

Heuristic Comparison in Minimax Algorithm for Chain Reaction Game

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1 Introduction

This report is based on the comparison of different heuristics used in the minimax algorithm in the Chain Reaction game. The heuristics have been compared based on the in-game performance of the agent and the time taken depending on the given depth.

2 Heuristics Description

Controlled Cell Difference

This heuristic calculates the number of cells controlled by the AI and the opponent and returns the difference. The idea is that the more cells controlled, the stronger the board position.

$$\text{Score} = \text{AI-controlled cells} - \text{Opponent-controlled cells}$$

Orb Count Difference

This heuristic calculates the number of orbs of the AI and the opponent and returns the difference.

$$\text{Score} = \text{AI total orbs} - \text{Opponent total orbs}$$

Edge Preferred Controlled Cell Difference

This heuristic specifically looks at edge and corner cells, giving preference to stable positions near the boundaries.

$$\text{Score} = (2 * \text{AI edge cells} + \text{other AI cells}) - (2 * \text{Opponent edge cells} + \text{other opponent cells})$$

Edge Preferred Orb Count Difference

This is a more refined version of the previous heuristic, preferring not just the number but the total orb count in edge cells.

$$\text{Score} = (2 * \text{AI edge orbs} + \text{other AI orbs}) - (2 * \text{Opponent edge orbs} + \text{other opponent orbs})$$

Critical Mass Proximity

This heuristic measures the proportion of orbs existing to the critical mass of a cell and returns the difference. This technique prefers cells that are close to exploding.

$$\text{Score} = \sum_{\text{AI cells}} \left(\frac{\text{cell_orbs}}{\text{critical_mass}} \right) - \sum_{\text{Opponent cells}} \left(\frac{\text{cell_orbs}}{\text{critical_mass}} \right)$$

3 Experimental Results

Table 1: Match Results for Controlled Cell Difference as Player 1

Player 2 (Heuristic)	Depth	Winner	Time Taken
Heuristic1	0	Player 1	00:00
	1	Player 1	00:02
	2	Player 2	00:05
	3	Player 2	00:42
Heuristic2	0	Player 1	00:00
	1	Player 2	00:01
	2	Player 1	00:05
	3	Player 2	01:06
Heuristic3	0	Player 1	00:02
	1	Player 1	00:02
	2	Player 1	00:07
	3	Player 1	00:52
Heuristic4	0	Player 1	00:00
	1	Player 2	00:01
	2	Player 1	00:05
	3	Player 2	00:56
Heuristic5	0	Player 1	00:00
	1	Player 1	00:00
	2	Player 1	00:11
	3	Player 1	01:27

Table 2: Match Results for Orb Count Difference as Player 1

Player 2 (Heuristic)	Depth	Winner	Time Taken
Heuristic1	0	Player 1	00:00
	1	Player 1	00:01
	2	Player 2	00:05
	3	Player 1	00:11
Heuristic2	0	Player 1	00:00
	1	Player 2	00:02
	2	Player 1	00:06
	3	Player 1	00:48
Heuristic3	0	Player 1	00:00
	1	Player 1	00:02
	2	Player 1	00:05
	3	Player 1	01:00
Heuristic4	0	Player 2	00:00
	1	Player 1	00:05
	2	Player 2	00:09
	3	Player 1	01:15
Heuristic5	0	Player 1	00:00
	1	Player 1	00:00
	2	Player 2	00:09
	3	Player 1	01:36

Table 3: Match Results for Edge Preferred Controlled Cell Difference as Player 1

Player 2 (Heuristic)	Depth	Winner	Time Taken
Heuristic1	0	Player 2	00:01
	1	Player 2	00:02
	2	Player 1	00:04
	3	Player 2	00:54
Heuristic2	0	Player 2	00:00
	1	Player 2	00:02
	2	Player 2	00:05
	3	Player 2	00:54
Heuristic3	0	Player 1	00:01
	1	Player 2	00:02
	2	Player 2	00:07
	3	Player 1	01:13
Heuristic4	0	Player 1	00:01
	1	Player 2	00:02
	2	Player 2	00:02
	3	Player 2	01:09
Heuristic5	0	Player 2	00:01
	1	Player 2	00:02
	2	Player 1	00:08
	3	Player 2	01:10

Table 4: Match Results for Edge Preferred Orb Count Difference as Player 1

Player 2 (Heuristic)	Depth	Winner	Time Taken
Heuristic1	0	Player 1	00:00
	1	Player 1	00:02
	2	Player 1	00:11
	3	Player 2	00:47
Heuristic2	0	Player 2	00:01
	1	Player 2	00:01
	2	Player 1	00:08
	3	Player 1	01:26
Heuristic3	0	Player 1	00:00
	1	Player 1	00:02
	2	Player 1	00:05
	3	Player 1	01:00
Heuristic4	0	Player 1	00:00
	1	Player 1	00:03
	2	Player 2	00:09
	3	Player 1	01:11
Heuristic5	0	Player 1	00:02
	1	Player 2	00:02
	2	Player 1	00:05
	3	Player 1	01:26

Table 5: Match Results for Critical Mass Proximity as Player 1

Player 2 (Heuristic)	Depth	Winner	Time Taken
Heuristic1	0	Player 1	00:00
	1	Player 1	00:02
	2	Player 2	00:08
	3	Player 1	00:51
Heuristic2	0	Player 1	00:00
	1	Player 2	00:02
	2	Player 2	00:07
	3	Player 2	00:52
Heuristic3	0	Player 1	00:00
	1	Player 1	00:02
	2	Player 1	00:09
	3	Player 1	01:11
Heuristic4	0	Player 1	00:01
	1	Player 1	00:02
	2	Player 2	00:09
	3	Player 1	01:03
Heuristic5	0	Player 1	00:00
	1	Player 1	00:00
	2	Player 2	00:09
	3	Player 1	01:34

Table 6: Heuristic Performance (Win Rate %)

Heuristic	Win Rate
Controlled Cell Difference	56.25%
Orb Count Difference	71.87%
Controlled Edge Cell Difference	9.37%
Edge Cell Orb Count Difference	68.75%
Critical Mass Proximity	25%

4 Discussion

From the table, it can be seen that the **Orb Count Difference** heuristic performs better in the given circumstances. However, an increase in depth improves the ability of each heuristic. Also, as the depth increases, the time taken by the heuristics and the algorithm also increases.

The **Orb Count Difference** and **Edge Cell Orb Count Difference** heuristics also perform well, suggesting that both orb quantity and positional advantage contribute significantly to success.

In contrast, **Controlled Edge Cell Difference** and **Critical Mass Proximity** were relatively less effective, indicating that focusing only on position without considering orb count may not be sufficient.