CPSC 625-600 Homework #1 (08 Fall)
Due 10/02/08, 11:10am (submit, in class)

Handwritten or printed hardcopy must be submitted

1 Uninformed Search

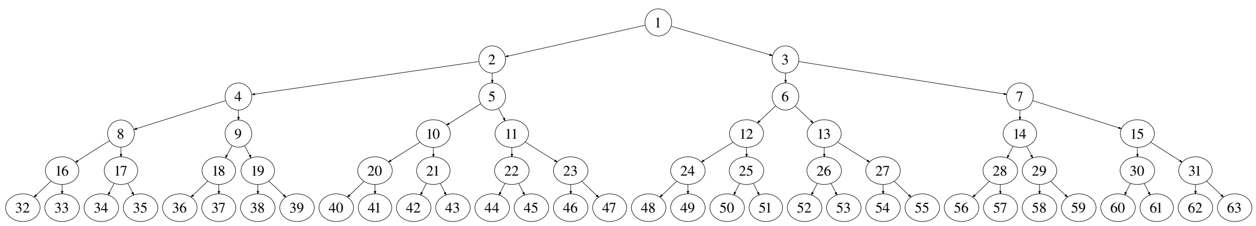

Figure 1: **Search Trees.**

Consider the search tree in Figure 2. Assume that the exploration of the children of a particular node proceeds from the left to the right for all search methods in this section.

Question 1 (4 pts): Give an example of when breadth-first search (BFS) and depth-first search (DFS) have the same time complexity. Pick on node number from the tree above as an example.

Question 2 (4 pts): Give an example when depth first search is suboptimal. Pick two node numbers as goal nodes as an example.

Question 3 (4 pts): What limitation in BFS does iterative deepening search overcome?

Question 4 (4 pts): Why is the space complexity of BFS $O(b^{d+1})$, not $O(b^d)$, where b is the branching factor and d is the goal depth?

Question 5 (4 pts): Can depth limited search become incomplete in the case of the finite search tree above? If so, give an example. If not, explain why not.

2 Informed Search

Question 6 (12 pts): Manually conduct greedy best-first search on the above graph, with initial node **a** and goal node **k**. Actual cost from node to node are shown as edge labels. The heuristic function value for each node is shown on the right. Show:

1. Node list content at each step
2. Node visit order
3. Solution path

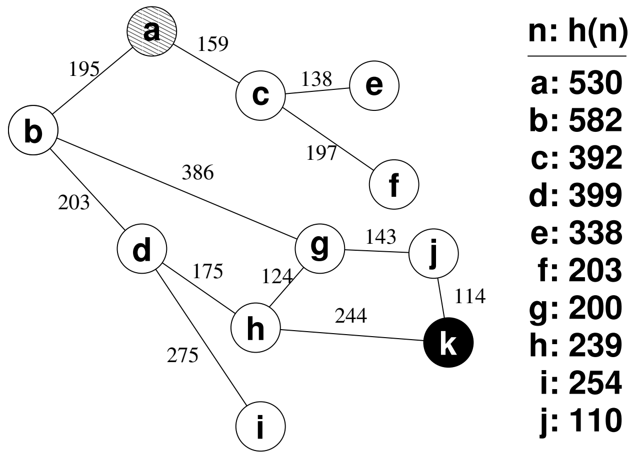

Figure 2: **Informed Search.**

4. Cost of the final solution.

Note: Assume that you are not allowed to go back immediately to where you came from (i.e., no backtracking from a dead end). For example, if you went from **a** to **c** to **f**, then you cannot expand **f** into **c**.

Question 7 (14 pts): (1) Repeat the problem right above with A* search. (2) In addition, show the $f(n)$ value for all nodes expanded. (3)Which one gives a shorter solution: Greedy best-first or A*? **Note:** Note that the same node can appear in the node list with a different $f(n)$ value, depending on the path taken.

Question 8 (8 pts): In the above problem (Fig. 2), greedy search can be incomplete when back-tracking from a dead end is allowed. Explain how it can happen, by example.

Question 9 (4 pts): Explain why A* is optimal. Explain in terms of an arbitrary node n on the path to an optimal goal G_1, and a separate suboptimal goal G_2.

3 Game Playing

3.1 Minmax Search

Question 10 (4 pts): Using the following figure 3, use minmax search to assign utility values for each internal node (i.e., non-leaf node) and indicate which path is the optimal solution for the MAX node at the root of the tree. Assume you explore the successors from left to right.

