



**UNIVERSITY
OF MALAYA**



WID 3009

Artificial Intelligence Game Programming

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Heuristic Analysis Report

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CUSTOM HEURISTICS AND ANALYSIS

Heuristic A: Point of view strategy

A heuristic that calculates from the point of view of the given player. It was composed of two types of rules and applied to both player and opponent agent. First if about the progression of the game which is the percentage of the game board filled follow by whether the agent crash with the boundary. The heuristic technique can be expressed as:

The percentage of unoccupied spaces:

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

Different conditions and rules:

When the player agent is far from the boundary and percentage is low, get a higher score(my score).

Else if the player is about to crash with the boundary or high occupied spaces, get a lower score.

Same conditions applied to the opponent agent(opponent score).

Heuristic calculation:

```
(my score - opponent score *  $\alpha$ )
```

where α is 1.5

Heuristic B: Difference between average scores for future moves of player and opponent

A heuristic technique that needs a computation of the value of each space beforehand in order to evaluate each move in the game. There are a total of 8 possible movements in the Isolation board game, the heuristic will check if a movement is considered valid and calculate the values for the spaces according to their positions and possibilities to get to space from the centre with a discount of 0.9. The space with the maximum value of 10 is the centre of the game board, if space is nearer to the centre and has higher possibility to access, then the higher score will be given and vice versa. The values of the board calculated is as the following:

```
[[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 pre-computed spaces value, the difference between average scores of the player and opponent agent can be calculated and is expressed 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
```

Heuristic C: Minimize opponents moves and maximize our moves

A heuristic that in anytime keeps trying to maximize the moves of player agent and meanwhile minimize the number of moves by opponent agent. The mathematical expression of this heuristic technique can be expressed as:

```
len(my available move) * len(my available move) -  $\alpha$  * len(available
opponent move) * len(available opponent move)
```

where α is 5.0

Heuristic D: Different movement with weight factor strategy

A heuristics technique that performs based on the calculation about the difference between the moves of the player and opponent, different weight factors are applied to both players and opponents to optimize the player agent's performance. Weight factor for the player is set to a constant of 1, while for the opponent agent is determined by the number of open spaces remaining in the game. Since this heuristic is based on the count of occupied spaces in the game, the player agent will perform differently according to the number of blank spaces in the game from time to time. The heuristic technique can be represented as:

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

Heuristic E: Offensive to defensive strategy

A heuristic technique which is based on the logic that lets the player agent play offensively to exhaust the possible moves for the opponent on the first half of the game. Then let the agent plays defensively to prioritize the player available movements. The switching of strategy is determined by the occupied spaces of the game board. This heuristic function can be mathematically expressed as:

For offensive strategy:

$$\text{len}(\text{my available moves}) - (\text{len}(\text{available opponent moves}) * \alpha)$$

For defensive strategy:

$$(\text{len}(\text{my available moves}) * \alpha) - \text{len}(\text{available opponent moves})$$

where α is 2.0

Ratio of occupied spaces:

$$(\text{number of space occupied}) / (\text{total number of spaces})$$

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

```
if(ratio of occupied spaces) <= 0.5: use offensive strategy  
else: use defensive strategy
```

Heuristic F: Blocking the opponent strategy

An aggressive heuristic function that lets the player agent seeks to hunt the opponent. It will keep checking the available moves for both player and opponent agent, if there are same available moves, lets player agent go for it. This heuristic technique can be expressed as:

The possible player moves counter:

when my available moves equal to opponent moves, counter plus 1

Heuristic calculation:

$$\text{len}(\text{my available moves}) - (\text{len}(\text{available opponent moves}) * \alpha) + \text{counter}$$

where α is 2.0.

RESULT AND EVALUATION

The performance of various agents and their ranking is shown in the table below. The experiment is run with deepening iterative by setting True for iterative in CUSTOM_ARGS. Besides, the number of matches used is 50 with a time limit of 150ms as the experimental setting.

CUSTOM_ARGS = {"method": 'alphabet', 'iterative': True}

Agent	Performance	Rank
<i>ID_Improved</i>	62.14%	11
<i>Student1</i>	66.25%	6
<i>Student2</i>	61.43%	12
<i>Student3</i>	60.71%	13
<i>Student4</i>	63.93%	8
<i>Student5</i>	63.75%	9
<i>Student6</i>	63.57%	10
<i>Student7</i>	68.21%	3
<i>Heuristic A</i>	68.75%	2
<i>Heuristic B</i>	70.00%	1
<i>Heuristic C</i>	67.50%	4
<i>Heuristic D</i>	66.96%	5
<i>Heuristic E</i>	64.11%	7
<i>Heuristic F</i>	63.93%	8

*Heuristic A: WONG HAO SHAN - 17122789

*Heuristic B: LIM JIA QI - 17134267

*Heuristic C: CHEAH JO YEN - 17059391

*Heuristic D: CHONG SIN MEI - 17103500

*Heuristic E: Offensive to Defensive

*Heuristic F: Blocking the Opponent

The raw experiment result can be found in the Appendix next page.

