LIM JIA QI (17134267/1)

Heuristic Analysis:

For an Adversarial Game Playing Agent for Isolation

Heuristic Analysis

In this task, different heuristics using minimax and alpha-beta pruning with iterative deepening against opponents that use different algorithms in the "Isolation" game are applied, excluding the evaluation functions provided in the base code (https://github.com/sumitbinnani/AIND-Isolation) , another 5 evaluation functions are implemented and compared. The evaluation functions are:

A. Heuristic 1: Difference between average scores for future moves of player and opponent

This heuristics technique required pre-computation of the value of each space to evaluate each move in the game. In the Isolation board game, there are 8 possible movements, this heuristic will check if the movement is valid and calculate the values for the spaces according to their positions and possibilities to get to the space from the center with a discount of 0.9. The space at the center point of the board has the maximum value of 10, if the space is nearer to the center and has higher possibility to access, then higher score will be given and vice versa. The values of the board calculated is as below:

```
[[8.1, 7.29, 8.1, 7.29, 8.1, 7.29, 8.1],
 [7.29, 6.561, 9.0, 8.1, 9.0, 6.561, 7.29],
 [8.1, 9.0, 8.1, 7.29, 8.1, 9.0, 8.1],
 [7.29, 8.1, 7.29, 10, 7.29, 8.1, 7.29],
 [8.1, 9.0, 8.1, 7.29, 8.1, 9.0, 8.1],
 [7.29, 6.561, 9.0, 8.1, 9.0, 6.561, 7.29],
 [8.1, 7.29, 8.1, 7.29, 8.1, 7.29, 8.1]]
```

With the precomputed values of spaces, the difference between average scores of the players and opponents can be calculated as below:

```
my_score = len(my available move) + value of my last move +
mean(value of my available move)

opponent_score = len(available opponent move) + value of
opponent last move + mean(value of opponent available move)

difference between average scores = my_score - opponent_score
```

B. Heuristic 2: Point of view strategy

For this heuristic, the value is calculated from the point of view of the given player. It was composed of two types of rules, the progression of the game which is the percentage of the game board filled and whether the player or opponent crash with the boundary. It can be expressed as:

The percentage of unoccupied spaces:

```
(len(current blank spaces)/(board width * board height)) * 100
```

Rules:

```
When the player agent is far from the boundary and percentage is
low, get a higher score(my score), vice versa. Same rules applied
to the opponent agent(opponent score).
```

Heuristic:

```
(my score - opponent score*1.5)
```

C. Heuristic 3: Move differences with weight factor

This heuristics technique is calculating the difference between the moves of the player and opponent, different weight factors are applied to both players and opponents to optimize the performance of the player. Weight factor for the player is set to a constant of 1, for opponent is based on the number of open spaces remaining in the game. This heuristics technique can be expressed as:

```
player weight factor * len(my available moves) + ((total number of spaces) / (number of space occupied) – opponent factor) * len(available opponent moves)
```

This evaluation function is depending on the number of occupied spaces in the game, so the player will perform differently from time to time according to the number of blank spaces in the game.

D. Heuristic 4: Minimizing opponents moves and maximizing our moves

This heuristic is based on the notion that at any time, the number of moves by the opponent are minimized and try to maximize our moves. The mathematical expression for this can be represented as:

```
len(my_moves) * len(my_moves)– α * len(opponent_moves) * len(opponent_moves)
```

E. Heuristic 5: Offensive to defensive strategy

For this heuristic, during the first half of the game where the occupied space of the board is less than half, the player plays aggressively by attempting to minimize and limit the opponent's available moves at weighted cost against the player's available moves. When the occupied space of the board is more than half, the player switches to defensive strategy by maximizing available moves of the player at a weight cost against the opponent's moves. The weight factor used in this algorithm is 2.

For offensive strategy, it can be mathematically expressed as:

```
len(my available moves) – (len(available opponent moves) *
weight factor)
```

For defensive strategy, it can be mathematically expressed as:

```
(len(my available moves)* weight factor) – len(available
opponent moves)
```

The offensive to defensive strategy is the combination of both strategies with conditions:

```
if ((number of space occupied) / (total number of spaces)) <=
0.5: use offensive strategy

else: use defensive strategy
```

Results and Evaluation

The table below shows the performance and ranking of agents using different heuristics:

This result obtained by running 20 matches with 150ms as time limit. Deepening iterative is implemented by setting True for iterative in `CUSTOM_ARGS`

```
CUSTOM_ARGS = {"method": 'alphabeta', 'iterative': True}
```

Agent	Performance (%)	Rank
ID_Improved	60.00	13
Student1	62.68	12
Student2	66.25	7
Student3	63.21	11
Student4	66.61	5
Student5	65.54	8
Student6	67.14	4
Student7	64.46	9
Heuristic 1 (LIM JIA QI 17134267)	74.29	1
Heuristic 2 (WONG HAO SHAN 17122789)	68.04	2
Heuristic 3 (CHEAH JO YEN 17059391)	67.32	3
Heuristic 4 (CHONG SIN MEI 17103500)	66.43	6
Heuristic 5 (Offensive to Defensive)	63.39	10

The raw evaluation result can be found in next page.

