CSE 571 Fall 2022

Homework 3

Due *September 20, Tuesday* online

Homework Instructions: Read Carefully

1. Only typed answers will be accepted. Solutions with **ANY** written part (except for hand-drawn illustrative figures) will not be given any credits. If you need to write equations, use "Insert->Equation" with *Word*. *LaTeX (e.g., Overleaf)* also supports equation typesetting.

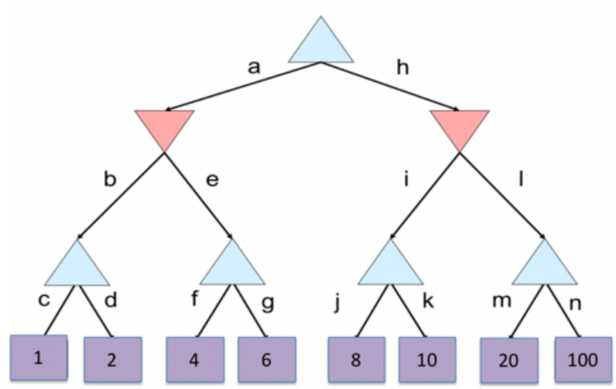
2. Do **NOT** include questions themselves in your answers. Failing to do some may result in failing the plagiarism check.

3. Answers without explanations will **NOT** be given any credits.

Be precise and concise in your answers. You may add hand-drawn figures when necessary.

Exercise 1.1 (9pt)

Answer the following questions about alpha-beta pruning. *Except for the root node, the labels for the edges are also used to refer to the corresponding child nodes.* An example tree is provided below:



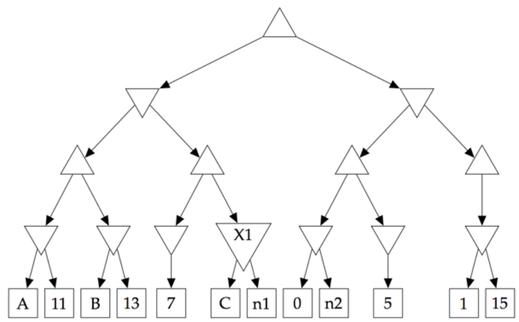
a. (3pt) Assuming we always explore from left to right, apply alpha-beta pruning to the tree where the leaf nodes {c, d, f, g, j, k, m, n} are valued {4, 6, 1, 2, 20, 100, 8, 10}, respectively. Provide the alpha-beta values at each node in the tree after completion.

b. (3pt) Assuming we always explore from left to right, apply alpha-beta pruning to the tree where the leaf nodes {c, d, f, g, j, k, m, n} are valued {10, 8, 100, 20, 2, 1, 6, 4}, respectively. Provide the alpha-beta values at each node in the tree after completion.

c. (3pt) Assuming we always explore from left to right for the tree below, can the leaf nodes at *j* and *k* be pruned when the values of the leaf nodes {c, d, f, g, j, k, m, n} are **selected from** the set of values {1, 2, 4, 6, 8, 10, 20, 100} (i.e., a one-to-one mapping). If so, provide the values of the leaf nodes when *j* and *k are pruned*, as well as the alpha-beta values at each node in the tree after completion. Otherwise, explain why.

Exercise 1.2 (9pt)

On the minimax game tree below, answer the following questions about alpha-beta pruning assuming left to right traversal, ***and explain your answers.***



a. (3pt) What are the values of A, B and C that ensure that X1 and its leaf nodes will ***not*** be pruned? If a value does not matter, say "does not matter". Otherwise, provide the ranges of values (not a single value).

b. (3pt) For the node n1 to be pruned (note that if X1 is pruned, n1 is also considered to be pruned), what are the requirements for the variables A, B and C?

c. (3pt) For the node n2 to be pruned, what are the requirements for the variables A, B and C?

Exercise 1.3 (14pt)

In the following, a "max" tree consists only of max nodes, whereas an "expectimax" tree consists of a max node at the root with alternating layers of chance and max nodes. At chance nodes, all outcome probabilities are nonzero. The goal is to find the value of the root with a bounded-depth search. For each of (a)–(f), either give an example or explain why this is impossible.

a. (2pt) Assuming that leaf values are finite but unbounded, is pruning (as in alpha–beta) ever possible in a max tree?
b. (2pt) Is pruning ever possible in an expectimax tree under the same conditions?
c. (2pt) If leaf values are all nonnegative, is pruning ever possible in a max tree? Give an example, or explain why not.
d. (2pt) If leaf values are all nonnegative, is pruning ever possible in an expectimax tree? Give an example, or explain why not.
e. (2pt) If leaf values are all in the range [0, 1], is pruning ever possible in a max tree? Give an example, or explain why not.

f. (2pt) If leaf values are all in the range [0, 1], is pruning ever possible in an expectimax tree?
g. (2pt) Consider the outcomes of a chance node in an expectimax tree. Which of the following evaluation orders is most likely to yield pruning opportunities? Explain.
   (i) Lowest probability first
   (ii) Highest probability first
   (iii) Doesn't make any difference

Exercise 1.4 (6pt)

Which of the following are true and which are false, assuming rational players are exactly computable (i.e., no evaluation function is used and the game tree has a finite depth)?

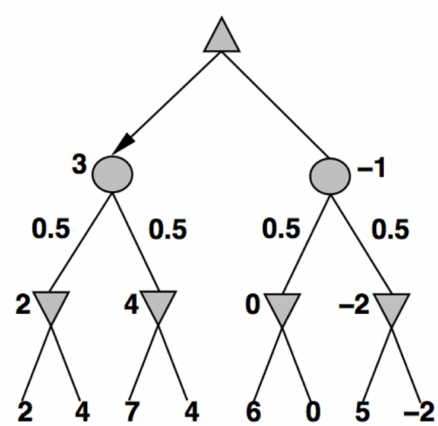
a. (2pt) In a fully observable, turn-taking, zero-sum game between two rational players, it does not help the first player to know what strategy the second player is using— that is, what move the second player will make, given the first player's move.

b. (2pt) In a partially observable, turn-taking, zero-sum game between two rational players, it does not help the first player to know what move the second player will make, given the first player's move.

c. (2pt) A rational Pacman never loses.

Exercise 1.5 (12pt)

In class, we discuss that, without any restriction on the values of the terminal nodes, an expectimax tree does not yield pruning opportunities. What about an expectiminimax tree (MAX → EXP → MIN → EXP → MAX → EXP …)? Explain your answer ***or*** provide an example of such a tree with pruning opportunities (and explain which nodes would be pruned).



a) (4pt) What about a zero-sum game where only the max agent's action will be affected by a dice while the min agent acts deterministically? In other words, the layers will be: MAX → EXP → MIN → MAX

→ EXP → MIN … Assume that the terminal nodes may be spawned out of any layer (max, min or exp). Explain your answer ***or*** provide an example of such a tree with pruning opportunities (and explain which nodes would be pruned).

c) (4pt) Modify the minimax under alpha-beta pruning algorithm discussed in class to work with any expectiminimax tree.