CS 440 Machine Problem 3 Results

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1 Minimax Implementation

Optimal Game Play:

$(-8, [('B', 0, 2), ('W', 0, 3), ('B', 1, 3), ('W', 0, 1), ('B', 3, 0),$
$('W', 2, 3), ('B', 0, 0), ('W', 3, 2), ('B', 3, 3), ('W', 3, 1), ('B', -1, -1)])$

Terminal State for optimal game play for 4x4 game:

['B', 'W', 'W', 'W']
[' ', 'W', 'W', 'W']
[' ', 'W', 'W', 'W']
['B', 'W', 'W', 'B']

It is interesting to note that the move sequence is not strictly alternating, although it does not appear in this case. In the case of the 4x4 game with 8 tokens in the initial state, we do see that B goes twice towards the end; this is because W has no moves at this certain state, but B does, so the game is not terminal. In this case, W does not have any moves and it becomes B's turn to go. As an observation, looking at the sequence of moves, it seems like the first player to get a token in any other four corners eventually wins the game.

From this answer, we can see that player with white token, player 2, has a clear advantage in this instance of the 4x4 game and is guaranteed to win. At the top level, for the 4x4 game, running the basic minimax algorithm results in 80986 terminal states being encountered.

2 Minimax with Alpha-Beta Pruning

Time for 4x4 game w/o alpha-beta pruning: 6.3111641407 seconds
Time for 4x4 game w/ alpha-beta pruning: 0.484816074371 seconds

Terminal nodes encountered for 4x4 game w/ alpha-beta pruning: 5288
Terminal nodes encountered for 5x5 game w/ alpha-beta pruning: 169845

Truncations encountered for 4x4 game w/ alpha-beta pruning: 3600
Truncations encountered for 5x5 game w/ alpha-beta pruning: 169845

Clearly, by pruning out the part of the game tree that we are sure will not affect the result, we can greatly increase performance of the minimax algorithm. We can see the by number of truncations and reduction in number of terminal nodes encountered that the alpha-beta pruning optimization is very helpful.

From the result of the 5x5 game, we can conclude that in the optimal game, there is no winner and the game results in a draw. Unlike the 4x4 game, no player is guaranteed to win in this 5x5 game.

Terminal State for optimal game play for 5x5 game:

W', 'W', 'W', ' ', ' '

W', 'W', ' ', ' ', ' '

W', ' ', ' ', ' ', 'B'

', ' ', ' ', 'B', 'B'

', ' ', 'B', 'B', 'B'