



Connect 4 AI

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Introduction & Game Rules



Our project implements AI agents for Connect 4.



The goal is to connect four of your pieces in a row, either horizontally, vertically, or diagonally.



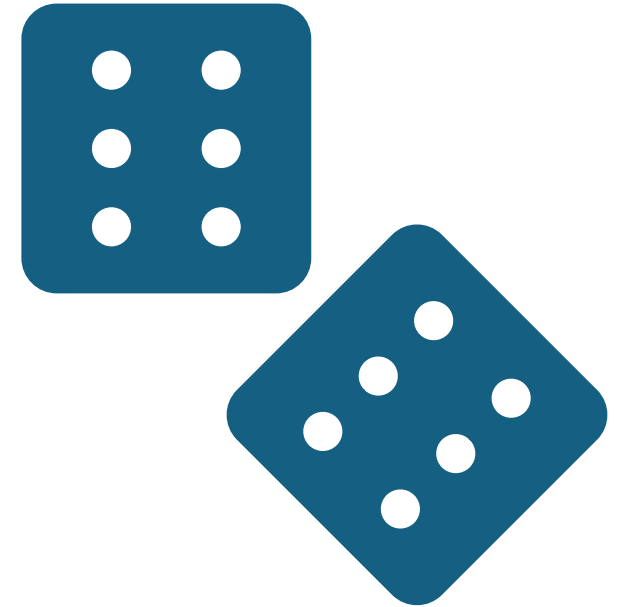
Connect 4 has over 4 trillion possible positions



We built four AI strategies of increasing intelligence: Random, Greedy, Minimax, and Minimax with Alpha-Beta pruning.

Heuristic Evaluation Function

- Heuristic function scans every possible four-cell window on the board and assigns scores.
- For example, three of our pieces with one empty space scores +5 because we're one move from winning. Three opponent pieces with one empty space scores -4, signaling we need to block.
- We also reward controlling the center column with +3 per piece, since center positions connect to more winning lines.
- This lets the AI judge how 'good' any position is without playing to the end."



Greedy Algorithm



looks one move ahead by simulating each possible column, calculating the heuristic score of the resulting position, and picking the move with the highest score.



Under 5 milliseconds, and beats random play. It blocks obvious threats and takes immediate wins.



Greedy has a major weakness: it can't see beyond one move.



Very susceptible to traps.



Minimax

- Minimax looks multiple moves ahead by building a game tree. It assumes both players play optimally
- we try to maximize our score, and the opponent tries to minimize it.
- By searching 4 or 5 moves deep, minimax can see traps coming and avoid them.
- With 7 possible moves per turn, depth 5 means checking 7 to the power of 5, which is about 17,000 positions.

Alpha-beta pruning

- It tracks two values: alpha, the best score we can guarantee, and beta, the best score the opponent can guarantee.
- When there is a branch with a beta less than or equal to alpha it gets pruned
- Alpha-Beta cuts 80 to 95 percent of the search space.
- Alpha-Beta AI at depth 5 responds faster than regular Minimax at depth 4, while playing significantly stronger.