Ramon Prieto

May 29, 2017

Heuristic Analysis

Our Isolation playing agents use a Minimax tree search algorithm to find the next move and use Alpha-Beta pruning to improve searching times. The efficacy of each move will be evaluated using a hybrid of the three different methods shown below. Each agent will play 20 games against a “Random” agent that selects its next move randomly, a “MM Improved” agent, and a “AB Improved” agent. The “MM Improved” and “AB Improved” agents use the same heuristic to evaluate their moves but the latter uses Alpha-Beta pruning to optimize its minimax tree search algorithm, while the former does not. A successful agent will have a high winning percentage, ideally, larger than the “AB Improved” agent.

Method #1

Method #1 is based on using space availability in the board to create a varying evaluation metric. It uses the number of available spaces as a weight in the score and allows our agent to have a strategy that changes as the game advances. The board in the game has a width and height of 7 spaces, so there are 49 spaces total.

Two cases are considered for this method. In the first case, the moves will be evaluated using the following formula, (occupied spaces * moves available to agent) - (available spaces * available moves to opponent), which will make the agent search for moves that reduce the mobility of the opponent at the start of the game and search for moves that maximize it's own mobility at the end of the game. In the second case, the weights are interchanged so that the behavior of the agent is defensive at the start of the game and offensive at the end. The results from both cases are shown below in Table 1.

Table 1: Winning Rates For Agents In Method #1

Opponent	AB Improved		First Case		Second Case	
	Won	Lost	Won	Lost	Won	Lost
Random	16	4	19	1	20	0
MM Improved	15	5	16	4	14	6
AB Improved	7	13	7	13	9	11
Win Rate	**63.4%**		**70%**		**71.7%**	

The second case results in a higher winning rate (71.7% vs. 70%). However, none of the agents are able to get a higher winning rate than the “AB Improved” agent. On the next method we'll explore using fixed weights.

Method #2

Method #2 uses fixed weights, varying from 1/4 to 4, on the number of moves available to our agent. In contrast to method #1 our agent will maintain the same strategy throughout the game. It'll be aggressive with smaller weights, focusing in minimizing the available moves the opponent has, and turn more defensive as the weight increases. Figure 1 below shows the winning rate of our agent for each different weight.

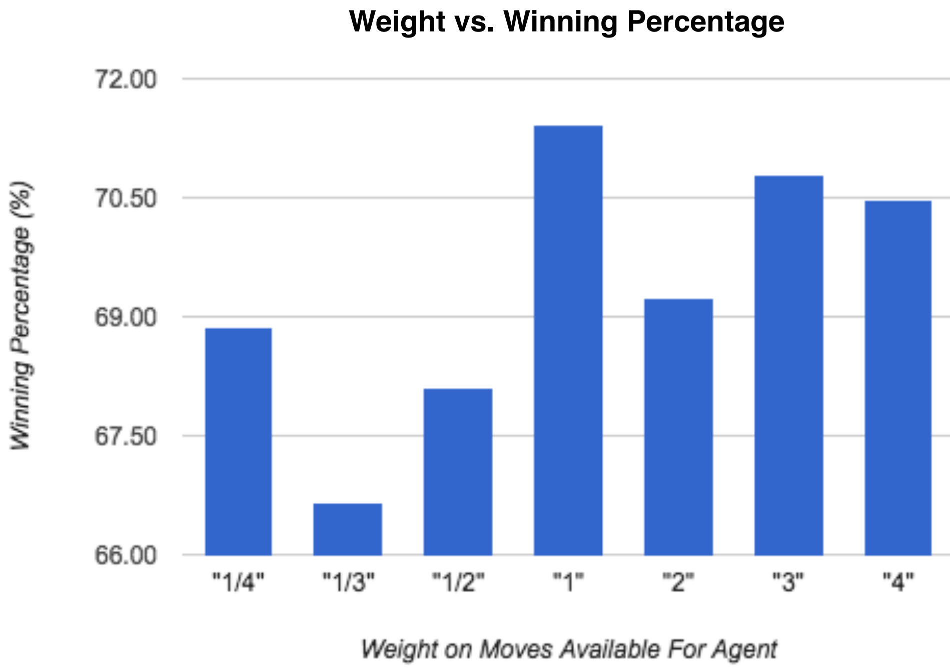

Figure 1: Winning percentages for agents with different weight on their evaluation metric

It is clear that the agent performs better when prioritizing its own survival rather than trying to reduce the life span of the opponent. Yet, as seen in Figure 1, the performance of our agent begins to degrade if the importance of limiting the moves available to our opponent becomes too small. Our agent performs best when using a weight of 1, which results in the same evaluation metric the “AB Improved” agent uses.

