Heuristic analysis

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Heuristic 1:
Calculates the square difference between player's move and opponent's move.

```
if game.is_loser(player):
    return float("-inf")
if game.is_winner(player):
    return float("inf")
own_moves = len(game.get_legal_moves(player))
next_player = game.get_opponent(player)
opp_move = len(game.get_legal_moves(next_player))
return float(own_moves**2 - opp_move**2)
```

own_moves is the number of steps player can move, opp_move is the number of steps opponent player can move.
Result:
It has 61.8%(173/280) of win rate overall, but it is lower when meet AB_improved opponent with only 30% win rate.

Heuristic 2:
Calculates the average square sum of player's move and opponent's move.

```
if game.is_loser(player):
    return float("-inf")
if game.is_winner(player):
    return float("inf")
own_moves = len(game.get_legal_moves(player))
next_player = game.get_opponent(player)
opp_move = len(game.get_legal_moves(next_player))
return float((own_moves**2 + opp_move**2) / 2)
```

own_moves is the number of steps player can move, opp_move is the number of steps opponent player can move.
Result:
It has 60.0%(168/280) of win rate overall, it wins more than Heuristic 1 when meet AB_improved.

Heuristic 3:

Outputs a score equal to square of the distance from the center of the board to the position of the player and opponent. It state the average between own location and opponent location.

```
if game.is_loser(player):
    return float("-inf")
if game.is_winner(player):
    return float("inf")
w, h = game.width / 2., game.height / 2.
y, x = game.get_player_location(player)
y1, x1 = game.get_player_location(game.get_opponent(player))
return float((((h - y)**2 + (w - x)**2)+((h - y1)**2 + (w - x1)**2))/2)
```

Result:
It has 58.9%(165/280) win rate overall, it wins more than Heuristic 1 when meet AB_improved opponent.

I have ran 4 times of the board:

```
                    **************************
                        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      7   |   3      8   |   2
    2       MM_Open       6   |   4      8   |   2      7   |   3      6   |   4
    3      MM_Center      9   |   1      6   |   4      7   |   3      7   |   3
    4     MM_Improved     8   |   2      7   |   3      5   |   5      6   |   4
    5       AB_Open       7   |   3      8   |   2      7   |   3      4   |   6
    6      AB_Center      8   |   2      5   |   5      4   |   6      4   |   6
    7     AB_Improved     5   |   5      3   |   7      4   |   6      4   |   6
------------------------------------------------------------------------------
           Win Rate:      71.4%        61.4%        58.6%        55.7%

 Match #    Opponent    AB_Improved    AB_Custom    AB_Custom_2    AB_Custom_3
                         Won  | Lost    Won  | Lost    Won  | Lost    Won  | Lost
    1       Random        9   |   1     10   |   0      8   |   2      8   |   2
    2       MM_Open       5   |   5      8   |   2      6   |   4      5   |   5
    3      MM_Center      8   |   2      8   |   2      7   |   3      9   |   1
    4     MM_Improved     7   |   3      7   |   3      5   |   5      5   |   5
    5       AB_Open       5   |   5      5   |   5      5   |   5      4   |   6
    6      AB_Center      4   |   6      3   |   7      4   |   6      4   |   6
    7     AB_Improved     5   |   5      3   |   7      7   |   3      5   |   5
------------------------------------------------------------------------------
           Win Rate:      61.4%        62.9%        60.0%        57.1%
```

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	7	3	10	0
2	MM_Open	6	4	5	5	7	3	6	4
3	MM_Center	4	6	7	3	8	2	7	3
4	MM_Improved	6	4	5	5	5	5	5	5
5	AB_Open	6	4	4	6	4	6	3	7
6	AB_Center	6	4	7	3	5	5	8	2
7	AB_Improved	3	7	5	5	6	4	5	5
	Win Rate:	58.6%		58.6%		60.0%		62.9%	

Match #	Opponent	AB_Improved		AB_Custom		AB_Custom_2		AB_Custom_3	
		Won	Lost	Won	Lost	Won	Lost	Won	Lost
1	Random	7	3	10	0	9	1	8	2
2	MM_Open	4	6	6	4	6	4	6	4
3	MM_Center	8	2	8	2	7	3	8	2
4	MM_Improved	8	2	7	3	8	2	5	5
5	AB_Open	5	5	5	5	3	7	5	5
6	AB_Center	5	5	3	7	6	4	4	6
7	AB_Improved	4	6	6	4	4	6	6	4
	Win Rate:	58.6%		64.3%		61.4%		60.0%	

As we can see from above, Heuristic 1 gives the best win rate over all, but it is still lower than AB_improved in some test. In general, it is more stable.
First, it gives higher win rate and sometimes performs better than AB_improved and more stable win rate;
Second, it is easier to implement compared to third heuristic;
Third, the square difference between player's move and opponent's move can predict further game result. If it is positive, player will have a good chance to win the game.