

Experimentation and Analysis of Chain Reaction AI Agents

Rageeb Hasan Shafee

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1 Introduction

Chain Reaction is a turn-based strategy game played on a 9×6 grid (default), where players take turns placing orbs in cells. When a cell exceeds its critical mass, it explodes, sending orbs to neighboring cells and potentially triggering chain reactions. The objective is to eliminate all of the opponent's orbs. This report analyzes the performance of different AI agents (Random, Minimax with various depths and heuristics) and compares them with human play.

2 Experimental Setup

2.1 Board Size

- The game is played on a 9×6 grid.

2.2 Agents

- **Random Agent:** Selects moves randomly.
- **Minimax Agent:** Uses minimax with alpha-beta pruning and custom heuristics.

2.3 Depths Tested

The following depths were tested for the Minimax agent:

- Depth 1
- Depth 2
- Depth 3
- Depth 4

2.4 Heuristics

- Heuristic 1: Simple Orb-Count Difference.
- Heuristic 2: Weighted by Critical Mass Proximity.
- Heuristic 3: Position Control
- Heuristic 4: Stability.
- Heuristic 5: Terrority.

2.5 Time Measurement

The time per move was measured, and total game time was recorded to compare efficiency.

2.6 Matches

- Minimax at depth d_1 vs. Minimax at depth d_2 (same heuristic).
- Minimax heuristic h_1 vs. Minimax heuristic h_2 (fixed depth).
- Human vs. AI (Minimax).

3 Results

3.1 Detailed Comparison Tables

3.2 Key Findings

- **Effect of Depth:** Increasing depth improves win rate but also increases computation time per move.

winner	red_agent	blue_agent	blue_depth	blue_heuristic
Blue	Human	minimax	2	0
Blue	Human	minimax	2	1

Table 1: Human vs AI Game Comparison

winner	red_agent	blue_agent	red_depth	blue_depth	winning_time
Red	Heuristic1	Heuristic2	2	2	1.54mins
blue	Heuristic1	Heuristic1	0	1	2.05mins

Table 2: AI vs AI Game Comparison

- **Heuristic Performance:** Heuristic 1 (Weighted by Critical Mass Proximity) outperforms the basic heuristic in some matchups, particularly in controlling corners and edges.
- **Human vs. AI:** The AI (Minimax) consistently outperforms human players at default settings.

4 Discussion

The experiments show that:

- **Minimax Strength:** The Minimax AI, even at depth 2, is substantially more effective than the Random agent.
- **Depth and Time Trade-offs:** While higher depths increase the AI’s win rate, they also make the decision-making process slower, especially for real-time play.
- **Human vs AI:** The Minimax AI consistently outperforms human players, showcasing its strategic depth.

5 Conclusion

Minimax with alpha-beta pruning and well-designed heuristics provides a strong AI for the Chain Reaction game. The performance and speed of the AI are influenced by both the depth and the heuristic choice. While higher

depths offer higher win rates, they can lead to longer move times, making them impractical for real-time play. Future improvements could include iterative deepening, transposition tables, or adaptive heuristics for even stronger and faster AI.