Heuristic Analysis

Evaluating a position requires a method to quantify how much of an advantage (or disadvantage) a player is in. If two players had identical positions (without taking temporal advantage – I.e. 'tempo' into account), then technically, the two positions would be equal. This assumption shall form the basis of our evaluation methodology. Thus our heuristic will try to measure the difference in positions between the two players.

The simplicity of the game Isolation means that there are only a few factors which can differ. One such factor is the number of available moves each player has in a given position. Since this factor is also relatively simple to measure, we use this as the core factor to our evaluation function. However, using this factor to derive a quantitative measure which we can use to evaluate a position has many possibilities which we have experimented with to ensure the best performance. (a = number of my legal moves, b = number of opponent's legal moves).

The simplest application was to measure the number of available moves that each player has and subtract their two values (value = a – b). This simple equations gives higher scores for positions that offer our player more moves than the other player. This heuristic performed fairly well in testing (7.2% better than another function), however the ratio of the two players' legal moves (value = a/b) produced a performance which was 7.1% better than subtracting them.

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**************************
    Playing Matches
**************************

Match #   Opponent      AB_Improved     AB_Custom     AB_Custom_2     AB_Custom_3
                        Won  | Lost     Won  | Lost   Won  | Lost    Won  | Lost
   1      Random          4  |   0      4  |   0     4  |   0      3  |   1
   2      MM_Open         3  |   1      3  |   1     2  |   2      3  |   1
   3      MM_Center       4  |   0      3  |   1     3  |   1      4  |   0
   4      MM_Improved     2  |   2      3  |   1     4  |   0      3  |   1
   5      AB_Open         0  |   4      2  |   2     1  |   3      2  |   2
   6      AB_Center       2  |   2      1  |   3     2  |   2      3  |   1
   7      AB_Improved     2  |   2      1  |   3     3  |   1      3  |   1
------------------------------------------------------------------------------
          Win Rate:      60.7%          60.7%         67.9%          75.0%
```

```
a = my moves
b = opponent moves

1) a/b - 2b/a
2) a - 2b
3) a/b
```

Therefore this evaluation heuristic (the ratio of the two players' available moves a/b) was compared against the squared ratio (value = a^2/b^2) and it was found to perform equally well (67.9%), however, was outperformed by 7.1% by the squared subtraction evaluation method (value = $a^2 - b^2$).

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**************************
    Playing Matches
**************************

Match #   Opponent      AB_Improved     AB_Custom     AB_Custom_2     AB_Custom_3
                        Won  | Lost     Won  | Lost   Won  | Lost    Won  | Lost
   1      Random          4  |   0      4  |   0     4  |   0      3  |   1
   2      MM_Open         2  |   2      3  |   1     3  |   1      2  |   2
   3      MM_Center       3  |   1      3  |   1     3  |   1      4  |   0
   4      MM_Improved     3  |   1      2  |   2     4  |   0      3  |   1
   5      AB_Open         2  |   2      2  |   2     3  |   1      1  |   3
   6      AB_Center       3  |   1      3  |   1     2  |   2      4  |   0
   7      AB_Improved     2  |   2      2  |   2     2  |   2      2  |   2
------------------------------------------------------------------------------
          Win Rate:      67.9%          67.9%         75.0%          67.9%
```

```
a = my moves
b = opponent moves

1) a/b
2) a^2 - b^2
3) a^2/b^2
```

Subsequent tests showed that the squared subtraction heuristic ($a^2 - b^2$) and the ratio heuristic (a/b) both perform highly against other methods, yet fluctuate in how well they perform in regards to one another.

```
**********
Playing Matches
**********

Match #   Opponent      AB_Improved   AB_Custom   AB_Custom_2   AB_Custom_3
                        Won | Lost    Won | Lost    Won | Lost    Won | Lost
   1      Random          4 |  0        4 |  0        3 |  1        4 |  0
   2      MM_Open         2 |  2        4 |  0        2 |  2        3 |  1
   3      MM_Center       4 |  0        3 |  1        4 |  0        4 |  0
   4      MM_Improved     3 |  1        4 |  0        4 |  0        2 |  2
   5      AB_Open         2 |  2        3 |  1        3 |  1        2 |  2
   6      AB_Center       1 |  3        2 |  2        2 |  2        2 |  2
   7      AB_Improved     2 |  2        2 |  2        2 |  2        1 |  3
--------------------------------------------------------------------------
         Win Rate:      64.3%        78.6%        71.4%        64.3%
```

```
a = my moves
b = opponent moves

1) a^2 - b^2
2) a/b
3) b/a
```

```
**********
Playing Matches
**********

Match #   Opponent      AB_Improved   AB_Custom   AB_Custom_2   AB_Custom_3
                        Won | Lost    Won | Lost    Won | Lost    Won | Lost
   1      Random          4 |  0        3 |  1        4 |  0        4 |  0
   2      MM_Open         3 |  1        4 |  0        3 |  1        2 |  2
   3      MM_Center       4 |  0        3 |  1        4 |  0        3 |  1
   4      MM_Improved     2 |  2        2 |  2        2 |  2        2 |  2
   5      AB_Open         2 |  2        2 |  2        4 |  0        3 |  1
   6      AB_Center       4 |  0        3 |  1        3 |  1        2 |  2
   7      AB_Improved     3 |  1        2 |  2        1 |  3        3 |  1
--------------------------------------------------------------------------
         Win Rate:      78.6%        67.9%        75.0%        67.9%
```

```
a = my moves
b = opponent moves

1) a^2 - b^2
2) a/b
3) b^2 - a^2
```

The final heuristic tested was the fraction of available moves (value = a/ a+b) which proved to produce better results than even the ratio (a/b) and squared subtraction ($a^2 - b^2$) methods.

```
**********
Playing Matches
**********

Match #   Opponent      AB_Improved   AB_Custom   AB_Custom_2   AB_Custom_3
                        Won | Lost    Won | Lost    Won | Lost    Won | Lost
   1      Random          3 |  1        4 |  0        4 |  0        4 |  0
   2      MM_Open         2 |  2        4 |  0        2 |  2        4 |  0
   3      MM_Center       4 |  0        4 |  0        4 |  0        4 |  0
   4      MM_Improved     2 |  2        3 |  1        2 |  2        4 |  0
   5      AB_Open         2 |  2        1 |  3        3 |  1        2 |  2
   6      AB_Center       2 |  2        2 |  2        2 |  2        2 |  2
   7      AB_Improved     1 |  3        2 |  2        2 |  2        2 |  2
--------------------------------------------------------------------------
         Win Rate:      57.1%        71.4%        67.9%        78.6%
```

```
a = my moves
b = opponent moves

1) a^2 - b^2
2) a/b
3) a/(a+b)
```

Future developments may look at more advanced heuristics which use implicit factors such as symmetry, board location and even non-linear functions trained on expert player moves.