

Heuristic Analysis

Heuristic functions

1st

The first function in the one given in the lectures. It measures the number of the legal moves for the player in his current position

```
player_moves
```

2nd

This function calculates the difference between the number of legal moves for the player and his opponent. It doesn't use the absolute value because if it's negative, it means that the opponent has more moves than the player and that is something to take into account

```
player_moves - opponent_moves
```

3rd

As the second one, it calculates the difference but squaring the opponent moves giving a penalty to the opponent moves.

```
player_moves - opponent_moves ** 2
```

4th

As the third one, it calculates the difference but squaring the player moves

```
(player_moves ** 2) - opponent_moves
```

Results

1st

```

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

Playing Matches:
-----
Match 1: ID_Improved vs Random      Result: 54 to 6
Match 2: ID_Improved vs MM_Null     Result: 53 to 7
Match 3: ID_Improved vs MM_Open     Result: 27 to 33
Match 4: ID_Improved vs MM_Improved Result: 19 to 41
Match 5: ID_Improved vs AB_Null     Result: 47 to 13
Match 6: ID_Improved vs AB_Open     Result: 41 to 19
Match 7: ID_Improved vs AB_Improved Result: 34 to 26

Results:
-----
ID_Improved      65.48%

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

Playing Matches:
-----
Match 1: Student vs Random      Result: 56 to 4
Match 2: Student vs MM_Null     Result: 51 to 9
Match 3: Student vs MM_Open     Result: 45 to 15
Match 4: Student vs MM_Improved Result: 37 to 23
Match 5: Student vs AB_Null     Result: 52 to 8
Match 6: Student vs AB_Open     Result: 47 to 13
Match 7: Student vs AB_Improved Result: 35 to 25

Results:
-----
Student          76.90%

```

2nd

```

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

Playing Matches:
-----
Match 1: ID_Improved vs Random      Result: 52 to 8
Match 2: ID_Improved vs MM_Null     Result: 52 to 8
Match 3: ID_Improved vs MM_Open     Result: 31 to 29
Match 4: ID_Improved vs MM_Improved Result: 29 to 31
Match 5: ID_Improved vs AB_Null     Result: 49 to 11
Match 6: ID_Improved vs AB_Open     Result: 42 to 18
Match 7: ID_Improved vs AB_Improved Result: 34 to 26

Results:
-----
ID_Improved      68.81%

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

Playing Matches:
-----
Match 1: Student vs Random      Result: 54 to 6
Match 2: Student vs MM_Null     Result: 56 to 4
Match 3: Student vs MM_Open     Result: 36 to 24
Match 4: Student vs MM_Improved Result: 37 to 23
Match 5: Student vs AB_Null     Result: 50 to 10
Match 6: Student vs AB_Open     Result: 41 to 19
Match 7: Student vs AB_Improved Result: 37 to 23

Results:
-----
Student          74.05%

```

3rd

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

Playing Matches:

Match 1:	ID_Improved	vs	Random	Result: 52 to 8
Match 2:	ID_Improved	vs	MM_Null	Result: 48 to 12
Match 3:	ID_Improved	vs	MM_Open	Result: 30 to 30
Match 4:	ID_Improved	vs	MM_Improved	Result: 30 to 30
Match 5:	ID_Improved	vs	AB_Null	Result: 48 to 12
Match 6:	ID_Improved	vs	AB_Open	Result: 38 to 22
Match 7:	ID_Improved	vs	AB_Improved	Result: 32 to 28

Results:

ID_Improved 66.19%

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

Playing Matches:

Match 1:	Student	vs	Random	Result: 54 to 6
Match 2:	Student	vs	MM_Null	Result: 54 to 6
Match 3:	Student	vs	MM_Open	Result: 38 to 22
Match 4:	Student	vs	MM_Improved	Result: 40 to 20
Match 5:	Student	vs	AB_Null	Result: 49 to 11
Match 6:	Student	vs	AB_Open	Result: 48 to 12
Match 7:	Student	vs	AB_Improved	Result: 42 to 18

Results:

Student 77.38%

4th

```

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

Playing Matches:
-----
Match 1: ID_Improved vs Random      Result: 54 to 6
Match 2: ID_Improved vs MM_Null     Result: 48 to 12
Match 3: ID_Improved vs MM_Open     Result: 31 to 29
Match 4: ID_Improved vs MM_Improved Result: 25 to 35
Match 5: ID_Improved vs AB_Null     Result: 52 to 8
Match 6: ID_Improved vs AB_Open     Result: 34 to 26
Match 7: ID_Improved vs AB_Improved Result: 33 to 27

Results:
-----
ID_Improved      65.95%

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

Playing Matches:
-----
Match 1: Student vs Random      Result: 56 to 4
Match 2: Student vs MM_Null     Result: 50 to 10
Match 3: Student vs MM_Open     Result: 40 to 20
Match 4: Student vs MM_Improved Result: 37 to 23
Match 5: Student vs AB_Null     Result: 53 to 7
Match 6: Student vs AB_Open     Result: 41 to 19
Match 7: Student vs AB_Improved Result: 36 to 24

Results:
-----
Student          74.52%

```

Conclusion

The best performance is given by the 3rd option `player_moves - opponent_moves ** 2`. Looks like givin penalty to the opponent moves is working. But we cannot conclude that that is the best option because all the results are really close to each other. The minimum is 74.52% and the maximum is 77.38%.

I choosed tho because:

1. It has the best score
2. It wins 2/3 of the times agains MM_Improved
3. It performs really well against Alpha Beta

We would need to run much more games in order to be more confident about the results, but the improvement looks minimum though. I wanted to try another heuristic but given the constrain of the `Board` it wouldn't have a lot of difference with the player moves. I wanted to try the liberty degrees of the player. I mean, the directions where a player can move. If the player is in the center, it can move up, down, right, left, and in 4 diagonals. That's a total of 8 degrees of liberty. If it is in a

corner it would have only 3. It sound like a really good feature to introduce in the heuristic, but our game is constrained to only L moves, so it doesn't have a lot of sense with this constrain given that it will be a multiple of the available moves (In the center, a player would have 8 Ls moves and 4 liberty degrees).