APPENDICES

A. APPENDIX: EVALUATION RESULT

This script evaluates the performance of the custom heuristic function by comparing the strength of an agent using iterative deepening (ID) search with alpha-beta pruning against the strength rating of agents using other heuristic functions. The `ID_Improved` agent provides a baseline by measuring the performance of a basic agent using Iterative Deepening and the "improved" heuristic (from lecture) on your hardware. The `Student` agent then measures the performance of Iterative Deepening and the custom heuristic against the same opponents.

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

Playing Matches:

Match 1:	ID_Improved vs	Random	Result: 72 to 8
Match 2:	ID_Improved vs	MM_Null	Result: 56 to 24
Match 3:	ID_Improved vs	MM_Open	Result: 42 to 38
Match 4:	ID_Improved vs	MM_Improved	Result: 37 to 43
Match 5:	ID_Improved vs	AB_Null	Result: 49 to 31
Match 6:	ID_Improved vs	AB_Open	Result: 48 to 32
Match 7:	ID_Improved vs	AB_Improved	Result: 44 to 36

Results:

ID_Improved 62.14%

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

Playing Matches:

Match 1:	Student1 vs	Random	Result: 69 to 11
Match 2:	Student1 vs	MM_Null	Result: 61 to 19
Match 3:	Student1 vs	MM_Open	Result: 47 to 33
Match 4:	Student1 vs	MM_Improved	Result: 45 to 35
Match 5:	Student1 vs	AB_Null	Result: 52 to 28
Match 6:	Student1 vs	AB_Open	Result: 51 to 29
Match 7:	Student1 vs	AB_Improved	Result: 46 to 34

Results:

Student1 66.25%

Evaluating: Student2

Playing Matches:

Match 1:	Student2	vs	Random	Result: 62 to 18
Match 2:	Student2	vs	MM_Null	Result: 53 to 27
Match 3:	Student2	vs	MM_Open	Result: 45 to 35
Match 4:	Student2	vs	MM_Improved	Result: 43 to 37
Match 5:	Student2	vs	AB_Null	Result: 56 to 24
Match 6:	Student2	vs	AB_Open	Result: 42 to 38
Match 7:	Student2	vs	AB_Improved	Result: 43 to 37

Results:

Student2 61.43%

Evaluating: Student3

Playing Matches:

Match 1:	Student3	vs	Random	Result: 66 to 14
Match 2:	Student3	vs	MM_Null	Result: 50 to 30
Match 3:	Student3	vs	MM_Open	Result: 40 to 40
Match 4:	Student3	vs	MM_Improved	Result: 38 to 42
Match 5:	Student3	vs	AB_Null	Result: 48 to 32
Match 6:	Student3	vs	AB_Open	Result: 46 to 34
Match 7:	Student3	vs	AB_Improved	Result: 52 to 28

Results:

Student3 60.71%

Evaluating: Student4

Playing Matches:

Match 1:	Student4	vs	Random	Result: 71 to 9
Match 2:	Student4	vs	MM_Null	Result: 59 to 21
Match 3:	Student4	vs	MM_Open	Result: 39 to 41
Match 4:	Student4	vs	MM_Improved	Result: 41 to 39
Match 5:	Student4	vs	AB_Null	Result: 59 to 21
Match 6:	Student4	vs	AB_Open	Result: 44 to 36
Match 7:	Student4	vs	AB_Improved	Result: 45 to 35

Results:

Student4 63.93%

Evaluating: Student5

Playing Matches:

Match 1:	Student5	vs	Random	Result: 70 to 10
Match 2:	Student5	vs	MM_Null	Result: 54 to 26
Match 3:	Student5	vs	MM_Open	Result: 47 to 33
Match 4:	Student5	vs	MM_Improved	Result: 37 to 43
Match 5:	Student5	vs	AB_Null	Result: 57 to 23
Match 6:	Student5	vs	AB_Open	Result: 48 to 32
Match 7:	Student5	vs	AB_Improved	Result: 44 to 36

Results:

Student5 63.75%

Evaluating: Student6

Playing Matches:

Match 1:	Student6	vs	Random	Result: 62 to 18
Match 2:	Student6	vs	MM_Null	Result: 60 to 20
Match 3:	Student6	vs	MM_Open	Result: 44 to 36
Match 4:	Student6	vs	MM_Improved	Result: 49 to 31
Match 5:	Student6	vs	AB_Null	Result: 55 to 25
Match 6:	Student6	vs	AB_Open	Result: 42 to 38
Match 7:	Student6	vs	AB_Improved	Result: 44 to 36

Results:

Student6 63.57%

Evaluating: Student7

Playing Matches:

