# Heuristic Analysis

## Heuristic 1

This heuristics uses:

```
own_moves - opp_moves + own_distance_from_centre - opp_distance_from_centre
```

It's a combination of the improved heuristics and players' distance from centre. The idea is that the player that are closer to the corners (away from centre) has higher chances of getting stuck. This heuristic is more computationally expensive than others because of `abs()`, and also it involves more complex calculation.

## Heuristic 2

This heuristics uses:

```
own_moves - opp_moves - distance_between_players
```

It's a combination of the improved heuristics and players' distance between player. The idea is that keeping the opponent close has higher chances of getting them stuck. By this reasoning though, the same applies to the agent too.

## Heuristic 3

This heuristics uses:

```
own_moves - opp_moves ** 2
```

It's the improved heuristics, but squares the opponent open moves so that we penalise the move quadratically when the opponent has more move. The idea is that the agent should prioritize minimizing opponent moves whenever possible, and then only tries to maximize own moves.

# Performance vs Other Agents

| | AB_Improved | | AB_Custom | | AB_Custom_2 | | AB_Custom_3 | |
|---|---|---|---|---|---|---|---|---|
| **Opponent** | Won | Lost | Won | Lost | Won | Lost | Won | Lost |
| Random | 997 | 3 | 980 | 20 | 982 | 18 | 986 | 14 |
| MM_Open | 858 | 142 | 840 | 160 | 872 | 128 | 857 | 143 |
| MM_Center | 965 | 35 | 963 | 37 | 945 | 55 | 959 | 41 |
| MM_Improved | 851 | 149 | 801 | 199 | 824 | 176 | 847 | 153 |
| AB_Open | 519 | 481 | 452 | 548 | 518 | 482 | 507 | 493 |
| AB_Center | 600 | 400 | 514 | 486 | 538 | 462 | 569 | 431 |
| AB_Improved | 489 | 511 | 434 | 566 | 504 | 496 | 516 | 484 |
| Win Rate: | **75.40%** | | **71.20%** | | **74.00%** | | **74.90%** | |

Refer to the table above. The alpha-beta iterative deepening agent consistently win against random agent and Minimax agent. However, the results are more interesting when the AB agents are pitted against each other. After 1000 runs, the win rate for all heuristics are around 50%, viz. neither agents with different heuristics outperforms the AB_Improved agent consistently. This is rather expected because the Improved heuristics, simple as it may be, it actually takes into accounts the crucial factors in the game.

# The Best Evaluation Function

The best heuristic would be the **improved heuristic**. Three reasons why it is the best heuristic is given as follows:

1. ## It is simple

   In a game where both agents are functionally equal, the main deciding factor for higher win rate would be the heuristic. The faster the heuristic is, the more nodes it can expand and evaluate. Therefore, the agent that can search deeper would have higher chances of winning. In this case, the improved heuristic is simple:

   ```
   own_moves - opp_moves
   ```

   Only one subtraction operation is used, which makes the heuristic more performant that other heuristic that uses more complex operations. From the table, AB_Custom 1 loses to the improved heuristic by a ratio of roughly 43:57. This is because AB_Custom has rather complex calculations compared to the improved heuristic.

## 2. It includes key parameters

One of the very influential aspect is the selection of heuristic parameters. In the improved heuristic, the open moves for self and opponent is chosen as the parameters. These are excellent parameters because it is the primary objective of isolation game: to completely remove the moves for the opponent, while keeping ours open. This can be observed in AB_Custom1 and 2, even though extra parameters are added, the agent did not perform any better. Two possible reason for this: first, they these parameters do not influence the game; second, these parameters are redundant, meaning that their effects are already included in the other parameters. For example, using distance from centre to determine the possibility of players getting stuck, is the subset of open moves.

## 3. It performs well

As demonstrated in the table, the improved heuristic performed consistently well against other agents with different heuristics. Although the win rate is marginal 50%, no other agent in the tournament can consistently outperform it either.