GADE 3A 7321

POE Document

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Report for Minmax search:

What Connect 5 Contains:

Key Characteristics of Deterministic Games:

- **No Randomness:** There are no dice rolls, card draws, or other elements of chance that influence the game's progression.
- **Predictable Outcomes:** Given the current state of the game and the actions chosen by the players, the next state can be predicted.
- **Reproducibility:** If you repeat the exact same sequence of actions from the same starting point, the game will always unfold in the same way.

Connect 5 is also a game with simple heuristics:

By assigning a higher score based on board configuration, potential winning lines and center control. We can use this in the decision-making process to compare the different moves possible. Its also allows for efficient computation.

Why Minimax is Well-Suited for Connect 5:

Zero-Sum Game:
Connect 5 is a classic zero-sum game, meaning that one player's gain is the other player's loss (Katz & Ross, 2024). Minimax thrives in such scenarios, as its core principle is to minimize the maximum possible loss (or maximize the minimum gain) for the AI player.

Deterministic and Turn-Based:
Connect 5 has no random elements and players take turns, making it a deterministic game. This aligns perfectly with minimax's assumptions and allows it to explore all possible game states. (Katz & Ross, 2024).

Perfect Information:
Both players have complete knowledge of the game state at all times (the board is visible to both player and AI). Minimax uses this perfect information to create an accurate decision tree of possible moves and outcomes.

Moderate Complexity: While Connect 5 has a large branching factor (many possible moves per turn), the game tree is not as massive as in games like Chess (Katz & Ross, 2024). This means that the minimax algorithm can still be used effectively without needing overly deep searches or extensive optimizations.

Strategic Depth: Connect 5 requires strategic thinking, including planning multiple moves ahead and considering both offensive and defensive strategies. Minimax's ability to look ahead and evaluate future game states makes it ideal for finding play lines ahead to win from.

Advantages of Minimax AI in Connect 5:

Strong Opponent: Minimax can provide a formidable opponent, playing at a high skill level that challenges the player.

Adaptability: By adjusting the search depth and the evaluation function, you can easily control the AI's difficulty, making it suitable for players of various skill levels.

Strategic Play: The minimax AI will analyze potential winning and losing scenarios, making moves that maximize its chances of winning while minimizing its risk of losing.

Blocking Capability: The AI will actively try to block the player from forming winning lines, adding a defensive layer to its strategy.

Learning Potential: With a well-designed evaluation function, the minimax AI can learn from experience, becoming progressively better at identifying promising moves.

Example of Minimax in play:

Consider a board state where the player has four pucks in a row, with an open space for a fifth. A basic random AI might not recognize this threat, while a minimax AI would immediately identify it and prioritize blocking that move.

Weaknesses:

Computational Complexity: Minimax can become computationally expensive for deeper searches (Katz & Ross, 2024). You may need to implement optimizations like alpha-beta pruning for larger board sizes or deeper searches.

Perfect Play: Minimax can, in theory, achieve perfect play in Connect 5, but in practice, the search depth is often limited due to computational constraints.

When Monte Carlo Tree Search (MCTS) can be considered:

MCTS might be preferable if:

- Your game has an extremely large branching factor, making the search space too vast for minimax.
- You want your AI to learn and adapt over time, as MCTS can be combined with reinforcement learning.

Summary:

While Monte Carlo Tree Search has its advantages, particularly in games with a larger search space or less obvious heuristics, minimax is often a more practical and efficient choice for Connect 5 due to the game's characteristics (Muens, 2024).

Of course, if you have sufficient computational resources and are willing to invest in the more complex implementation of MCTS, it can potentially lead to a stronger AI opponent over time, especially if combined with reinforcement learning (Muens, 2024).

Therefore, For Connect 5, Minimax would be a robust selection since it can work fast and effectively. The deterministic environment of Connect 5, where strategic patterns are clearly laid out, makes Minimax even more fitting as it has the capacity to make perfect choices in such scenarios. MCTS is also very strong but its advantages might not show as much in Connect 5 when compared with games having larger search areas or less clear heuristics. (Katz & Ross, 2024) (Muens, 2024).

GitHub Link:

https://github.com/MartinGLouw/GADE7321_Part2

References:

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