Gomoku AI Evaluation Report

Overview

Gomoku is a strategic two-player game played on a 10×10 grid where players aim to connect five consecutive stones in a line. This implementation includes a visually appealing Pygame UI and a difficulty-scaled AI opponent using the Minimax algorithm enhanced by alpha-beta pruning.

Evaluation Function Design

1. Easy

- **Depth:** 1
- **Goal:** Provide a casual, winnable experience.
- **Strategy:** Recognize simple winning patterns; add slight randomness.
- **Scoring:**
  - 5 in a row: $+100$
  - 4 in a row + 1 empty: $+10$
  - 3 in a row + 2 empty: $+5$
  - Random noise: $[-5, +5]$

2. Medium

- **Depth:** 2
- **Goal:** Balanced offensive and defensive tactics.
- **Strategy:** Evaluate both AI and opponent patterns. Prioritize blocks and setups.
- **Scoring:**
  - Player 4-in-a-row: -100

  - AI 4-in-a-row: +100
  - Includes minor randomness to avoid determinism.

3. Hard

- **Depth:** 2
- **Goal:** Simulate a smarter opponent with shape-aware logic.
- **Strategy:** Uses position weighting (center control) and prioritizes open-ended threats (e.g., "-XXX-").
- **Scoring:**
  - Pattern shape and position bonuses
  - Blocking high-risk player moves
  - Center-weighted bonuses

Design Highlights

- **Minimax with Alpha-Beta Pruning:** Efficient pruning of the decision tree.
- **UI:** Gradient backgrounds, animated floating particles, center-aligned layout, hover effects, and in-game tips.

Conclusion

This project demonstrates effective AI design for progressive player engagement using heuristics. The AI scales from casual to challenging, with meaningful evaluation strategies and a visually rich user interface.