

Heuristics Analysis for Game Isolation

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Abstract—This report will summarize three heuristics functions - move score, center focused score, a combined score of the above two with different weights, which changes depends on the progress of the game. These heuristics functions have been studied for their effectiveness in helping build a game agent to play the game Isolation.

I. HEURISTICS FUNCTIONS OVERVIEW

THREE heuristic functions chosen for evaluating the game agent of Isolation game are:

- 1) moves calculation heuristics: This evaluation function uses the number of player's move minus the number of opponent move with a weight factor to adjust the aggressiveness of player going after the opponent.

$$N_{my_move} - opp_weight * N_{opp_move}$$

- 2) Center focus strategy: This function is under the assumption that it is an advantage to occupy the closer-to-center cells. This will provide player more space for future moves. The center focused heuristic function gives more score for cells in the center. The edge cells, on the other hand, might give the opponent opportunities to block the player, therefore are given less scores. A linear scoring system is utilized and the center square of the board is given the highest score, whereas all its direct vertical, horizontal and diagonal neighbors have 1 point less in score. The same trend goes on and the edge of the board has the lowest score.

$$F = center_Score - layer_from_center$$

Table I here demonstrates the scoring system for center focused strategy on a 5*5 board. On the given 9*9 board, center cell score is set as 4.5, to avoid having 0 set to the edge squares.

TABLE I
CENTER FOCUSED SCORE

2.5	2.5	2.5	2.5	2.5
2.5	3.5	3.5	3.5	2.5
2.5	3.5	4.5	3.5	2.5
2.5	3.5	3.5	3.5	2.5
2.5	2.5	2.5	2.5	2.5

- 3) The combined strategy: This strategy combines the move function and the center focused function. They are given different weights based on the progress of the game. At the first half of the game, it is more crucial to stay as close to the center as possible whereas towards the end of the game, number of moves left are more

emphasized.

The proposed heuristic function combines the above two functions and give them different weights at different stages of the game. The overall score is the addition of the above two scores with different weights to adjust for their contributions.

At the first half of the game:

$$F = Score_{move} + game_weight * Score_{center}$$

At the second half of the game:

$$F = game_weight * Score_{move} + Score_{center}$$

II. PERFORMANCE STUDY

The weight for move function is selected through agents self play. Agents using with move function as heuristics play against each other, the only variable changed here is the opp_weight used for opponent moves. The result shows that 4.0 as the optimized value. The move heuristic function therefore becomes:

$$N_{my_move} - 4.0 * N_{opp_move}$$

Same procedure has been followed to determine the game_weight for the combined heuristic function. 5.0 has been elected to maximize winning, the combined score evaluation function therefore becomes:

$$F = Score_{move} + 5.0 * Score_{center}$$

for the first half of the game, while:

$$F = 5.0 * Score_{move} + Score_{center}$$

for the second half of the game.

Table II illustrates the result of three candidate heuristics used as evaluation functions for the agent to play against nominal agents. It show that combined score heuristics provides the best average winning rate of 91.67%, which is a significant improvement of ID_Improved's 79.53%.

TABLE II
GAME WINNING RATIO OF HEURISTICS AGAINST NOMINAL AGENTS

	ID_Improved	Move	Center	Combine
Match 1	76.43%	84.29%	81.43%	90.71%
Match 2	79.29%	87.86%	76.43%	92.86%
Match 3	82.86%	90.71%	82.14%	91.43%
Average	79.53%	87.62%	80%	91.67%

The combined score heuristic function has also been studied through playing the other two candidate heuristics as well as ID_Improved in order to confirm whether it remains a winning strategy. The result is shown in Table III. The combined score heuristic function has demonstrated a consistent winning rate of 56.67%, 58.33% and 66.67% against all three other heuristics.

TABLE III
DIRECT BATTLE OF HEURISTICS

	Against ID_Improved	Against Move_Function	Against Center_Focused
Match 1	55%	55%	60%
Match 2	55%	55%	70%
Match 3	60%	65%	70%
Average	56.67%	58.33%	66.67%

III. CONCLUSION

After evaluating three heuristic functions through game play against varies of agents, the heuristic function with a combined score of moves function and center focused function is elected. It emphasizes on these two strategies based on the progress of the game. The result shows a significant increase in game winning ratio of **91.67%**, in comparison to **79.53%** in ID_Improve baseline.

The reasons for selecting the combined score heuristics are as following:

- It uses different weights depending on the progress of the game, which adjusts itself to focus on different winning strategies accordingly. Compared to the other two heuristics, which employs the same strategy throughout the game, the combined score heuristic gives different focus points. It acts smarter in the game.
- It provides the best performance in the winning ratio against nominal agents among the three heuristics.
- When directly competing against the other two chosen heuristics and the baseline, it is more likely to beat the other heuristic agents. The "direct combat" provides more confidence for the combined score heuristic.
- It makes the search more efficient to carry out without compromising on the performance. At the beginning of the game, when it is more important to occupy the center cells, the search algorithm doesn't have to concern itself with the opponent's moves. It only has to pick moves from a static book which is center focused only. Only at the last half of the game, it calculates the moves of its own and the opponent's. Compared to the moves focused heuristic, it simplified the search for half of the game. Although the center-focused heuristic is even simpler in search compared to the combined-score one, it compromised on performance. Overall, the combined score heuristic presents the best choice among these three.