

## Part 1: Heuristic Analysis

### Heuristic-1:

This heuristic gives a huge bonus if we find a move that blocks the opponent movement. This is an aggressive heuristic that focuses on 'cornering' the opponent. Because only a fraction of the states will have a blocking move, we also calculate the difference between player's number of available moves and opponent moves.

The formula is:  $100 * (\# \text{ of blocking moves}) + (\# \text{ of player moves}) - (\# \text{ of opponent moves})$

```
AIND-Isolation — -bash — 92x50
[(aind) Murats-MacBook-Pro-2:AIND-Isolation muratozgul$ python tournament.py

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: 17 to 3
Match 2: ID_Improved vs MM_Null     Result: 17 to 3
Match 3: ID_Improved vs MM_Open     Result: 16 to 4
Match 4: ID_Improved vs MM_Improved Result: 16 to 4
Match 5: ID_Improved vs AB_Null     Result: 16 to 4
Match 6: ID_Improved vs AB_Open     Result: 13 to 7
Match 7: ID_Improved vs AB_Improved Result: 11 to 9

Results:
-----
ID_Improved      75.71%

*****
Evaluating: Student
*****

Playing Matches:
-----
Match 1: Student vs Random      Result: 19 to 1
Match 2: Student vs MM_Null     Result: 17 to 3
Match 3: Student vs MM_Open     Result: 15 to 5
Match 4: Student vs MM_Improved Result: 14 to 6
Match 5: Student vs AB_Null     Result: 17 to 3
Match 6: Student vs AB_Open     Result: 14 to 6
Match 7: Student vs AB_Improved Result: 14 to 6

Results:
-----
Student          78.57%
(aind) Murats-MacBook-Pro-2:AIND-Isolation muratozgul$
```

## Heuristic-2:

This heuristic is the modified version of the first one, this time we have a weight to adjust “aggressiveness” of the heuristic while calculating the difference of legal moves. The formula is:

The formula is:  $100 * (\# \text{-of-blocking-moves}) + (\# \text{-of-player-moves}) - \text{weight} * (\# \text{-of-opponent-moves})$

```
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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: 18 to 2
Match 2: ID_Improved vs MM_Null     Result: 20 to 0
Match 3: ID_Improved vs MM_Open     Result: 14 to 6
Match 4: ID_Improved vs MM_Improved Result: 14 to 6
Match 5: ID_Improved vs AB_Null     Result: 16 to 4
Match 6: ID_Improved vs AB_Open     Result: 10 to 10
Match 7: ID_Improved vs AB_Improved Result: 15 to 5

Results:
-----
ID_Improved      76.43%

*****
Evaluating: Student
*****

Playing Matches:
-----
Match 1: Student vs Random      Result: 20 to 0
Match 2: Student vs MM_Null     Result: 17 to 3
Match 3: Student vs MM_Open     Result: 16 to 4
Match 4: Student vs MM_Improved Result: 16 to 4
Match 5: Student vs AB_Null     Result: 19 to 1
Match 6: Student vs AB_Open     Result: 15 to 5
Match 7: Student vs AB_Improved Result: 11 to 9

Results:
-----
Student          81.43%
(aind) Murats-MacBook-Pro-2:AIND-Isolation muratozgul$
```

Using a weight of 1.5 seemed to work better and in this configuration it performs better than heuristic-1.

### Heuristic-3:

This heuristic is a simpler one that just calculates the difference of legal moves with a weight. It is similar to heuristic-2 but without the blocking moves calculation. I wanted to see if the cost for calculating the blocking moves worth it.

The formula is:  $(\# \text{-of-player-moves}) \cdot \text{weight} \cdot (\# \text{-of-opponent-moves})$

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

Playing Matches:
-----
Match 1: ID_Improved vs Random      Result: 18 to 2
Match 2: ID_Improved vs MM_Null     Result: 17 to 3
Match 3: ID_Improved vs MM_Open     Result: 19 to 1
Match 4: ID_Improved vs MM_Improved Result: 15 to 5
Match 5: ID_Improved vs AB_Null     Result: 16 to 4
Match 6: ID_Improved vs AB_Open     Result: 13 to 7
Match 7: ID_Improved vs AB_Improved Result: 17 to 3

Results:
-----
ID_Improved      82.14%

*****
Evaluating: Student
*****

Playing Matches:
-----
Match 1: Student vs Random      Result: 17 to 3
Match 2: Student vs MM_Null     Result: 15 to 5
Match 3: Student vs MM_Open     Result: 15 to 5
Match 4: Student vs MM_Improved Result: 15 to 5
Match 5: Student vs AB_Null     Result: 15 to 5
Match 6: Student vs AB_Open     Result: 14 to 6
Match 7: Student vs AB_Improved Result: 11 to 9

Results:
-----
Student          72.86%
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```

I used a weight of 2 during this run and it performed worse compared to ID\_Improved.

**Decision:**

I choose **heuristic-2** because it was performing better than ID\_Imoroved and it was the only heuristic I tried that passed the 80% threshold. We can clearly see the positive contribution of considering blocking moves if we compare it heuristic-3. Also when compared to heuristic-1, we can conclude that fine-tuning the weight increased the win-rate by almost 3%.

Heuristic	Win Rate	ID_improved	Decision
1	78.57%	75.71%	OK
2	<b>81.43%</b>	76.43%	Best (Chosen)
3	<b>72.86%</b>	82.14%	Avoid