



ISOLATION GAME

HEURISTIC REPORT

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INTRODUCTION

The objective of the project is to design and implement an AI agent which is capable of playing a turn based strategy game called Isolation against other AI agents (as well against humans) and consistently beat them within the given time limit. We developed many heuristic functions to be used with the following search techniques in the program.

- MINIMAX
- ALPHA-BETA PRUNING
- ITERATIVE / PROGRESSIVE DEEPENING

HEURISTIC ALGORITHMS

In order to use these search techniques effectively, we ideated and experimented with numerous evaluation functions to measure the goodness of the board at the desired depth for our player and managed to implement four of them in this program.

(i) custom_seek_sum_movements

The improved score (from lecture) returns the difference in legal moves left for each player at the desired depth. Our evaluation takes one more step, it returns the difference in sum of all available branching options pursuable from every legal move left at the desired depth for both players.

Ex: If our player has three legal moves left at the leaf node – LM₁, LM₂, LM₃ and taking each of them has 2, 3, 1 branching options, the function returns $2 + 3 + 1 = 6$

There is a higher possibility of the result being skewed based on few entries, but that entry may never be pursued in next turn. It is observed the performance is of acceptable level and consistently reached the desired depth without timeout resignations. Because of simplicity, it can achieve deeper levels if required. It also scored the highest of all other heuristics *[79.29% wins of 140 games]*.

```
*****
Evaluating: ID_Improved
*****
```

Playing Matches:

```
-----
Match 1: ID_Improved vs Random      Result: 18 to 2
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: 14 to 6
Match 5: ID_Improved vs AB_Null     Result: 17 to 3
Match 6: ID_Improved vs AB_Open     Result: 15 to 5
Match 7: ID_Improved vs AB_Improved Result: 13 to 7
```

Results:

```
-----
ID_Improved      75.00%
```

```
*****
Evaluating: Student
*****
```

Playing Matches:

```
-----
Match 1: Student vs Random      Result: 16 to 4
Match 2: Student vs MM_Null     Result: 16 to 4
Match 3: Student vs MM_Open     Result: 13 to 7
Match 4: Student vs MM_Improved Result: 17 to 3
Match 5: Student vs AB_Null     Result: 15 to 5
Match 6: Student vs AB_Open     Result: 17 to 3
Match 7: Student vs AB_Improved Result: 17 to 3
```

Results:

```
-----
Student          79.29%
PS C:\Users\AARONW10\Desktop\STUDY\UDACITY\AIND\AIND-Isolation>
```

(ii) custom_seek_average_movements

This one is built on top of earlier one, with instead of returning the difference of sum of all pursuable movements, it returns the sum of average movements pursuable from each legal move left.

Ex: Using the earlier case, the function returns $(2 + 3 + 1) / 3 = 2$

It is observed the performance is of acceptable level and consistently reached the desired depth without timeout resignations. However we realized, instead of average, logarithm might be of better choice (for future iteration).

```
*****
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: 14 to 6
Match 4: ID_Improved vs MM_Improved Result: 12 to 8
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: 13 to 7

Results:
-----
ID_Improved      70.00%

*****
Evaluating: Student
*****

Playing Matches:
-----
Match 1: Student vs Random      Result: 15 to 5
Match 2: Student vs MM_Null     Result: 13 to 7
Match 3: Student vs MM_Open     Result: 12 to 8
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: 11 to 9
Match 7: Student vs AB_Improved Result: 13 to 7

Results:
-----
Student          65.00%
PS C:\Users\AARONW10\Desktop\STUDY\UDACITY\AIND\AIND-Isolation>
```

(iii) custom_seek_center_position

This one is seeking positional advantage of the board for our player. We implemented a basic version, thereby determining who is closest to the center of the board under the belief, that player may have more degree of freedom to expand across the board and able to partition the board to restrict the opponent to edges.

It is observed the performance is of acceptable level and consistently reached the desired depth without timeout resignations. This can be more effective in a constrained 7x7 board with KNIGHT movement, rather than bigger board with QUEEN movement. Unlike most games, center position is occupied only once, so we need to take partitions taken into account [future iteration].

```
*****
Evaluating: ID_Improved
*****

Playing Matches:
-----
Match 1: ID_Improved vs Random      Result: 16 to 4
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: 15 to 5
Match 5: ID_Improved vs AB_Null     Result: 16 to 4
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      72.14%

*****
Evaluating: Student
*****

Playing Matches:
-----
Match 1: Student vs Random      Result: 13 to 7
Match 2: Student vs MM_Null     Result: 15 to 5
Match 3: Student vs MM_Open     Result: 9 to 11
Match 4: Student vs MM_Improved Result: 11 to 9
Match 5: Student vs AB_Null     Result: 18 to 2
Match 6: Student vs AB_Open     Result: 12 to 8
Match 7: Student vs AB_Improved Result: 11 to 9

Results:
-----
Student          63.57%
PS C:\Users\AARONW10\Desktop\STUDY\UDACITY\AIND\AIND-Isolation>
```

(iv) custom_seek_movements_positions

This combines (i) and (iii) in an attempt to move towards better positions which hopefully has more freedom of movement. Like (iii), this also needs refinement by considering partitions on board.

It is observed the performance is of acceptable level and consistently reached the desired depth without timeout resignations.

```
Evaluating: ID_Improved
*****

Playing Matches:
-----
Match 1: ID_Improved vs Random      Result: 16 to 4
Match 2: ID_Improved vs MM_Null     Result: 14 to 6
Match 3: ID_Improved vs MM_Open     Result: 10 to 10
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: 14 to 6

Results:
-----
ID_Improved      67.86%

*****

Evaluating: Student
*****

Playing Matches:
-----
Match 1: Student vs Random      Result: 17 to 3
Match 2: Student vs MM_Null     Result: 15 to 5
Match 3: Student vs MM_Open     Result: 11 to 9
Match 4: Student vs MM_Improved Result: 12 to 8
Match 5: Student vs AB_Null     Result: 17 to 3
Match 6: Student vs AB_Open     Result: 13 to 7
Match 7: Student vs AB_Improved Result: 13 to 7

Results:
-----
Student          70.00%
PS C:\Users\AARONW10\Desktop\STUDY\UDACITY\AIND\AIND-Isolation>
```

CONCLUSION

We explored other heuristics like endgame and transposition tables and tried advanced positional algorithm with partition identifier but couldn't implement them for this project. Based on (i) pure win% (ii) simplicity (iii) performance we recommend using [custom_seek_sum_movements](#) in our agents but we wish to develop [custom_seek_movements_positions](#) with partition identifier for future iterations.

Evaluation Function	ID_Improved Score	Student Score
custom_seek_sum_movements	75.00%	79.29%
custom_seek_average_movements	70.00%	65.00%
custom_seek_center_position	72.14%	63.57%
custom_seek_movements_positions	67.86%	70.00%