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Analysis of Heuristic Functions

In order of accomplish the task proposed by Udacity Artificial Intelligence Nanodegree a Minimax with alpha beta pruning technique have been implemented and three Heuristic functions have been built to evaluate position in the game of Isolation. These functions performance have been measured on a series of games played until the end of the game against some other heuristics functions. It’s important to say that every match have been done using the same minimax agents, with the only difference being the heuristic evaluation function.

1. Description of Heuristics

The heuristics use some ideas over graphs and the main idea is about get the biggest amount of possible moves in the next move.

First Heuristics: The first heuristics analysed is a graph model for the board. In this analysis every square in the board is viewed as a node of the board graph, when a piece is in a square we say that the component connected to it are the ones where the pieces can move (see figure 1). Them the function computes the difference of the square sum of the degree of the possible vertex to move from the actual square (see figure 2). That gives preference to positions where there exists vertex with a biggest amount of neighbour squares with high degree like in figure 2. The calculation using the formula $\sigma = \sum_{i=0}^{n} W_i^2 - \sum_{j=0}^{n} B_j^2$, where σ is the evaluation of the position, W_i is the i-th valid move for white piece and B_i is the i-th valid move for black pieces (in image 2the function evaluates the white position better resulting a value of $\sigma = 95$).

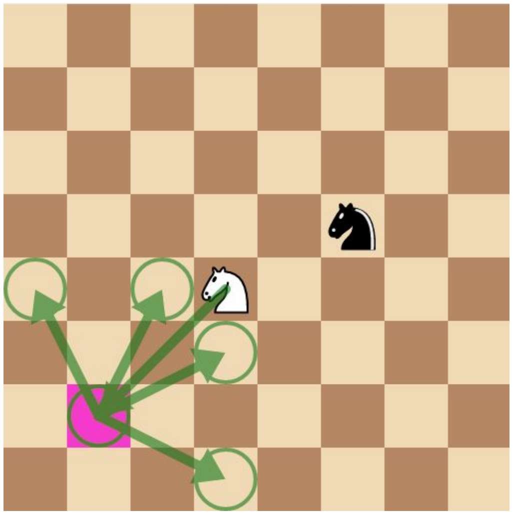

Image 1 - The representation of the adjacent nodes to some square in the board as graph representation (in this image the pink square has a degree of 4)

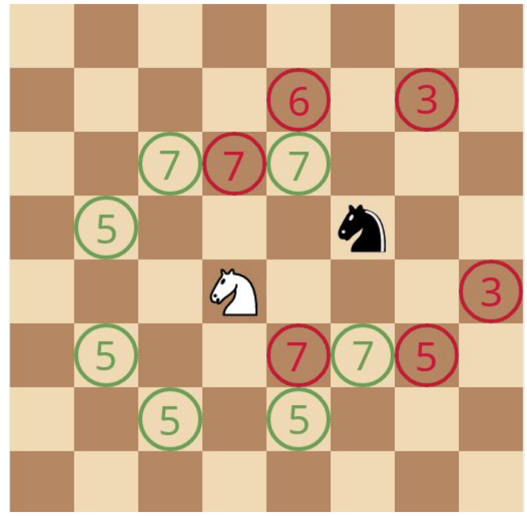

Image 2 - The available moves to both players (green for player 1 and red for player 2) with the node degree after the move have been made.

Second Heuristics: This heuristics uses the difference of the squared value of the degree of the actual square where the piece resides being represented by the formula $\sigma = W^2 - B^2$, for example in the image 2 the evaluation is $\sigma = 5^2 - 5^2 = 0$ which leads the evaluation to be of equal value for both players.

Third Heuristics: The last heuristics implemented uses a formula equivalent to the second one, but tries to be achieve a more offensive playing with the equation being $\sigma = W^4 - 2 \cdot B^4$ which leads to a major amount of games with a huge amount of negative values and only give positive values to really winning positions where white has a higher degree than the Black one and it leads white to keep attacking black pieces to remove it's squares to achieve a bigger value. In case of image 2 the evaluation is $\sigma = 5^4 - 2 \cdot 5^4 = -625$.

2. Results

The heuristic functions have been tested a huge amount of times putting them to play against some well known agents and against each other. For proper Statistical analysis every heuristic played 860 games against another heuristic and every agent had a process time of 150ms to achieve an answer for it's move. Based on it have been made a table with this result.

		AB_Improved		AB_Custom		AB_Custom_2		AB_Custom_3	
Match #	Opponent	Won	Lost	Won	Lost	Won	Lost	Won	Lost
1	Random	712	148	735	125	706	154	721	139
2	MM_Open	509	351	541	319	521	339	537	323
3	MM_Center	605	255	573	287	583	277	584	276
4	MM_Improved	495	365	489	371	520	340	488	372
5	AB_Open	443	417	421	439	432	428	455	405
6	AB_Center	503	357	488	372	516	344	511	349
7	AB_Improved	437	423	405	455	453	407	415	445
Win Rate:		0,615282392		0,6066445183		0,6197674419		0,6164451827	

Table 1 - Results of analysis

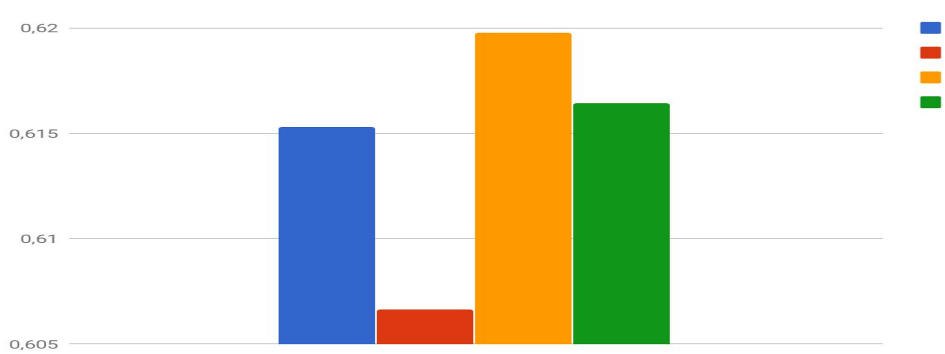

Image 3 - Relative values of the analysis

2. CONCLUSION

The three heuristics functions considers the situation of both players to keep playing the game using as a parameter the possibility of it to make a move in the next position, but the chosen heuristics was the second one. The first reason for choosing the second is that it has the lower computational cost of the three presented one. In comparison with the first heuristics, which is the hardest to compute from the four ones, once it needs up to 49 times more time to compute a single evaluation, it to goes deeper in the search tree and can surpass quiescent search situations. Another point can be viewed in comparison with the third heuristics, this one as described has a nature of follows the opponent moves, but once it has a higher power(which is hard to compute) it can accomplish the move which can leads to the loss if it does not have enough time to surpass the quiescent search situation.

All of those can be clearly seen in the collected data by the tournament matches, which shows a decreasing game performance once the necessary time to compute the heuristics grows, showing the first heuristics as the lower in game performance, even lower than AB_Improved, once it is the hardest to compute. The third heuristics shows a slight difference to the second heuristics once it is just a bit harder to compute and the best performance going to the second heuristics, but for a better result the second one have been chosen.