

Heuristic Analysis for Isolation

Parth Pankaj Tiwary

Introduction

In this paper I present my analysis of the three heuristics that I have created and tested in a tournament for the game of Isolation. The game playing agent has been developed to search the game tree and return the best possible move using the evaluation function, iterative deepening, and alpha-beta pruning in a time bound manner.

- 1) Minimax algorithm was implemented for searching the game tree
- 2) Alpha beta pruning was used to make the minimax more efficient, by pruning the branches which are not required to be visited, in order to find an optimal move.
- 3) Then iterative deepening was implemented, for time bound nature of this project, so that if we encounter a time out, we at least have a move to return before the time runs out, which is the optimal move depending on how much tree has been searched till that point.

One of the most important and most challenging aspect of game playing, (especially when the search space is large, and searching through the search tree in a time bound manner to find an optimal move, given the search space is not feasible) is to put in place an evaluation function(heuristic) for the board state so that the states which are more likely to lead to wins are rewarded and the states which are more likely to lead to losses, are penalized. Using such a function we can avoid visiting such branches which are more likely to result in losses, reducing our search space significantly and improving the efficiency of the search as a result of it.

While I was going through the lessons, I could notice that somehow in the game of Isolation one of the most important ways of winning a game is to simply limit the number of available moves for your opponent, and on continuously choosing board states in which available moves for opponent are scarce, it will eventually lead to a board state where the opponent will be left with no moves, and as a result it will be a win for the active player. I went ahead to design these heuristics for the evaluation function around this fundamental concept of limiting moves for the opponent.

1 Heuristic-One

This heuristic focuses on the possibility of limiting future moves for the opponent. Assign higher evaluation function score to the state if the possibility of future moves for the opponent is scarce, and assign lower score if that is not the case.

1.1 Intuition behind the heuristic

The intuition behind this heuristic is quite fundamental. If we continuously go on choosing or rewarding the board states in which opponent is forced to have less available moves in the current game state and in the future game states, that are generated from that very game state, we will eventually reach a state where there will be no available moves for the opponent, but there will still be available moves for the player and in Isolation the player who makes the last move, wins.

1.2 Tournament Results

Evaluating : ID Improved

Playing Matches :

Match 1 : ID Improved vs Random Result : 19 to 1
 Match 2 : ID Improved vs MM Null Result : 15 to 5
 Match 3 : ID Improved vs MM Open Result : 14 to 6
 Match 4 : ID Improved vs MM Improved Result : 10 to 10
 Match 5 : ID Improved vs AB Null Result : 12 to 8
 Match 6 : ID Improved vs AB Open Result : 11 to 9
 Match 7 : ID Improved vs AB Improved Result : 14 to 6

Results : ID Improved 67.86%

Evaluating : Student

Playing Matches :

Match 1 : Student vs Random Result : 17 to 3
 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 : 14 to 6
 Match 5 : Student vs AB Null Result : 16 to 4
 Match 6 : Student vs AB Open Result : 12 to 8
 Match 7 : Student vs AB Improved Result : 12 to 8

Results : Student 70.00%

2 Heuristic-Two

This heuristic evaluates a board state two folds, first it scores the board on the number of moves available to the player, with respect to the available moves to the opponent, and if the player has more moves available than the opponent, then the board is assigned a higher score, else the board is penalized. This heuristic also goes ahead and normalizes the difference in moves with the Manhattan distance between the player. Taking in account the fact that, if the Manhattan distance between the player and the opponent is large, the player will find it hard, to be able to block the moves for the opponent, and hence in this case, the board will be penalized, else rewarded.

2.1 Intuition behind the heuristic

The intuition behind the heuristic was also quite simple, it took in account the fact that a board state in which moves for the opponent are scarce and the Manhattan between the players is small, then the board will be rewarded, because as far as my understand of the game goes, the closer the players are, and if the opponent has less available moves, it will be easier for the active player to block the moves for the opponent, and as a result of it winning the game.

