Research Paper

Vasiliy Mikhailov

Udacity Artificial Intelligence

Isolation Game

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Heuristic functions for Isolation Game

Summary: three functions were implemented and studied:

1) Chase score
2) Next move score
3) In isolation score
4) Chase + In isolation score

Best results were achieved with Chase + In isolation score, that gives 83% of wins (+/- 6% 95%, sure) over 76% (+/- 6%, 95% sure) for Improved score.

Chase score. The idea behind this heuristic is to generalise two heuristics - open score heuristic and improved heuristic - in one function and find maximum of generalised function. Those two heuristics can be generalised as: Chase score = w1 * player_legal_moves - w2 * opponent_legal_moves, where w1 and w2 are weights in range [0..1]. For open score heuristics w1 is 1 and w2 is 0, for improved w1 is 1 and w2 is 1.

To find maximum of Chase score I studied following set of (w1, w2) = (1.0, 1.0), (0.75, 1.0), (0.5, 1.0), (0.25, 1.0), (0.0, 1.0), (1.0, 0.75), (1.0, 0,5), (1.0, 0,25), (1.0, 0.0) for 10 runs 5 games 150 ms turn. Reason why 10 runs of 5 games was chosen over 1 run of 50 games is because analysing 10 runs can provide standard deviation and give hint on win rate average along with precision, while 1 run 50 games can provide only win rate average. Studying set mentioned above, I found maximum in (w1, w2) = (0.25, 1), then I checked values near maximum (w1, w2) = (0.25, 1.0) stepping half left and half right from 0.25 to closest known value, which gave me next maximum, and I stepped

half left and half right again to known maximum, until I found maximum of Chase score function in point (w1, w2) = (0.3125, 1.0), with win ratio 83%, std dev = 3%, it turned to be better by 6% than Improved score (w1, w2) = (1.0, 1.0) with win ratio 77%, std dev 3%. Detailed data is shown in Table 1.

Table 1. Output of Chase score with different w1 and w2

Round	w1	w2	win rate	std dev	Advantage over Improved score
1	1	1	76% (*)	3%	0%
1	0,75	1	80%	2%	4%
1	0,5	1	80%	3%	4%
1	0,25	1	**81%**	2%	5%
1	0	1	73% (**)	3%	-3%
1	1	0,75	80%	3%	4%
1	1	0,5	76%	3%	0%
1	1	0,25	77%	3%	1%
1	1	0	73%	3%	-3%
2	0,375	1	80%	2%	4%
2	0,125	1	80%	3%	4%
3	0,3125	1	80%	3%	4%
3	0,1875	1	**81%**	2%	5%
4	0,28125	1	81%	2%	5%
4	0,21875	1	81%	4%	5%
4	**0,15625**	**1**	**82%**	**2%**	**6%**

(*) - Improved score, (**) - Open move score, (***) - Chase score

Win ratio of Chase score is 82%, std dev 2%.

Interpretation of Chase score: number of opponent's available moves is times more important than number of my own available moves, so I should chase opponent and reduce number of his moves (step on his available cell) whenever it is possible.

Heuristic pros: very fast on every stage of game, better than Improved score, can be combined with other heuristics

Heuristic cons: not very efficient

Next move score. Idea behind this heuristic: if player and opponent has equal number of moves, then compare number of moves available next move.

Complete formula can be written as: player_legal_moves + player_next_moves * 0.1 - opponent_legal_moves - opponent_legal_next_moves * 0.1

This heuristic gives win ratio 79%, std dev 2% over Improved score.

Heuristic pros: very fast on every stage of game

Heuristic cons: not very efficient, cannot be combined with Chase score.

In isolation score. Idea behind this heuristic: if player and his opponent are separated, then only number of player moves matter, so we can completely ignore opponent number of moves evaluating our turn. Since checking if player and his opponent are isolated, I chose to apply this heuristic only from turn N (like 30), before that Improved score is used.

Round	Move from which heuristic is applied	win rate	std dev	Advantage over Improved score
1	5	47%	3%	-29%
1	15	54%	3%	-22%
1	25	77%	2%	1%
1	35	78%	2%	2%
1	45	78%	2%	2%
2	30	77%	2%	1%
2	40	77%	2%	1%
3	34	**81%**	2%	5%
3	36	79%	1%	3%
4	31	76%	2%	0%

Round	Move from which heuristic is applied	win rate	std dev	Advantage over Improved score
4	32	78%	3%	2%
4	33	76%	2%	0%

This heuristic gave me win ratio 78% and std dev 2% with N = 30.

Pros: moderate speed on late stages of game, can be combined with Chase score.

Cons: very slow on early stages of game, hard to tell if it is early stage of game or not, quick study showed that move 25 is early, move 30 is not.

Possible future research on In isolation score (not for this paper) - basically it is better to evaluate longest path instead of open move heuristics when players are isolated and there's no need to evaluate opponent's moves, so it can be done much more cheaper on late stages of game.

Chase + In isolation score. This is combination of Chase with (w1, w2) = (0.3125, 1.0) before move 30 and In isolation score from move 30.

This heuristic gives win ratio 83%, std dev 3% over Improved score.

Heuristic chosen. Chase + In isolation score was chosen as recommended heuristic. It's pros:

1) 7% better than Improved score
2) Fast on early stages of game
3) Has moderate speed on end stages of game
4) Has reasoning for Chase part - limiting number of opponent moves is more important than having large number of own moves
5) Has reasoning for In isolation part - when players are isolated, opponent movement does not matter, the only task is to keep player moving.