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I’ve included a debug output displaying how many state nodes the AI had to parse in order to come to a decision.

Below is the output with no efficiencies, when the AI makes the first move:



**IMPROVEMENT 1: ALPHA BETA PRUNING**

If given a simulation of the board during a player’s turn, assuming that this player has found a way to get them closer to winning than during a previous iteration of the board, the previous player will purposely avoid giving them that board state. As a result, several leaf nodes are clipped from the tree.

Below is the output with Alpha Beta pruning:



**IMPROVEMENT 2: SYMMETRY PRUNING**

If a given board state is symmetrical in any way (by flip or by rotation), certain squares will not be tested in accordance with a random priority stat given at the beginning of the game – a function asks a square if it shares a symmetry with a square of a higher priority while the board itself possesses that symmetry, and if it does, that square is ignored for that iteration of the simulation.

Example:

1(\_) 2(O) 3(\_)

4(\_) 5(X) 6(\_)

7(\_) 8(\_) 9(\_)

Assuming the above board, squares (1, 3), (4, 6), (7, 9) are identical on a board that has Y axis symmetry, so only one from each pair will get leaf nodes for that iteration.

Below is the output with Symmetry pruning AND Alpha Beta pruning:



Note that due to the fact that priorities are distributed at random per game, the exact value of the states processed may vary slightly.