2.2 Tournament Results

Evaluating : ID Improved

Playing Matches :

Match 1 : ID Improved vs Random Result : 18 to 2
 Match 2 : ID Improved vs MM Null Result : 16 to 4
 Match 3 : ID Improved vs MM Open Result : 12 to 8
 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 : 13 to 7
 Match 7 : ID Improved vs AB Improved Result : 12 to 8

Results :ID Improved 70.71%

Evaluating : Student

Playing Matches :

Match 1 : Student vs Random Result : 20 to 0
 Match 2 : Student vs MM Null Result : 18 to 2
 Match 3 : Student vs MM Open Result : 14 to 6
 Match 4 : Student vs MM Improved Result : 15 to 5
 Match 5 : Student vs AB Null Result : 17 to 3
 Match 6 : Student vs AB Open Result : 12 to 8

Match 7 : Student vs AB Improved Result : 13 to 7

Results : Student 77.86%

3 Heuristic-Three

Inner square occupation heuristic, in this heuristic we evaluate the board state based on how many positions does the player occupy in the inner square of the game board, rewarding the states in which the active player occupies more center position, than the opponent, and penalizing the states in which the opponents occupies more position in inner square than the active player. We will also go ahead and ensemble it with the Manhattan distance, taking in account the fact that, if the active player occupies more inner square positions, and is closer to the opponent, he will be able to block moves for the opponent, and hence this board state will be rewarded, and else it will be penalized.

3.1 Intuition behind the heuristic

The intuition behind the heuristic largely incorporates the fact that we want to pursue the board states in which player holds most of the inner square positions, and minimizing the not occupied positions in the inner square aggressively, we also go ahead and normalize this with the Manhattan distance, taking the account the fact that if our player holds most of the inner square circle, and is closer to the other player in terms of Manhattan distance, then the player will be able to more effectively block the moves for the opponent, and as a result will generate board states which are more likely a win.

3.2 Tournament Results

Evaluating : ID Improved

Playing Matches

Match 1 : ID Improved vs Random Result : 17 to 3

Match 2 : ID Improved vs MM Null Result : 14 to 6

Match 3 : ID Improved vs MM Open Result : 13 to 7

Match 4 : ID Improved vs MM Improved Result : 14 to 6

Match 5 : ID Improved vs AB Null Result : 15 to 5

Match 6 : ID Improved vs AB Open Result : 11 to 9

Match 7 : ID Improved vs AB Improved Result : 12 to 8

Results : ID Improved 68.57%

Evaluating : Student

Playing Matches :

Match 1 : Student vs Random Result : 18 to 2
 Match 2 : Student vs MM Null Result : 14 to 6
 Match 3 : Student vs MM Open Result : 13 to 7
 Match 4 : Student vs MM Improved Result : 11 to 9
 Match 5 : Student vs AB Null Result : 19 to 1
 Match 6 : Student vs AB Open Result : 12 to 8
 Match 7 : Student vs AB Improved Result : 12 to 8

Results : Student 70.71%

Comparison of heuristics			
Hueristic	ID Improved	Student	Difference
Heuristic-One	67.86%	70.00%	2.14%
Heuristic-Two	70.71%	77.86%	7.15%
Heuristic-Three	68.57%	70.71%	2.14%

4 Recommendations

Based on the results that I have obtained in the tournament of all the three heuristics, I would be inclined to go ahead and recommend heuristic-two to be used because of the following reasons :

- 1) Out of all the heuristics that I have deployed in the tournament, heuristic-three was the one which performed the best against AB Improved.
- 2) Heuristic-three out of all the heuristics deployed in the tournament, defeated the Id Improved with the largest margin of 7.15% among all the other heuristics.
- 3) In order for the heuristics to perform well, and search to the greater depths, it is necessary that the calculations involved in evaluating a board are not computationally exhaustive. Heuristic-three seems to be incorporating the core of the game of Isolation, that is to block available move to the opponent, and always choosing board states where there is a possibility for the player to block the opponent. It is also not computationally exhaustive in terms of the calculations that are being done in each board state.