

Heuristic Analysis

Local machine information:

Notebook Model	Processor	Memory	Operating System
Lenovo T440s	Intel i7-4600U @ 2.10GHz x 4	8Gb	Ubuntu 16.1

There are three different custom_score function in order to score different branch in the game three. We can therefore choose the highest score one to win the game finally.

All these three score functions are based on the remain legal moves of both side to calculate.

1. Host's legal moves - opposites' legal moves:

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

Playing Matches:
-----
Match 1: ID_Improved vs Random      Result: 14 to 6
Match 2: ID_Improved vs MM_Null     Result: 12 to 8
Match 3: ID_Improved vs MM_Open     Result: 12 to 8
Match 4: ID_Improved vs MM_Improved Result: 11 to 9
Match 5: ID_Improved vs AB_Null     Result: 12 to 8
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      60.71%

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

Playing Matches:
-----
Match 1: Student vs Random      Result: 14 to 6
Match 2: Student vs MM_Null     Result: 14 to 6
Match 3: Student vs MM_Open     Result: 11 to 9
Match 4: Student vs MM_Improved Result: 11 to 9
Match 5: Student vs AB_Null     Result: 14 to 6
Match 6: Student vs AB_Open     Result: 12 to 8
Match 7: Student vs AB_Improved Result: 10 to 10

Results:
-----
Student          61.43%
```

The idea here is very simple. The model is caring that the host should have more legal move then opposite.

We can see the result that ID_improved has 60.71% winning rate and Student 61.43% winning rate.

2. Host's legal moves/2 - opposites' legal moves:

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

Playing Matches:
-----
Match 1: ID_Improved vs Random      Result: 14 to 6
Match 2: ID_Improved vs MM_Null     Result: 13 to 7
Match 3: ID_Improved vs MM_Open     Result: 10 to 10
Match 4: ID_Improved vs MM_Improved Result: 12 to 8
Match 5: ID_Improved vs AB_Null     Result: 13 to 7
Match 6: ID_Improved vs AB_Open     Result: 10 to 10
Match 7: ID_Improved vs AB_Improved Result: 11 to 9

Results:
-----
ID_Improved      59.29%

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

Playing Matches:
-----
Match 1: Student vs Random      Result: 15 to 5
Match 2: Student vs MM_Null     Result: 16 to 4
Match 3: Student vs MM_Open     Result: 11 to 9
Match 4: Student vs MM_Improved Result: 11 to 9
Match 5: Student vs AB_Null     Result: 15 to 5
Match 6: Student vs AB_Open     Result: 10 to 10
Match 7: Student vs AB_Improved Result: 11 to 9

Results:
-----
Student          63.57%
```

Here the idea is trying to give a higher rate to opposites' legal moves. It means that it is trying to give a tougher calculation than the above one.

From the result, we can see that ID_improved has 59.29% winning rate and student has 63.57% winning rate.

3. Host's legal moves/Remain empty place - opposites' legal moves/ Remain empty place:

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

Playing Matches:
-----
Match 1: ID_Improved vs Random      Result: 11 to 9
Match 2: ID_Improved vs MM_Null     Result: 11 to 9
Match 3: ID_Improved vs MM_Open     Result: 13 to 7
Match 4: ID_Improved vs MM_Improved Result: 12 to 8
Match 5: ID_Improved vs AB_Null     Result: 16 to 4
Match 6: ID_Improved vs AB_Open     Result: 12 to 8
Match 7: ID_Improved vs AB_Improved Result: 12 to 8

Results:
-----
ID_Improved      62.14%

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

Playing Matches:
-----
Match 1: Student vs Random      Result: 13 to 7
Match 2: Student vs MM_Null     Result: 16 to 4
Match 3: Student vs MM_Open     Result: 13 to 7
Match 4: Student vs MM_Improved Result: 12 to 8
Match 5: Student vs AB_Null     Result: 14 to 6
Match 6: Student vs AB_Open     Result: 11 to 9
Match 7: Student vs AB_Improved Result: 12 to 8

Results:
-----
Student          65.00%
```

Here, the program is using the percentage of legal moves as the calculation rather than the actual number.

As we can see in the result that ID_improved has 62.14% winning rate and Student has 65% wining rate.

As a result, the second method, Host's legal moves/2 - opposites' legal moves, will be chosen as my final scoring function in my project, although the third one provides a high winning rate comparing to the rest.

In this project, my goal is to develop a heuristic such that Student outperforms ID_Improved. In this sense, we will find that the winning of student agent is higher than ID_Improved 0.72% in the first method, 4.28% higher in second method and 2.86% higher in the third one. Moreover, all these methods have a very neary time using, which are all about 7 minutes.

To conclude, the second method is the most suitable one based on the aims of our project.