Method #3

Method #3 uses the squared distance between the two player to determine the next move. Two case are considered. In one case the agent will try to minimize the distance between the opponent with each move and in the other, it will try to maximize it. The results from both cases are shown below in Table 2.

Table 2: Winning Rates For Agents In Method #3

Opponent	**AB Improved**		**Max. Distance**		**Min. Distance**	
	Won	Lost	Won	Lost	Won	Lost
Random	18	2	18	2	19	1
MM Improved	14	6	16	4	11	9
AB Improved	11	9	10	10	9	11
Win Rate	**71.6%**		**67.1%**		**65%**	

Merging Methods

All individual methods resulted in relatively good performing agents. Now they are merged together. Using method #1 we can have our agent begin a game focused on maximizing the distance between it and its opponent using method #3, which should create a board with more distributed occupied spaces, and end the game focused on maximizing its own moves and minimizing those of the opponent using method #2. This newly created agent is compared to the "AB Improved" agent in Table 3.

Table 3: Winning Rates For The "Merged Methods"Agent

Opponent	**AB Improved**		**Max. Distance + Balanced Moves**	
	Won	Lost	Won	Lost
Random	20	0	19	1
MM Improved	18	2	16	4
AB Improved	8	12	12	8
Win Rate	**76.7%**		**78.3%**	

Finally, the following heuristics are compared in Figure 2.

Max. Distance + Balanced Moves:

Filled Spaces*(3*My Moves - Opponent Moves) + Free Spaces*(Squared Distance Between Players)

Max. Distance:

Squared Distance Between Players

Balanced Moves:

3*My Moves - Opponent Moves

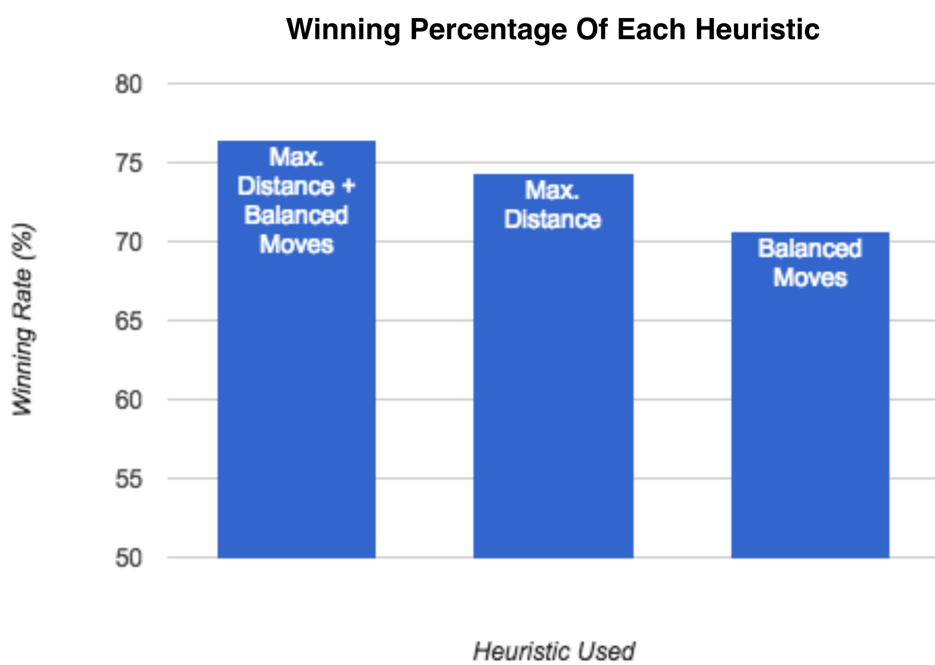

Figure 2: Comparison between the heuristic functions used to evaluate possible moves

Recommendation

The "Max. Distance. + Balanced Moves" heuristic results in the greatest win rate, while maintaining the same time complexity (O(b^d)) as the other heuristics. Moreover, the heuristic function is easy to implement and understand. Therefore, it is recommended as the main score function.

Conclusion

None of the evaluation methods discussed result in an evaluation metric that is clearly better than the one used by the “AB Improved” . However, when they were merged together in the “Max. Distance. + Balanced Moves” heuristic, the winning rate went up and the one on one match against “AB Improved” was won. It is important to note that due to the relatively small number of games being played in each tournament, the statistics can be volatile and are not fully representative of the performance of each agent. None the less, they shed light on their approximate level.