Report: Evaluation of Heuristic Functions in Chain Reaction AI

# 1. Experimental Setup

In this experiment, we tested five heuristic functions designed to evaluate board states in the Chain Reaction game. These heuristics aim to help an AI player make better decisions by assigning scores based on different strategic factors.  
  
The heuristics tested were:  
- Critical Cells Bonus: Rewards cells that are close to exploding (critical mass minus 1 or 2 orbs).  
- Orb Count: Counts total orbs owned by the player.  
- Controlled Cells: Counts how many cells the player controls.  
- Vulnerable Cells Penalty: Penalizes cells that are close to exploding but next to opponent cells (making them vulnerable).  
- Corner Bonus: Rewards control of corner cells, which are strategically safer.  
  
We tested these heuristics by applying them to game states of size ROWS x COLS (e.g., 9x6 board). The AI was given a fixed time limit to evaluate moves, and the heuristics’ scores guided its decision-making.

# 2. Results

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| Heuristic | Description | Effect |
| Critical Cells Bonus | +5 or +2 points for cells near explosion | Encourages aggressive plays |
| Orb Count | Sum of orbs in all owned cells | Encourages accumulating orbs |
| Controlled Cells | Number of owned cells | Rewards board control |
| Vulnerable Cells Penalty | Negative points for cells near threats | Encourages defensive moves |
| Corner Bonus | +3 points for each corner controlled | Promotes strategic positioning |

# 3. Discussion

Among these heuristics, Critical Cells Bonus strongly encourages the AI to focus on cells about to explode, potentially triggering chain reactions for a strong attack. This can lead to aggressive strategies but might expose the player to counter-attacks if not carefully managed.  
  
The Orb Count and Controlled Cells heuristics provide a more general assessment of strength by counting the player’s orbs and controlled cells. These tend to favor slower, more stable expansion.  
  
The Vulnerable Cells Penalty is a defensive heuristic that discourages the AI from holding positions that are easily captured by the opponent. This helps avoid risky moves but can sometimes be too conservative.  
  
Finally, the Corner Bonus rewards controlling corners, which are safer and harder for the opponent to attack, promoting a strong positional advantage.

# 4. Rationale

The choice of heuristics balances between offensive and defensive playstyles. Critical Cells Bonus pushes for tactical, high-impact moves, while Vulnerable Cells Penalty keeps the AI cautious. Orb Count and Controlled Cells heuristics give a broad measure of overall strength and board control, and Corner Bonus adds strategic positional considerations. Combining these allows for flexible AI behavior adapted to different situations.