Appendix

```
************************
 Evaluating: ID_Improved
************************

Playing Matches:
----------
  Match 1: ID_Improved vs   Random    Result: 69 to 11
  Match 2: ID_Improved vs   MM_Null   Result: 52 to 28
  Match 3: ID_Improved vs   MM_Open   Result: 34 to 46
  Match 4: ID_Improved vs MM_Improved Result: 40 to 40
  Match 5: ID_Improved vs   AB_Null   Result: 53 to 27
  Match 6: ID_Improved vs   AB_Open   Result: 48 to 32
  Match 7: ID_Improved vs AB_Improved Result: 40 to 40


Results:
----------
ID_Improved         60.00%

************************
  Evaluating: Student1
************************

Playing Matches:
----------
  Match 1:  Student1   vs   Random    Result: 67 to 13
  Match 2:  Student1   vs   MM_Null   Result: 55 to 25
  Match 3:  Student1   vs   MM_Open   Result: 43 to 37
  Match 4:  Student1   vs MM_Improved Result: 37 to 43
  Match 5:  Student1   vs   AB_Null   Result: 51 to 29
  Match 6:  Student1   vs   AB_Open   Result: 53 to 27
  Match 7:  Student1   vs AB_Improved Result: 45 to 35


Results:
----------
Student1            62.68%

************************
  Evaluating: Student2
************************

Playing Matches:
----------
  Match 1:  Student2   vs   Random    Result: 67 to 13
  Match 2:  Student2   vs   MM_Null   Result: 61 to 19
  Match 3:  Student2   vs   MM_Open   Result: 47 to 33
```

```
  Match 4:  Student2   vs MM_Improved Result: 43 to 37
  Match 5:  Student2   vs   AB_Null   Result: 57 to 23
  Match 6:  Student2   vs   AB_Open   Result: 47 to 33
  Match 7:  Student2   vs AB_Improved Result: 49 to 31


Results:
----------
Student2            66.25%

*************************
  Evaluating: Student3
*************************

Playing Matches:
----------
  Match 1:  Student3   vs   Random    Result: 63 to 17
  Match 2:  Student3   vs   MM_Null   Result: 54 to 26
  Match 3:  Student3   vs   MM_Open   Result: 45 to 35
  Match 4:  Student3   vs MM_Improved Result: 38 to 42
  Match 5:  Student3   vs   AB_Null   Result: 54 to 26
  Match 6:  Student3   vs   AB_Open   Result: 46 to 34
  Match 7:  Student3   vs AB_Improved Result: 54 to 26


Results:
----------
Student3            63.21%

*************************
  Evaluating: Student4
*************************

Playing Matches:
----------
  Match 1:  Student4   vs   Random    Result: 72 to 8
  Match 2:  Student4   vs   MM_Null   Result: 55 to 25
  Match 3:  Student4   vs   MM_Open   Result: 48 to 32
  Match 4:  Student4   vs MM_Improved Result: 42 to 38
  Match 5:  Student4   vs   AB_Null   Result: 57 to 23
  Match 6:  Student4   vs   AB_Open   Result: 46 to 34
  Match 7:  Student4   vs AB_Improved Result: 53 to 27


Results:
----------
Student4            66.61%

*************************
  Evaluating: Student5
*************************
```

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Playing Matches:
----------
  Match 1:  Student5   vs   Random    Result: 72 to 8
  Match 2:  Student5   vs   MM_Null   Result: 56 to 24
  Match 3:  Student5   vs   MM_Open   Result: 47 to 33
  Match 4:  Student5   vs MM_Improved Result: 43 to 37
  Match 5:  Student5   vs   AB_Null   Result: 58 to 22
  Match 6:  Student5   vs   AB_Open   Result: 46 to 34
  Match 7:  Student5   vs AB_Improved Result: 45 to 35


Results:
----------
Student5            65.54%

*************************
  Evaluating: Student6
*************************

Playing Matches:
----------
  Match 1:  Student6   vs   Random    Result: 69 to 11
  Match 2:  Student6   vs   MM_Null   Result: 60 to 20
  Match 3:  Student6   vs   MM_Open   Result: 52 to 28
  Match 4:  Student6   vs MM_Improved Result: 42 to 38
  Match 5:  Student6   vs   AB_Null   Result: 56 to 24
  Match 6:  Student6   vs   AB_Open   Result: 48 to 32
  Match 7:  Student6   vs AB_Improved Result: 49 to 31


