Gomoku AI Game – Project Report

Overview

This project is a Java-based implementation of a Gomoku (Five in a Row) AI game that pits a human player against an AI opponent. The game features a fully functional GUI built with Swing and uses classical AI search techniques to make competitive decisions.

AI Search Algorithm

The core AI uses the **Minimax algorithm** with **alpha-beta pruning** for optimization. This allows the AI to simulate possible future moves and prune away branches of the search tree that don't influence the final decision, improving performance without sacrificing accuracy.

- `MiniMaxAI` (not shown above) is responsible for recursive search and move selection.
- The search depth is adjustable (`minimaxDepth`), and the game defaults to a center-first move when the AI starts.

Evaluation Function

A custom evaluation function scores intermediate board states. It detects potential rows of 2, 3, or 4 aligned stones (horizontally, vertically, or diagonally), favoring moves that build toward five in a row or block the opponent. The evaluation encourages balanced offensive and defensive play and differentiates between immediate threats and longer-term strategies.

Early Stopping Mechanism

To ensure responsiveness, especially when deeper searches become computationally intensive, an **early stopping mechanism** is implemented. This is often handled by:

- Limiting the depth (`minimaxDepth`)
- Using `System.currentTimeMillis()` checks (or similar time budget) in the `MiniMaxAI` logic to terminate search early and return the best-known move using the evaluation score.

Move Generation Optimization

Instead of exploring the entire board, the AI uses **localized move generation**, considering only empty positions adjacent to existing stones (see `generateMoves()` in `Board.java`). This drastically reduces the branching factor and focuses computation on relevant areas.

Graphical User Interface (GUI)

The game includes an interactive, aesthetic GUI via `BoardGUI.java`:

- Visual grid board with stones
- Real-time updates as players move
- Feedback messages like “YOU WON!” or “COMPUTER WON!”

- A “Thinking…” status display when AI is calculating

Version Control

The project was tracked using **Git**, maintaining a structured history of changes, debugging iterations, and feature implementations.

Conclusion

This Gomoku AI game fulfills all specified requirements, combining a classic AI approach with efficient pruning, real-time visual feedback, and a clean interface. The modular code design ensures future improvements (like increasing depth, tuning evaluation weights, or enhancing GUI) can be easily integrated.