Heuristic Functions

1. Function Introduction

1.1 Function 1(Original):

The first heuristic is a simple combination of the second and thrid heuristics. If the available moves matter more than comprehensive score, rf will be more than 0.5(<1); if not, rf will be less than 0.5. In this heuristic, rf is an adjustable factor. If this competition focus more on preventing opponent's move, then rf should be more than 0.5. If its importance is on averting to touch edges or overall estimation, then rf should be less than 0.5. It really depends on the current situation and what agent wants.

1.2 Function 1(Added by reviewer):

This function counts agent moves and opponent moves, and give them weights respectively. Agent moves will be counted positively, and opponent moves vice versa. The weights of opponent moves are designed as w, which is listed below:

$$w = \frac{10}{move\_count + 1}$$

Then return:

$$own\_moves - (w{\times}oppo\_moves)$$

As the designed score.

1.3 Function 2:

The second heuristic is a simple combination of agent moves and opponent moves. Basically, the number of opponent moves is more considerable than agent moves, cause when the weight of opp_score is less than agent's, greedy in improving agent's moves will lead to possible failure. On the contrary, if the weight of opp_score is much more than agent's, the system will not be so much effective as well.

In this heuristic, weight is an adjustable factor. If opponents' move really matters, then you should make this weight as huge as possible, which may lead to a coward agent. On the contrary, if this weight is less than 1, then the agent may ignore opponents'move at all.

1.4 Function 3 (Original):

The third heuristic is designed with multiple conditions for approaching edges and board filling ratio. Condition are listed in the function.

In this heuristic, all the boundary conditions are affiliated with filling rate. If this value approaches a specific number, then the agent should be more careful in case approaching edges or run out of space.

1.5 Function 4 (Added by reviewer):

The third function(reviewed) was added by the last reviewer, and I replaced the original third function with this one. This heuristic was focused on available area and potential choices, which was similar to the original one as well. The choices(area and potential) the player had would add score towards move selection, and decrease it for opponent choices.

2. Heuristic Comparison

2.1 Custom Score 1

The result of this heuristic is shown below:

```
            ************************
                 Playing Matches
            ************************

Match #    Opponent    AB_Improved    AB_Custom    AB_Custom_2    AB_Custom_3
                       Won | Lost    Won | Lost    Won | Lost    Won | Lost
   1        Random      10 |  0       8  |  2       8  |  2       9  |  1
   2        MM_Open      8 |  2       6  |  4       7  |  3       7  |  3
   3        MM_Center    9 |  1       8  |  2       8  |  2       8  |  2
   4        MM_Improved  7 |  3       7  |  3       6  |  4       7  |  3
   5        AB_Open      5 |  5       7  |  3       4  |  6       5  |  5
   6        AB_Center    6 |  4       6  |  4       6  |  4       7  |  3
   7        AB_Improved  3 |  7       5  |  5       5  |  5       3  |  7
---------------------------------------------------------------------------
            Win Rate:     68.6%         67.1%         62.9%         65.7%
```

There were 4.0 timeouts during the tournament -- make sure your agent handles search timeout correctly, and consider increasing the timeout margin for your agent.

Your agents forfeited 241.0 games while there were still legal moves available to play.

2.2 Custom Score 2

The result of this heuristic is shown below:

```
                    ************************
                        Playing Matches
                    ************************

Match #    Opponent    AB_Improved     AB_Custom     AB_Custom_2    AB_Custom_3
                       Won | Lost     Won | Lost     Won | Lost     Won | Lost
   1        Random      8  |  2        8  |  2        8  |  2       10  |  0
   2        MM_Open     6  |  4        6  |  4        6  |  4        9  |  1
   3        MM_Center   8  |  2        7  |  3        9  |  1        5  |  5
   4        MM_Improved 4  |  6        8  |  2        4  |  6        6  |  4
   5        AB_Open     6  |  4        6  |  4        6  |  4        6  |  4
   6        AB_Center   6  |  4        6  |  4        5  |  5        6  |  4
   7        AB_Improved 4  |  6        6  |  4        5  |  5        7  |  3
---------------------------------------------------------------------------
          Win Rate:       60.0%         67.1%         61.4%          70.0%
```

There were 6.0 timeouts during the tournament -- make sure your agent handles search timeout correctly, and consider increasing the timeout margin for your agent.

Your agents forfeited 240.0 games while there were still legal moves available to play.

2.3 Custom Score 3

The result of this heuristic is shown below:

```
                    ************************
                        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        6  |  4        6  |  4        8  |  2
   2        MM_Open     7  |  3        6  |  4        7  |  3        7  |  3
   3        MM_Center   9  |  1        9  |  1        5  |  5        6  |  4
   4        MM_Improved 8  |  2        8  |  2        5  |  5        6  |  4
   5        AB_Open     5  |  5        5  |  5        6  |  4        3  |  7
   6        AB_Center   5  |  5        7  |  3        5  |  5        6  |  4
   7        AB_Improved 6  |  4        5  |  5        4  |  6        4  |  6
---------------------------------------------------------------------------
          Win Rate:       67.1%         65.7%         54.3%          57.1%
```

There were 1.0 timeouts during the tournament -- make sure your agent handles search timeout correctly, and consider increasing the timeout margin for your agent.

Your agents forfeited 252.0 games while there were still legal moves available to play.

3. Analysis and Conclusion

The comparison among three heuristics is shown below:

Heuristic	Average Win Rate(%)	Timeout Times	Forfeited Games
Custom Score	66.075	4	241
Custom Score 2	64.625	6	240
Custom Score 3	61.05	1	252

I choose the first heuristic (Custom Score), and the reasons are listed below:

● The highest average win rate among all the three heuristics, which matters

- Relatively easy to implement comparing with the other two (especially comparing with the third one), cause it only involved with own moves and opp moves, and a little bit design of w

- Average timeout time and forfeited game number are acceptable

- The overall trade-off should consider the reasons listed above, and all in all, the first heuristic is the best