Heuristic Analysis

Author: Erik Taheri

ID Result

ID improved provided a baseline to compare my heuristics. I did not anticipate the baseline heuristic to be so effective.

```
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: 15 to 5
  Match 4: ID_Improved vs MM_Improved Result: 13 to 7
  Match 5: ID_Improved vs   AB_Null   Result: 15 to 5
  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         71.43%
```

Custom Heuristics

minimize_opponent_heuristic

This heuristic rewards the player for minimizing the amount of component moves.

- `opponent_moves`

By minimizing the opponent moves, the player should be aggressive and eliminate the opponents possible moves.

```
Playing Matches:
------
  Match 1:   Student   vs   Random    Result: 18 to 2
```

```
  Match 2:   Student   vs   MM_Null   Result: 15 to 5
  Match 3:   Student   vs   MM_Open   Result: 15 to 5
  Match 4:   Student   vs MM_Improved Result: 15 to 5
  Match 5:   Student   vs   AB_Null   Result: 16 to 4
  Match 6:   Student   vs   AB_Open   Result: 11 to 9
  Match 7:   Student   vs AB_Improved Result: 11 to 9


Results:
————————
Student             72.14%
```

Result

This heuristic performs marginally better than ID_Improved. At 72.14%, the benefit is negligible if any real improvement.

center_heuristic

This heuristic rewards the player for the number of available legal moves and penalizes for moves that stray away from the center of the 7x7 board.

```
moves_count - distance_from_center
```

```
Playing Matches:
————————
  Match 1:   Student   vs   Random    Result: 19 to 1
  Match 2:   Student   vs   MM_Null   Result: 15 to 5
  Match 3:   Student   vs   MM_Open   Result: 13 to 7
  Match 4:   Student   vs MM_Improved Result: 9 to 11
  Match 5:   Student   vs   AB_Null   Result: 15 to 5
  Match 6:   Student   vs   AB_Open   Result: 13 to 7
  Match 7:   Student   vs AB_Improved Result: 10 to 10

Results:
————————
Student             67.14%
```

Result

This heuristic performs poorly compared to ID_Improved. Playing near the center of the board seems to be a poor strategy.

outside_heuristic

This heuristic rewards the player for the number of available legal moves and rewards for moves furthest from the center of the 7x7 board.

```
moves_count - distance_from_center
```

```
Playing Matches:
----------
  Match 1:   Student   vs   Random    Result: 19 to 1
  Match 2:   Student   vs   MM_Null   Result: 18 to 2
  Match 3:   Student   vs   MM_Open   Result: 14 to 6
  Match 4:   Student   vs MM_Improved Result: 14 to 6
  Match 5:   Student   vs   AB_Null   Result: 18 to 2
  Match 6:   Student   vs   AB_Open   Result: 15 to 5
  Match 7:   Student   vs AB_Improved Result: 12 to 8


Results:
----------
Student             78.57%
```

Result

This heuristic performs exceptionally well compared to `ID_Improved` and `center_heuristic`. Playing away from the center of the board appears to be an advantageous strategy.

filled_spaces_heuristic

This heuristic builds on the simple heuristic of `moves_count - (x * opponent_moves_count)` by incorporating the number of filled spaces on the board.

```
(moves_count - (x * opponent_moves_count)) * filled_spaces
```

```
Playing Matches:
----------
  Match 1:   Student   vs   Random    Result: 18 to 2
  Match 2:   Student   vs   MM_Null   Result: 15 to 5
  Match 3:   Student   vs   MM_Open   Result: 14 to 6
  Match 4:   Student   vs MM_Improved Result: 15 to 5
  Match 5:   Student   vs   AB_Null   Result: 19 to 1
```

```
  Match 6:   Student   vs   AB_Open   Result: 15 to 5
  Match 7:   Student   vs AB_Improved Result: 11 to 9


Results:
----------
Student              76.43%
```

Result

This heuristic performs well compared to `ID_Improved` and `center_heuristic`. It did not perform as well as `outside_heuristic`. I evaluated the heuristic using `x=3`. `3` tended to return the best result.

Conclusion

Based on the results of the custom heuristics, `outside_heuristic` appears to be the most effective option. Awarding play on the perimeter of the board seems like an effective strategy. However, this option does have several disadvantages. It does not take into consideration other states of the game, such as the opponent or important board states. This makes the outside_heuristic prone to the horizon effect and may not be effective in all situations.

Further Exploration

Board partitions are an important concept in Isolation. Due to our variation of Isolation, a partition has unique characteristics. Once a partition is discovered, a simple heuristic of `moves_count` can be used. At this point in the game, the player with the most available moves will win. Adding an additional check for a partition in the above heuristics could offer a performance improvement. It could avoid cases where the player causes itself to lose inside of a partition where it has more spaces than the opponent.