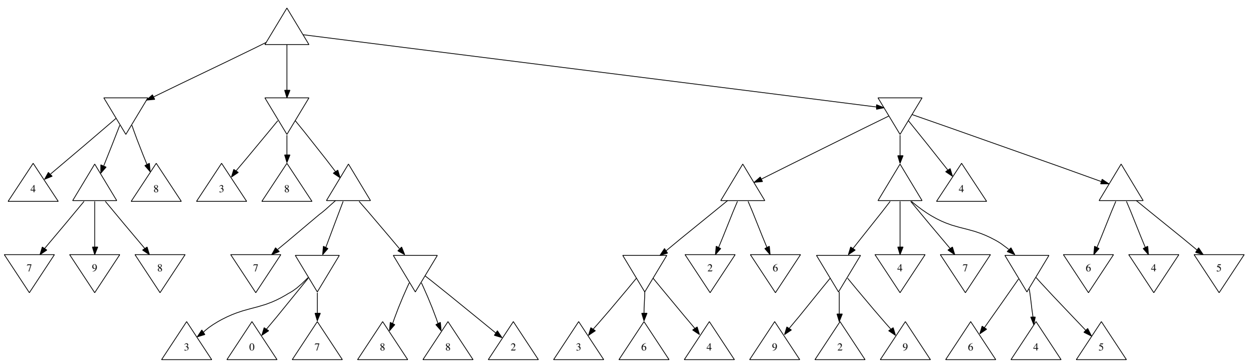

Figure 3: **Game Tree.** Solve using minmax search.

3.2 $\alpha - \beta$ pruning

Question 11 (8 pts): Using the following figure 4, use $\alpha - \beta$ pruning to (1) assign utility values for each internal node (i.e., non-leaf node) and indicate which path is the optimal solution for the MAX node at the root of the tree. (2) For each node, indicate the final α and β values. (Note that initial values at the root are $\alpha = -\infty, \beta = \infty$.) (3) For each cut that happens, draw a line to cross out that subtree.

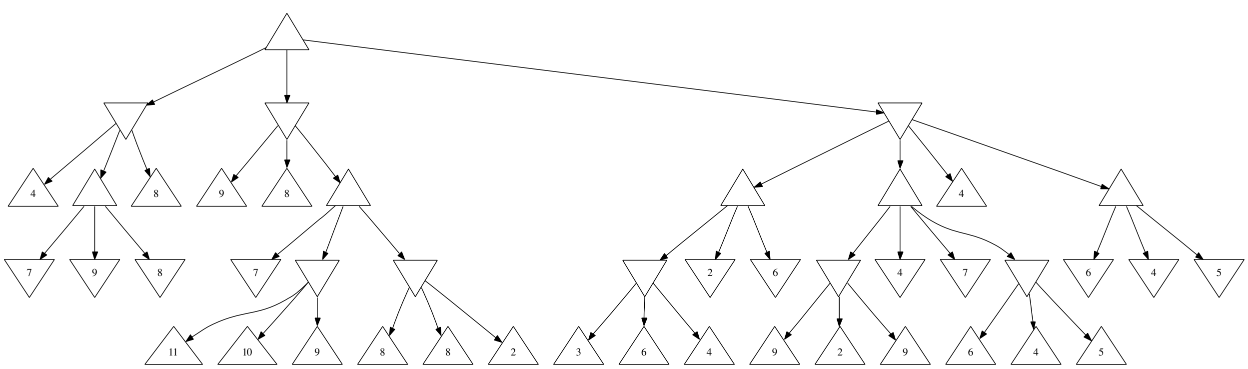

Figure 4: **Game Tree.** Solve using $\alpha - \beta$ pruning. This tree is the same as figure 3.

Question 12 (6 pts): In Minmax search, we used a depth-first exploration through the use of recursion. We know that Minmax gives an optimal solution, however, we also know that depth-first search is suboptimal. Explain why Minmax gives an optimal solution even when it is using a depth-first exploration.

4 Propositional Logic

4.1 Normal forms

In all of the problems in this section, show each step of the derivation and indicate which axioms (or other rules) you used: For example, *distributive law, by definition, etc.*

Question 13 (4 pts): Convert $\neg(P \rightarrow \neg S) \vee (\neg(S \rightarrow (Q \rightarrow R)))$ into conjunctive normal form.

Question 14 (4 pts): Convert $\neg T \rightarrow (R \wedge (\neg(P \wedge Q) \rightarrow \neg S))$ into disjunctive normal form.

Question 15 (4 pts): Convert $(R \wedge S) \rightarrow (\neg(\neg P \vee T) \rightarrow \neg Q)$ into horn normal form. After that, show the equivalent expression with a single implication ($\rightarrow$) and some conjunctions ($\wedge$) where all literals are positive literals.

4.2 Theorem proving

Question 16 (12 pts): Given:

1. $A \vee \neg B$
2. $\neg A \vee C$
3. $C \rightarrow D$
4. $(C \wedge A \wedge D) \rightarrow E$

show that $B \rightarrow E$ is a logical consequence of the above using **resolution**.

Hint: first, transform the problem into a set of clauses, and the follow the resolution steps.