Heuristic Evaluation for Advanced Game Playing Project (Udacity AI ND)

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This paper presents a brief discussion of various heuristics (value functions) used by the iterative deepening alpha beta search technique playing the game of Isolation with chess-knight rules.

Many heuristics were investigated, but the three chosen were:

1. an available moves ratio heuristic, which attempted to improve on the available moves difference heuristic, by incorporating the magnitude of the numbers, as well as their relative magnitudes. For instance, a difference heuristic would equally weight 2 – 1 and 3 – 2 as being 1, however the ratio heuristic would rate 2/1 higher than 3/2. Therefore, the fewer number of moves the opponent has, the better the score. To be consistent and because 4/2 = 2/1, we subtract the active player's possible move count by 8 (the max).
2. a “humble”/”inferiority-complex” version of the available moves heuristic. This heuristic assumes that if the player in question is the active player, then any moves taken from this point on will only reduce their options. In a sense, it attempts to optimize the options available, while still comparing them in a ratio fashion to the number of opponent's options.
3. a “hiding” heuristic. This heuristic seeks out areas that are crowded and attempts to run through them, creating blocks of unusable areas for the opponent (theoretically).

As can be seen in the tables below, all algorithms outperformed the random player. Interestingly, the AB_Improved sometimes lost to the MM_Improved, which is unexpected, but perhaps due to shortcomings in the heuristic or due to some other random factor in the tournament logic.

Below are some typical results, using a ***short time limit*** (20 ms) and 25 matches:

Opponent	AB_Improved		Ratio Heur.		“Humble” Heur.		Hiding Heur.	
	Won	Lost	Won	Lost	Won	Lost	Won	Lost
Random	**42**	8	**46**	4	**44**	6	**42**	8
MM_Open	**28**	22	**29**	21	**34**	16	22	**28**
MM_Center	**33**	17	**42**	8	**37**	13	**43**	7
MM_Improved	22	**28**	22	**28**	**27**	23	**28**	22
AB_Open	**27**	23	**31**	19	**26**	24	**27**	23
AB_Center	25	25	**30**	20	24	**26**	24	**26**
AB_Improved	25	25	**28**	22	**27**	23	**27**	23
Win Rate	57.7%		65.1%		62.6%		60.9%	

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Below are results taken with a ***time limit of 50, 75, and 150ms*** and 20 or 25 matches:

Time	Opponent	AB_Improved		Ratio Heur.		“Humble” Heur.		Hiding Heur.	
		Won	Lost	Won	Lost	Won	Lost	Won	Lost
50	AB_Improved	23	27	27	23	27	23	25	25
50	Win Rate	46%		54%		54%		50%	
75	AB_Improved	19	21	21	19	21	19	18	22
75	Win Rate	47.5%		52.5%		52.5		45%	
150	AB_Improved	25	25	26	24	24	26	25	25
150	Win Rate	50%		52%		48%		50%	

As can be seen, the ratio heuristic out performed all others in the short and long tests. Both the humble and the hiding heuristics performed well also. The longer games produced more of a break-even scenario, in which case it's likely that much of the search space was discovered in the longer time (the CPU to run these tests was built within the past 2 months). Therefore, the shorter games are the most revealing.

The ratio heuristic is recommended, because it achieved the highest win ratio across all opponents, it is fast, and it preserves information about the active player's and opponent's number of moves, as well as their relative magnitudes.