HEURISTIC ANALYSIS FOR AN ISOLATION GAME ON A 7X7 BOARD WITH L-SHAPED MOVEMENTS

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***Abstract**: Development of an an adversarial search agent to play the game "Isolation". Isolation is a deterministic, two-player game of perfect information in which the players alternate turns moving a single piece from one cell to another on a board. Whenever either player occupies a cell, that cell becomes blocked for the remainder of the game. The first player with no remaining legal moves loses, and the opponent is declared the winner.*

***Keywords:** isolation, artificial intelligence, alphabeta pruning, heuristic*

1. Introduction

This document goes through the analysis of heuristics used to evaluate the score of an adversarial search agent used to play the game "Isolation". Isolation is a deterministic, two-player game of perfect information in which the players alternate turns moving a single piece from one cell to another on a board. Whenever either player occupies a cell, that cell becomes blocked for the remainder of the game. The first player with no remaining legal moves loses, and the opponent is declared the winner. This paper consider a version of Isolation where each agent is restricted to L-shaped movements (like a knight in chess) on a rectangular grid (like a chess or checkerboard). The agents can move to any open cell on the board that is 2-rows and 1-column or 2-columns and 1-row away from their current position on the board. Movements are blocked at the edges of the board (the board does not wrap around), however, the player can "jump" blocked or occupied spaces (just like a knight in chess). Additionally, agents will have a fixed time limit each turn to search for the best move and respond. If the time limit expires during a player's turn, that player forfeits the match, and the opponent wins.

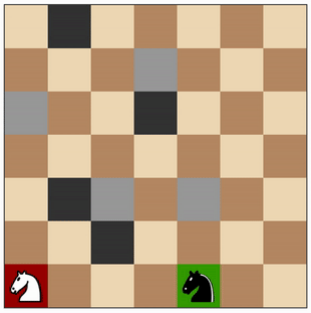

Figure 1: 7x7 Board where the white horse loses

2. Heuristic functions

The information used to build the heuristics to play the game are: the number of available movements for the player, the number of movements for the opponents, the distance respect to the center of the board. The benefit of using this information is that our calculation doesn't rely on the history or the future, but it just depends on the current state of the board with benefits for performance. The heuristic functions compared to find the best approach are seven and have been evaluated after 65 games. In the end, we'll compare the scores with the ones achieved with an *AB_Improved* heuristic that reached a score of 69,1%.

2.1 Heuristic 1: Difference of the squares of the win chances

The heuristic uses the win chances for the player and the opponent and combine them in non-linear function that gives more weight to its elements the more they increase their value. The score is based on the following evaluation function:

$$f(p_{move}, o_{move}) = {p_{move}}^2 - {o_{move}}^2$$

Where p_{win}= movements available to the player and o_{move}= movements available to the opponent.

The final win rate is: 69,14%

2.2 Heuristic 2: Lower opponent movements available

The heuristic uses the win chances for the player and the opponent and tries to maximize the movement of the player as giving more weight to the movement available to the opponent. The score is based on the following evaluation function:

$$f(p_{move}, o_{move}) = p_{move} - 2 \cdot o_{move}$$

Where p_{win}= movements available to the player and o_{move}= movements available to the opponent.

The final win rate is: 69,6%

2.3 Heuristic 3: Increase player movements available

The heuristic uses the win chances for the player and the opponent and tries to maximize the movement of the player giving more weight to the movement available to the player. The score is based on the following evaluation function:

$$f(p_{move}, o_{move}) = 2 \cdot p_{move} - o_{move}$$

Where p_{win}= movements available to the player and o_{move}= movements available to the opponent.

The final win rate is: 71,86%

2.4 Heuristic 4: Compare movements available to the players balancing weights in to prefer states where the opponent has less movements

The heuristic uses the win chances for the player and the opponent and tries to maximize the movement of the player applying weights to balance the selection of the state in favor of the states where the opponent has less movements available. The score is based on the following evaluation function:

$$f(p_{move}, o_{move}) = 0{,}3 \cdot p_{move} - 0{,}7 \cdot o_{move}$$

Where p_{win}= movements available to the player and o_{move}= movements available to the opponent.

The final win rate is: 67,48%

2.5 Heuristic 5: Compare movements available to the players balancing weights in to prefer states where the player has more movements

The heuristic uses the win chances for the player and the opponent and tries to maximize the movement of the player applying weights to balance the selection of the state in favor of the states where the player has more movements available. The score is based on the following evaluation function:

$$f(p_{move}, o_{move}) = 0{,}7 \cdot p_{move} - 0{,}3 \cdot o_{move}$$

Where p_{win}= movements available to the player and o_{move}= movements available to the opponent.

The final win rate is: 70,00%

2.6 Heuristic 6: Compare movements available to the players balancing weights in to prefer states where the player has more movements and the player position is closer to the center of the board

The heuristic uses the win chances for the player and the opponent and tries to maximize the movement of the player applying weights to balance the selection of the state in favor of the states where the player has more movements available and its position is closer to the center of the board. The score is based on the following evaluation function:

$$f(p_{move}, o_{move}, w, h, x, y) = (0{,}7 \cdot p_{move} - 0{,}3 \cdot o_{move}) + 0.01 * ((h - y)^2 + (w - x)^2)$$

Where p_{win}= movements available to the player, o_{move}= movements available to the opponent, h = player position on the y-axis, w = player position on the x-axis, h = x-axis coordinate of the center of the board and w = y-axis coordinate of the center of the board.

The final win rate is: 71,00%

2.7 Heuristic 7: Compare movements available to the players balancing weights in to prefer states where the opponent has less movements and the player position is closer to the center of the board

The heuristic uses the win chances for the player and the opponent and tries to maximize the movement of the player applying weights to balance the selection of the state in favor of the states where the opponent has less movements available and its position is closer to the center of the board. The score is based on the following evaluation function:

$$f(p_{move}, o_{move}, w, h, x, y) = (0{,}3 \cdot p_{move} - 0{,}7 \cdot o_{move}) + 0.01 * ((h - y)^2 + (w - x)^2)$$

Where p_{win}= movements available to the player, o_{move}= movements available to the opponent, h = player position on the y-axis, w = player position on the x-axis, h = x-axis coordinate of the center of the board and w = y-axis coordinate of the center of the board.

The final win rate is: 71,22%

3. Win rates comparison

Below is the table summarizing all the results obtained after 65 games with the 7 heuristics along with the *AB_Improved* they are compared with:

Heuristic	*Win Rate*
AB_Improved	69,1%
Heuristic 1	69,14%
Heuristic 2	69,6%
Heuristic 3	71,86%
Heuristic 4	67,48%
Heuristic 5	70,00%
Heuristic 6	71,00%
Heuristic 7	71,22%

Table 1 Heuristic win rate

4. Conclusions

The test showed that all the heuristic did better than the *AB_Improved* after 65 games. The best performance has been obtained by applying the Heuristic 3, that applies a linear multiplicative factor to give more weight to the movements available to the player respect to the one available to the opponent. Thus, the Heuristic 3 is the recommended one becase:

- It has the highest win rate
- It uses both the information about the player and the opponents, which is critical when it comes to considering which move to make.
- It depends just on the movements available to the player and its opponent at a given state, without making any other calculation