Isolation

AIND-Project 2
Heuristic Evaluation

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Introduction:

This project is an introduction to several important concepts in artificial intelligence and machine learning. Several well known functions and models (alpha-beta, minimax, etc.) are implemented to show the results of decision tree searching evaluated with different criteria and parameters.
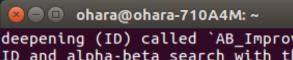
For this project, three different custom heuristics were implemented:

1) Movements based on center position [center]

2) Movements based on empty squares [empty]

3) Movements based on common sets [common]

Please note that more than three iterations were taken for testing, but these images best represent the data. Occasionally, heuristics would win all of the rounds in a testing phase and then lose all of the rounds in a subsequent test without altering any code. The averages in the tables represent average values when the sum of the results is normalized to the number of test completed.

Visual Representation:

Below are three different tables that were acquired by the terminal text-GUI. These images show three Tournament runs comparing the three custom heuristics to the improved AB function.


```
ohara@ohara-710A4M: ~

deepening (ID) called `AB_Improved`. The three `AB_Custom` agents use
ID and alpha-beta search with the custom_score functions defined in
game_agent.py.


                        *************************
                              Playing Matches
                        *************************


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         7  |   3        9  |   1
   2       MM_Open        5  |   5        6  |   4         6  |   4        8  |   2
   3      MM_Center       6  |   4        6  |   4         8  |   2       10  |   0
   4     MM_Improved      5  |   5        7  |   3         6  |   4        6  |   4
   5       AB_Open        5  |   5        5  |   5         5  |   5        6  |   4
   6      AB_Center       7  |   3       10  |   0         5  |   5        7  |   3
   7     AB_Improved      5  |   5        6  |   4         5  |   5        4  |   6
---------------------------------------------------------------------------------
            Win Rate:       60.0%           70.0%           60.0%           71.4%

Your ID search forfeited 167.0 games while there were still legal moves availabl
e to play.


(aind) ohara@ohara-710A4M:~$
        136      #This heuristic is designed evaluate movements based on empty spaces
```
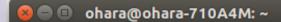
3

Test 2:

Test 3:

```
ohara@ohara-710A4M: ~/Documents/Nanodegree/AIND/AIND-Isolation-master

deepening (ID) called `AB_Improved`. The three `AB_Custom` agents use
ID and alpha-beta search with the custom_score functions defined in
game_agent.py.

                    *************************
                          Playing Matches
                    *************************

Match #    Opponent    AB_Improved      AB_Custom     AB_Custom_2     AB_Custom_3
                        Won  |  Lost    Won  |  Lost   Won  |  Lost    Won  |  Lost
   1        Random       7   |   3       9   |   1      8   |   2      10   |   0
   2       MM_Open       6   |   4       7   |   3      7   |   3       8   |   2
   3      MM_Center      7   |   3      10   |   0      6   |   4       8   |   2
   4     MM_Improved     5   |   5       8   |   2      5   |   5       7   |   3
   5       AB_Open       6   |   4       6   |   4      4   |   6       6   |   4
   6      AB_Center      4   |   6       5   |   5      7   |   3       6   |   4
   7     AB_Improved     4   |   6       7   |   3      6   |   4       5   |   5
-----------------------------------------------------------------------------------
         Win Rate:      55.7%          74.3%          61.4%          71.4%

Your ID search forfeited 162.0 games while there were still legal moves availabl
e to play.

(aind) ohara@ohara-710A4M:~/Documents/Nanodegree/AIND/AIND-Isolation-master$
```

The results are that the [center] heuristic regularly has a higher performance than the other options, while the [common] heuristic is able to achieve a higher maximum W/L ratio. The [center] choice can usually dominate the Random, MM_improved and AB_Center tests, though it occasionally struggles against the AB_improved. The [common] heuristic can perform well against the MM_center test and has a robust performance elsewhere. The [empty] heuristic is usually on par with the AB_improved, but only performs slightly better. The results of the [empty] heuristic were unexpected, but it likely could be improved with some modifications.

Based on these results, the recommendation is to use the [center] heuristic, since it has a higher precision of results over multiple testing evaluations. While the [common] heuristic has a higher maximum W/L ratio, the difference between the resulting high value does not justify its usage.

1) Not all positions are equal. The center move provides optimal placement with the most freedom of choice for remaining moves.

2) Blocking can be achieved, since the board was partitioned and the next move can be the same as the opponent ("reflecting" in the lecture video).

3) If the move is the same as the opponent, an optimal move can be selected for the next move.

Final note: There were many forfeited moves based the code not being optimized. The heuristics would have a higher performance rating (W/L) if the search algorithms were optimized.