ARTIFICIAL INTELLIGENCE COMP813

AUCKLAND UNIVERSITY OF TECHNOLOGY M3
EXERCISES

Adversarial Search and Games

Question 1. *Tic-Tac-Toe.*

This problem exercises the basic concepts of game playing, using tic-tac-toe (naughts and crosses) as an example, so that you have a better understanding on building the Deep Blue beating the best human player.

We define X_n as the number of rows, columns or diagonals with exactly n X's and no O's. Similarly, On is the number of rows, columns or diagonals with just n O's. The utility function assigns +10 to any position with $X_3 >= 1$ and -10 to any position with $O_3 >= 1$. All other terminal positions have utility 0. For the nonterminal positions, we use a linear evaluation function defined as

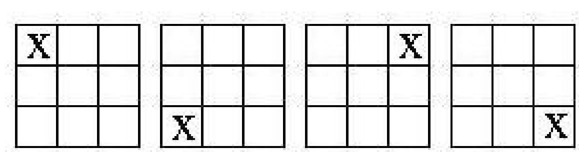
$$Eval(s) = 3X_2(s) + X_1(s) - (3O_2(s) + O_1(s))$$

The game start with Xplayer.

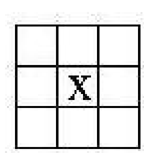
(a) Approximately how many possible games of tic-tac-toe are there? One game play is a sequence of moves from initial state till a terminal state.

(b) Show the whole game tree starting from an empty board down to depth 2 (i.e. one X and one O on the board), taking **symmetry** *into account.*

By symmetry, we mean that if you turn the whole board around (without moving the relative position of the pieces), you'll get the same configuration. For example, the following 4 states are the same under symmetry.



They are different from the following state:



(c) Mark on your tree the evaluations of all the positions at depth 2.

(d) Using the minimax algorithm, mark on your tree the backed-up values for the positions at depths 1 and 0, and use those values to choose the best starting move.

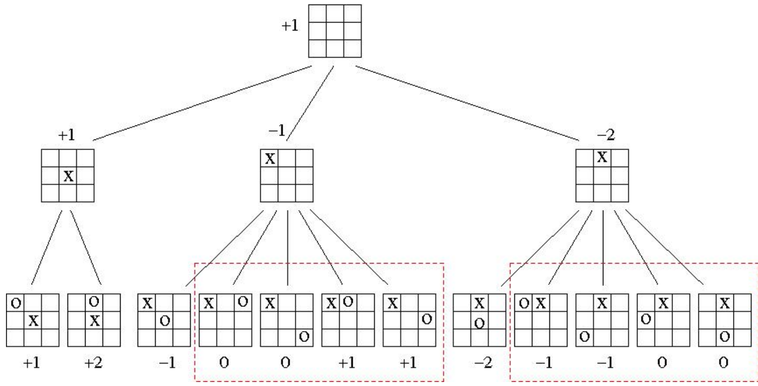
(e) Circle the nodes at depth 2 that would not be evaluated if alpha-beta pruning were applied, assuming the nodes are generated in the optimal order for alpha-beta pruning.

Model Answer:

- *(a) There are 9 choices for the 1st move, 8 for the 2nd move, 7 for the 3rd move, etc., giving us an upper bound of 9! = 9*8*7*6*5*4*3*2*1 = 362880. But this is an overestimate, because some games end in 5, 6, 7 or 8 moves. The true figure is actually 255168.*

  If we take symmetry into account, the number reduces substancially. For example, there are now only 3 choices for the first move and at most 5 choices for the second move. In fact, the total is reduced to 26830 distinct games, of which 172 end in 5 moves, 579 end in 6 moves, 5115 end in 7 moves, 7426 end in 8 moves, 8670 result in a win in 9 moves and 4868 result *in a draw. There are a number of Web sites providing a full analysis. See for example* **`http://www.se16.info/hgb/tictactoe.htm`**

- *(b),(c), (d), (e)*



Question 2. *We played the Take-away game during the lecture.*

(a) *Represent the game in a game tree. Estimate how many decision nodes are there for each players and how many strategies are there for each players. Show your working.*

(b) *Does a player have a winning strategy (a way to enforce a win no matter what the other player does)? Show your working.*

(c) *Analyse the game using the Minimax algorithm.*

(d) *Implement the minimax algorithm to test your results in (a) and (b).*

Model Answer: *Omitted*