Results:
----------
Student6            67.14%

*************************
  Evaluating: Student7
*************************

Playing Matches:
----------
  Match 1:  Student7   vs   Random    Result: 72 to 8
  Match 2:  Student7   vs   MM_Null   Result: 54 to 26
  Match 3:  Student7   vs   MM_Open   Result: 42 to 38
  Match 4:  Student7   vs MM_Improved Result: 44 to 36
  Match 5:  Student7   vs   AB_Null   Result: 48 to 32
  Match 6:  Student7   vs   AB_Open   Result: 49 to 31
  Match 7:  Student7   vs AB_Improved Result: 52 to 28


Results:
----------
Student7            64.46%
```

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```
************************
Evaluating: LIM JIA QI - 17134267
************************

Playing Matches:
----------
  Match 1: LIM JIA QI - 17134267 vs   Random     Result: 73 to 7
  Match 2: LIM JIA QI - 17134267 vs   MM_Null    Result: 68 to 12
  Match 3: LIM JIA QI - 17134267 vs   MM_Open    Result: 59 to 21
  Match 4: LIM JIA QI - 17134267 vs MM_Improved  Result: 48 to 32
  Match 5: LIM JIA QI - 17134267 vs   AB_Null    Result: 61 to 19
  Match 6: LIM JIA QI - 17134267 vs   AB_Open    Result: 57 to 23
  Match 7: LIM JIA QI - 17134267 vs AB_Improved  Result: 50 to 30


Results:
----------
LIM JIA QI - 17134267     74.29%

************************
Evaluating: WONG HAO SHAN - 17122789
************************

Playing Matches:
----------
  Match 1: WONG HAO SHAN - 17122789 vs   Random        Result: 70 to 10
  Match 2: WONG HAO SHAN - 17122789 vs   MM_Null       Result: 57 to 23
  Match 3: WONG HAO SHAN - 17122789 vs   MM_Open       Result: 45 to 35
  Match 4: WONG HAO SHAN - 17122789 vs MM_Improved     Result: 44 to 36
  Match 5: WONG HAO SHAN - 17122789 vs   AB_Null       Result: 57 to 23
  Match 6: WONG HAO SHAN - 17122789 vs   AB_Open       Result: 55 to 25
  Match 7: WONG HAO SHAN - 17122789 vs AB_Improved     Result: 53 to 27


Results:
----------
WONG HAO SHAN - 17122789     68.04%

************************
Evaluating: CHEAH JO YEN 17059391
************************

Playing Matches:
----------
  Match 1: CHEAH JO YEN - 17059391 vs   Random        Result: 67 to 13
  Match 2: CHEAH JO YEN - 17059391 vs   MM_Null       Result: 62 to 18
  Match 3: CHEAH JO YEN - 17059391 vs   MM_Open       Result: 49 to 31
  Match 4: CHEAH JO YEN - 17059391 vs MM_Improved     Result: 42 to 38
  Match 5: CHEAH JO YEN - 17059391 vs   AB_Null       Result: 55 to 25
  Match 6: CHEAH JO YEN - 17059391 vs   AB_Open       Result: 48 to 32
  Match 7: CHEAH JO YEN - 17059391 vs AB_Improved     Result: 54 to 26
```

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Results:
----------
CHEAH JO YEN 17059391     67.32%

*************************
Evaluating: CHONG SIN MEI - 17103500
*************************

Playing Matches:
----------
  Match 1: CHONG SIN MEI - 17103500 vs   Random       Result: 65 to 15
  Match 2: CHONG SIN MEI - 17103500 vs   MM_Null      Result: 52 to 28
  Match 3: CHONG SIN MEI - 17103500 vs   MM_Open      Result: 49 to 31
  Match 4: CHONG SIN MEI - 17103500 vs MM_Improved    Result: 40 to 40
  Match 5: CHONG SIN MEI - 17103500 vs   AB_Null      Result: 59 to 21
  Match 6: CHONG SIN MEI - 17103500 vs   AB_Open      Result: 57 to 23
  Match 7: CHONG SIN MEI - 17103500 vs AB_Improved    Result: 50 to 30


Results:
----------
CHONG SIN MEI - 17103500   66.43%

*************************
Evaluating: Offensive to defensive
*************************

Playing Matches:
----------
  Match 1: Offensive to defensive vs   Random    Result: 69 to 11
  Match 2: Offensive to defensive vs   MM_Null   Result: 56 to 24
  Match 3: Offensive to defensive vs   MM_Open   Result: 45 to 35
  Match 4: Offensive to defensive vs MM_Improved Result: 35 to 45
  Match 5: Offensive to defensive vs   AB_Null   Result: 55 to 25
  Match 6: Offensive to defensive vs   AB_Open   Result: 47 to 33
  Match 7: Offensive to defensive vs AB_Improved Result: 48 to 32


Results:
----------
Offensive to defensive     63.39%
```