Student vs MM_Improved Result: 13 to 7

Match 5: Student vs AB_Null Result: 14 to 6

Match 6: Student vs AB_Open Result: 14 to 6

Match 7: Student vs AB_Improved Result: 9 to 11

Results:

Student 65.71%

HEURISTIC 2

Evaluating: ID_Improved

Playing Matches:

Match 1: ID_Improved vs Random Result: 15 to 5

Match 2: ID_Improved vs MM_Null Result: 13 to 7

Match 3: ID_Improved vs MM_Open Result: 13 to 7

Match 4: ID_Improved vs MM_Improved Result: 13 to 7

Match 5: ID_Improved vs AB_Null Result: 16 to 4

Match 6: ID_Improved vs AB_Open Result: 16 to 4

Match 7: ID_Improved vs AB_Improved Result: 15 to 5

Results:

ID_Improved 72.14%

Evaluating: Student

Playing Matches:

tournament.py:100: UserWarning: One or more agents lost a match this round due to timeout. The get_move() function must return before time_left() reaches 0 ms. You will need to leave some time for the function to return, and may need to increase this margin to avoid timeouts during tournament play.

warnings.warn(TIMEOUT_WARNING)

Match 1: Student vs Random Result: 18 to 2

Match 2: Student vs MM_Null Result: 12 to 8

Match 3: Student vs MM_Open Result: 9 to 11

Match 4: Student vs MM_Improved Result: 9 to 11

Match 5: Student vs AB_Null Result: 13 to 7

Match 6: Student vs AB_Open Result: 8 to 12

Match 7: Student vs AB_Improved Result: 3 to 17

Results:

Student 51.43%

HEURISTIC 3

Evaluating: ID_Improved

Playing Matches:

Match 1: ID_Improved vs Random Result: 16 to 4
Match 2: ID_Improved vs MM_Null Result: 15 to 5
Match 3: ID_Improved vs MM_Open Result: 13 to 7
Match 4: ID_Improved vs MM_Improved Result: 15 to 5
Match 5: ID_Improved vs AB_Null Result: 11 to 9
Match 6: ID_Improved vs AB_Open Result: 14 to 6
Match 7: ID_Improved vs AB_Improved Result: 10 to 10

Results:

ID_Improved 67.14%

Evaluating: Student

Playing Matches:

Match 1: Student vs Random Result: 16 to 4
Match 2: Student vs MM_Null Result: 11 to 9
Match 3: Student vs MM_Open Result: 8 to 12
Match 4: Student vs MM_Improved Result: 13 to 7
Match 5: Student vs AB_Null Result: 12 to 8
Match 6: Student vs AB_Open Result: 9 to 11
Match 7: Student vs AB_Improved Result: 9 to 11

Results:

Student 55.71%

HEURISTIC 4

Evaluating: ID_Improved

Playing Matches:

Match 1: ID_Improved vs Random Result: 18 to 2

Match 2: ID_Improved vs MM_Null Result: 17 to 3

Match 3: ID_Improved vs MM_Open Result: 15 to 5

Match 4: ID_Improved vs MM_Improved Result: 14 to 6

Match 5: ID_Improved vs AB_Null Result: 16 to 4

Match 6: ID_Improved vs AB_Open Result: 11 to 9

Match 7: ID_Improved vs AB_Improved Result: 13 to 7

Results:

ID_Improved 74.29%

Evaluating: Student

Playing Matches:

Match 1: Student vs Random Result: 20 to 0
Match 2: Student vs MM_Null Result: 19 to 1
Match 3: Student vs MM_Open Result: 16 to 4
Match 4: Student vs MM_Improved Result: 12 to 8
Match 5: Student vs AB_Null Result: 15 to 5
Match 6: Student vs AB_Open Result: 16 to 4
Match 7: Student vs AB_Improved Result: 12 to 8

Results:

Student 78.57%

HEURISTIC 5

Evaluating: ID_Improved

Playing Matches:

Match 1: ID_Improved vs Random Result: 17 to 3
Match 2: ID_Improved vs MM_Null Result: 16 to 4
Match 3: ID_Improved vs MM_Open Result: 12 to 8
Match 4: ID_Improved vs MM_Improved Result: 14 to 6
Match 5: ID_Improved vs AB_Null Result: 14 to 6
Match 6: ID_Improved vs AB_Open Result: 11 to 9
Match 7: ID_Improved vs AB_Improved Result: 13 to 7

Results:

ID_Improved 69.29%

Evaluating: Student

Playing Matches:

Match 1: Student vs Random Result: 18 to 2

Match 2: Student vs MM_Null Result: 16 to 4

Match 3: Student vs MM_Open Result: 10 to 10

Match 4: Student vs MM_Improved Result: 10 to 10

Match 5: Student vs AB_Null Result: 12 to 8

Match 6: Student vs AB_Open Result: 11 to 9

Match 7: Student vs AB_Improved Result: 9 to 11

Results:

Student 61.43%