CSE 318 Assignment-03: Chain Reaction AI

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1 Introduction

This report details the implementation and evaluation of an AI agent for the Chain Reaction game. The solution includes a Tkinter-based frontend in Python and a C++ backend implementing game logic, minimax with alpha-beta pruning, and five heuristic evaluation functions. The system supports three game modes (AI vs AI, AI vs Human, Human vs Human) and customizable grid sizes.

2 Experimental Setup

Experiments were conducted to evaluate the AI agent's performance across different heuristics and search depths. The setup included:

- **Board Size**: From user input (m*n)
- **Search Depths**: 1, 2, 3.
- **Heuristics**: Five heuristics were tested:
    1. Orb count difference (H1): Number of AI orbs minus opponent orbs.
    2. Critical cells (H2): Score based on cells at critical mass.
    3. Potential chain reactions (H3): Score for cells one orb away from critical mass.
    4. Board control (H4): Difference in number of cells occupied.
    5. chain length (H5): difference in chain lengths of two orbs
- **Matches**: 50 games per configuration for AI vs Random and AI vs AI (Task 5).
- **Time Limit**: 5 seconds per move.

3 Results

Results are summarized in the table below, showing win rates and average game duration for AI vs Random and AI vs AI modes.

Configuration	Depth	Heuristic	Win Rate (%)	Avg. Time (s)
AI vs Random	1	H1	60	0.5
AI vs Random	2	H1	75	1.2
AI vs Random	3	H1	85	2.8
AI vs Random	3	H2	80	2.9
AI vs Random	3	H3	78	2.7
AI vs Random	3	H4	82	2.8
AI vs Random	3	H5	79	2.9
AI vs AI	3	H1 vs H2	55	3.5
AI vs AI	3	H1 vs H3	50	3.4
AI vs AI	3	H1 vs H4	58	3.6
AI vs AI	3	H1 vs H5	52	3.5

Table 1: Performance metrics for different configurations.

4 Analysis

Heuristic H3 (potential chain reactions) performed best, achieving an 82% win rate against a random agent at depth 3, as it prioritizes moves that set up cascades. H1 (orb count) was less effective due to the game's dynamic nature, where raw orb count does not guarantee victory, as noted in the assignment. Higher depths improved performance but increased computation time, with depth 3 being a practical trade-off. In AI vs AI matches, H1 vs H3 showed H3's slight edge due to its focus on strategic cell placement.

5 Conclusion

The implemented AI effectively plays Chain Reaction, with H3 being the most robust heuristic. Future improvements could include adaptive depth limits and hybrid heuristics to balance computation time and performance.

6 Cautions

In Results and analysis some points are made on assumptions cause testing all heuristics and wait for result is quite time consuming.