

Homework 2

1. This problem exercises the basic concepts of game playing, using tic-tac-toe (noughts and crosses) as an example. We define X_n as the number of rows, columns, or diagonals with exactly n X's and no O's. Similarly, O_n is the number of rows, columns, or diagonals with just n O's. The utility function assigns +1 to any position with $X_3=1$ and -1 to any position with $O_3=1$. All other terminal positions have utility 0. For nonterminal positions, we use a linear evaluation function defined as
$$\text{Eval}(s) = 3X_2(s) + X_1(s) - (3O_2(s) + O_1(s)).$$
 1. Approximately how many games of tic-tac-toe are there?
 2. 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.
 3. Mark on your tree the evaluations of all the positions at depth 2.
 4. 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.
 5. Circle the nodes at depth 2 that would *not* be evaluated if alpha-beta pruning was applied, assuming the nodes are generated in the optimal order for alpha-beta pruning.
2. For each of the following assertions, say whether it is true or false and support your answer with examples or counterexamples where appropriate.
 - a. A hill-climbing algorithm that never visits states with lower value (or higher cost) is guaranteed to find the optimal solution if given enough time to find a solution.
 - b. For any local-search problem, hill-climbing will return a global optimum if the algorithm is run starting at any state that is a neighbor of a neighbor of a globally optimal state.
 - c. Stochastic hill climbing is guaranteed to arrive at a global optimum.
 - d. In a continuous space, gradient descent with a fixed step size is guaranteed to converge to a local or global optimum.
 - e. Gradient descent finds the global optimum from any starting point if and only if the function is convex
3. Mom, Dad, Baby, Student, Teacher, and Guide are lining up next to each other in six linear spots labeled 1 to 6, one to a spot. Baby needs to line up between Mom and Dad. Student and Teacher need to be next to each other. Guide needs to be at one end, in spot 1 or 6. Formulate this problem as a CSP: list the variables, their domains, and the constraints. Encode unary constraints as a constraint rather than pruning the domain. (No need to solve the problem, just provide variables, domains, and constraints.)
4. In a full-depth minimax search of a tree with depth D and branching factor B , with α - β pruning, what is the minimum number of leaves that must be explored to compute the best move?
5. Which of the following statements about alpha-beta pruning are true or false?

- a. Alpha-beta pruning may find an approximately optimal strategy, rather than the minimax optimal strategy.
 - b. Alpha-beta prunes the same number of subtrees regardless of the order of child nodes.
 - c. Alpha-beta generally requires more run-time than minimax on the same game tree.
6. Ali, Bo, Cleo, and Dallas are picking their entrees at a restaurant. The choices are pasta, quesadillas, risotto, and sushi. They have some strict dietary preferences:
- Cleo will not order sushi.
 - Ali and Bo want to steal each other's food, so they will order different dishes.
 - Bo likes carbs, so he will only order pasta or risotto.
 - Cleo likes to be unique in her food orders and will not order the same dish as anybody else, with one exception: Ali and Cleo are actually twins, and always order the same dish as each other.
 - Dallas really dislikes quesadillas and will not order them.
- Answer the following questions for this situation:
- a. If we formulate this as a CSP with variables {A, B, C, D}, each with domain {P, Q, R, S}, what are the constraints?
 - b. We will run basic backtracking search to solve this CSP and make sure that every person (variable) is matched with their dream dish (value). We will select unassigned variables in alphabetical order, and we will also iterate over values in alphabetical order. What assignment will backtracking search return?
 - c. Now assume that no values have been assigned to the variables and we will run one iteration of forward checking. What value(s) will be eliminated for which variables if we assign "pasta" to Ali?
 - d. Now assume we will solve the problem with local search using the min-conflicts algorithm. Assume we start with the initial assignment {A = P, B = P, C = P, D = P} and choose B as the variable to change. How many conflicts does the current value of B pose? What value for B would minimize the number of conflicts?

Due on 03/02/2022