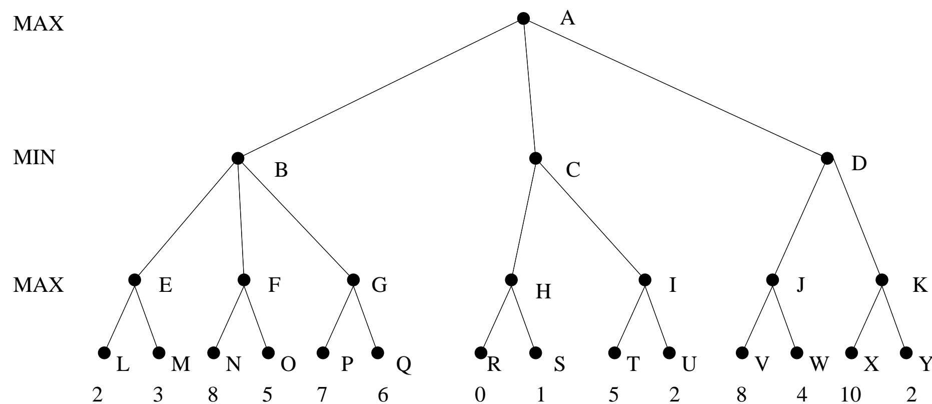
University of Pittsburgh
CS 1571 Introduction to Artificial Intelligence — Handout 7
Professor Milos Hauskrecht — October 8, 2009

Problem assignment 4
Due: Thursday, October 15, 2009

Adversarial search

Problem 1. Adversarial search.

Consider the game search tree in the figure below



Assume the first player is the max player and the values at leaves of the tree reflect his/her utility. The opponent wants the same utility to be minimized.

Part a. Compute the minimax values for each node in the tree? What move should the first player choose? What is the solution path the rational players would play.

Part b. Assume we use alpha-beta algorithm to explore the game tree and we do this in the left-to-right order and determine the players strategies. List all nodes that are cut off from the tree and are never examined by the alpha beta procedure (see lecture notes for an example of how the alpha beta procedure works).

Part c. Assume we use alpha-beta algorithm but explore the tree in the right-to-left order. What nodes would not need to be examined by the alpha-beta algorithm and pruned away?

Problem 2. Tic-tac-toe-10

The goal of this assignment is to implement a program capable of playing Tic-tac-toe on the 10×10 board. The 3×3 version of the game is discussed in the textbook on page 164. Both 3×3 and 10×10 versions of the Tic-tac-toe are related to the old Japanese game of Go.

Rules. The game is played on a rectangular 10×10 board. There are two players, one plays crosses, the other plays zeroes. The players alternate their moves. The first one to achieve five of his marks in a row, a column or on a diagonal wins.

The player program you have to build will always play crosses. To test your program you may use board positions stored in the *boards* subdirectory. It is always X's turn. We encourage you to create some interesting board positions yourself.

The program's input is a current board position. The output is a number identifying the board position chosen by the program. A position on a 10×10 board, can be represented using two digits with values 0-9. The first digit indexes the row, the second digit the column. For example, the output '23' indicates the program chose to put its mark (an 'x') to the second row and the third column. Note that your program chooses only its next move.

To get you started we provide you with the most basic player in `player.cpp`. This player is deterministic and extremely weak. Please familiarize yourself with the code. There is one global variable used by the program: the variable *board* that holds a 10×10 array representing the board configuration. The array contains 'X', 'O' and '_' characters, with the obvious interpretation. The variable *board* is initialized by the board configuration on the standard input. The main function takes care of the initialization.

Tournament support. The support code written for this assignment lets you play two different programs against each other. The code takes care of switching between xs and 0s so both programs are assumed to be 'x' players. The support program is written in perl and the name of the script is `driver.pl`. By default the script iteratively calls playerA and playerB programs. To play two different programs you need to name one of them `playerA` and the other `playerB`. To play the same program against itself `playerA` and `playerB` programs are the same.

Part a. A tic-tac-toe player with a board evaluation heuristic.

Our objective is to create a decent player of the game. Ideally a player would search the complete game tree and compute the best move while considering the best (rational) responses of its opponent. However, in this and many other games we do not have the luxury of exploring the full game tree before making the move. To address this issue we consider a limited-depth exploration of the game tree, where nodes at the depth (or cutoff) limit are evaluated using a board evaluation heuristic. If the depth of the tree is k we refer to the procedure as to k-ply search.

The program `player.cpp` calls a minimax (alpha-beta) search procedure that takes a board position as its input, searches the game tree corresponding till level k and outputs the best next move according to the heuristic board evaluation function. The default level is k=2. The heuristic board evaluation function is given to you in file `heuristics.cpp`. Note that the heuristic function is used to evaluate the leafs of the tree only. Please compile the current player and run the two versions of the program against each other using the tournament `driver.pl`. Play at least 10 matches and report the table with results you have achieved in terms of wins, draws and losses of Player A (moves first) and Player B (moves second).

Part b. A tic-tac-toe player with improved heuristic evaluation.

One way we can improve a tic-tac-toe player is to improve its evaluation heuristic. The current heuristic function (file heuristic.cpp) analyzes the game configuration and identifies different line configurations of X and 0 symbols (in rows, columns and on diagonals). The line configurations found are assigned a qualitative label (win, good, threat, etc) which is then used to calculate the utility of the position. Propose modifications of the the file `heuristics.cpp`. by trying: (1) different scoring of line configurations (2) addition of new line configurations. Experiment with different heuristics. Once you think your heuristic performs well copy it to file `heuristics2b.cpp`, compile it and play the new player against the player from part a. You should submit the new heuristic code in `heuristics2b.cpp`. Describe the changes you have made in the report including the intuition behind these changes.

Play the new player versus part-a-player 10 times starting the new player as Player A, and 10 times starting it as Player B. Report win, loss, draw statistics. If you think your new player is better than the part-a-player argue the case using statistics obtained in part a and part b.