

## Artificial Intelligence Nanodegree - Project 2 – Build a Game-Playing Agent

### Heuristic Analysis

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I experimented with quite a few heuristics. I found none that performed significantly better than the simple “own moves minus opponent moves” formula used by ID Improved. Though I never found a good combination that worked, the best solution probably would be a combination of heuristics that uses one strategy early in the game and a different strategy late in the game. Also, to the extent possible, end-game specific logic could have a positive win rate boost.

### Summary

Heuristic	Description	Win rate
Baseline	Own moves minus opponent moves (one level deep)	67%
custom_score_A( )  <i>Submitted code uses this method.</i>	Standard own moves minus opponent moves for most of game. End game uses second level moves (own minus opponent) with a higher score for cases where we can block one of the opponent’s next moves.	70%
custom_score_B()	Board position (inner, outer squares)	60%
custom_score_C()	Own moves minus opponent moves (second level deep)	65%

### Recommendation

Use custom\_score\_A( ) because:

- It uses different strategies for early game and end-game.
- It uses the simplistic but proven “own moves minus opponent moves” strategy for much of the game. This works when there are plenty of spaces.
- At end game it looks at second-level moves and also assigns a higher score during the end-game when we have the opportunity to block the opponent’s next move. This should give us an advantage.

## Baseline – own moves minus opponent moves

Compare counts of next moves – one level deep.

### Performance

Simple but tough to beat.

Playing Matches:

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Match 1: ID_Improved vs    Random    Result: 35 to 5  
Match 2: ID_Improved vs    MM_Null   Result: 38 to 2  
Match 3: ID_Improved vs    MM_Open   Result: 24 to 16  
Match 4: ID_Improved vs MM_Improved Result: 23 to 17  
Match 5: ID_Improved vs    AB_Null   Result: 32 to 8  
Match 6: ID_Improved vs    AB_Open   Result: 21 to 19  
Match 7: ID_Improved vs AB_Improved Result: 17 to 23
```

Results:

```
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ID_Improved          67.86%
```

## custom\_score\_A( ) – multiple strategies

Standard “own moves minus opponent moves” for most of game. End game uses second level moves (own minus opponent). In the end game, we increase the score for cases where we can block one of the opponent’s next moves.

### Performance

In practice, this heuristic gave marginally better results than the baseline.

Playing Matches:

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Match 1:	Student	vs	Random	Result: 38 to 2
Match 2:	Student	vs	MM_Null	Result: 36 to 4
Match 3:	Student	vs	MM_Open	Result: 23 to 17
Match 4:	Student	vs	MM_Improved	Result: 26 to 14
Match 5:	Student	vs	AB_Null	Result: 34 to 6
Match 6:	Student	vs	AB_Open	Result: 21 to 19
Match 7:	Student	vs	AB_Improved	Result: 18 to 22

Results:

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Student	70.00%
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## custom\_score\_B( ) – board position

This heuristic assumes that inner board positions are advantageous over outer positions. In practice, there is probably much overlap with the standard “own moves minus opponent moves” in that inner positions also have more own moves.

We assume a 7x7 board and assign tiers, then assign a score to the current position (own and opponent):

- tier 0 = the ring of 24 outer squares
- tier 1 = the ring of 16 squares one space in from the outer ring
- tier 2 = the center 9 squares

## Performance

The results were worse than the baseline.

Playing Matches:

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Match 1:	Student	vs	Random	Result: 36 to 4
Match 2:	Student	vs	MM_Null	Result: 34 to 6
Match 3:	Student	vs	MM_Open	Result: 19 to 21
Match 4:	Student	vs	MM_Improved	Result: 16 to 24
Match 5:	Student	vs	AB_Null	Result: 29 to 11
Match 6:	Student	vs	AB_Open	Result: 20 to 20
Match 7:	Student	vs	AB_Improved	Result: 14 to 26

Results:

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Student	60.00%
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## custom\_score\_C( ) – own minus opponent - second level moves

Count the number of second moves (next move plus one) for each player. Use heuristic formula “own second moves minus opponent second moves.” This should give a better sense of the future board score than the baseline.

### Performance

In practice, this heuristic produced slightly worse results than the baseline.

Playing Matches:

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Match 1:	Student	vs	Random	Result: 37 to 3
Match 2:	Student	vs	MM_Null	Result: 29 to 11
Match 3:	Student	vs	MM_Open	Result: 26 to 14
Match 4:	Student	vs	MM_Improved	Result: 22 to 18
Match 5:	Student	vs	AB_Null	Result: 33 to 7
Match 6:	Student	vs	AB_Open	Result: 19 to 21
Match 7:	Student	vs	AB_Improved	Result: 18 to 22

Results:

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Student	65.71%
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