Match 1:	Student7	vs	Random	Result: 67 to 13
Match 2:	Student7	vs	MM_Null	Result: 60 to 20
Match 3:	Student7	vs	MM_Open	Result: 43 to 37
Match 4:	Student7	vs	MM_Improved	Result: 47 to 33

Match 5:	Student7	vs	AB_Null	Result: 58 to 22
Match 6:	Student7	vs	AB_Open	Result: 56 to 24
Match 7:	Student7	vs	AB_Improved	Result: 51 to 29

Results:

Student7 68.21%

Evaluating: WONG HAO SHAN - 17122789

Playing Matches:

Match 1:	WONG HAO SHAN - 17122789	vs	Random	Result: 72 to 8
Match 2:	WONG HAO SHAN - 17122789	vs	MM_Null	Result: 60 to 20
Match 3:	WONG HAO SHAN - 17122789	vs	MM_Open	Result: 43 to 37
Match 4:	WONG HAO SHAN - 17122789	vs	MM_Improved	Result: 42 to 38
Match 5:	WONG HAO SHAN - 17122789	vs	AB_Null	Result: 62 to 18
Match 6:	WONG HAO SHAN - 17122789	vs	AB_Open	Result: 55 to 25
Match 7:	WONG HAO SHAN - 17122789	vs	AB_Improved	Result: 51 to 29

Results:

WONG HAO SHAN - 17122789 68.75%

Evaluating: LIM JIA QI - 17134267

Playing Matches:

Match 1:	LIM JIA QI - 17134267	vs	Random	Result: 70 to 10
Match 2:	LIM JIA QI - 17134267	vs	MM_Null	Result: 66 to 14
Match 3:	LIM JIA QI - 17134267	vs	MM_Open	Result: 49 to 31
Match 4:	LIM JIA QI - 17134267	vs	MM_Improved	Result: 41 to 39
Match 5:	LIM JIA QI - 17134267	vs	AB_Null	Result: 56 to 24
Match 6:	LIM JIA QI - 17134267	vs	AB_Open	Result: 53 to 27
Match 7:	LIM JIA QI - 17134267	vs	AB_Improved	Result: 57 to 23

Results:

LIM JIA QI - 17134267 70.00%

Evaluating: CHEAH JO YEN - 17059391

Playing Matches:

Match 1:	CHEAH JO YEN - 17059391	vs	Random	Result:	71 to 9
Match 2:	CHEAH JO YEN - 17059391	vs	MM_Null	Result:	63 to 17
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:	53 to 27
Match 6:	CHEAH JO YEN - 17059391	vs	AB_Open	Result:	52 to 28
Match 7:	CHEAH JO YEN - 17059391	vs	AB_Improved	Result:	48 to 32

Results:

CHEAH JO YEN - 17059391 67.50%

Evaluating: CHONG SIN MEI - 17103500

Playing Matches:

Match 1:	CHONG SIN MEI - 17103500	vs	Random	Result:	67 to 13
Match 2:	CHONG SIN MEI - 17103500	vs	MM_Null	Result:	61 to 19
Match 3:	CHONG SIN MEI - 17103500	vs	MM_Open	Result:	50 to 30
Match 4:	CHONG SIN MEI - 17103500	vs	MM_Improved	Result:	41 to 39
Match 5:	CHONG SIN MEI - 17103500	vs	AB_Null	Result:	56 to 24
Match 6:	CHONG SIN MEI - 17103500	vs	AB_Open	Result:	55 to 25
Match 7:	CHONG SIN MEI - 17103500	vs	AB_Improved	Result:	45 to 35

Results:

CHONG SIN MEI - 17103500 66.96%

Evaluating: Offensive to Defensive

Playing Matches:

Match 1:	Offensive to Defensive	vs	Random	Result:	72 to 8
Match 2:	Offensive to Defensive	vs	MM_Null	Result:	51 to 29
Match 3:	Offensive to Defensive	vs	MM_Open	Result:	43 to 37
Match 4:	Offensive to Defensive	vs	MM_Improved	Result:	44 to 36
Match 5:	Offensive to Defensive	vs	AB_Null	Result:	50 to 30
Match 6:	Offensive to Defensive	vs	AB_Open	Result:	48 to 32
Match 7:	Offensive to Defensive	vs	AB_Improved	Result:	51 to 29

Results:

Offensive to Defensive 64.11%

Evaluating: Blocking the Opponent

Playing Matches:

Match 1: Blocking the Opponent vs	Random	Result: 58 to 22
Match 2: Blocking the Opponent vs	MM_Null	Result: 59 to 21
Match 3: Blocking the Opponent vs	MM_Open	Result: 48 to 32
Match 4: Blocking the Opponent vs	MM_Improved	Result: 43 to 37
Match 5: Blocking the Opponent vs	AB_Null	Result: 54 to 26
Match 6: Blocking the Opponent vs	AB_Open	Result: 48 to 32
Match 7: Blocking the Opponent vs	AB_Improved	Result: 48 to 32

Results:

Blocking the Opponent 63.93%
