OSU CSE 3521
Homework #1: Problem Set

January 21, 2023

Submission Instructions

Due Date: February 3rd (23:59 ET), 2023

Submission: Please submit your solutions in a single PDF file named HW1_name_number.pdf (e.g., HW1_chao_209.pdf) to Carmen. You may write your solutions on paper and scan it, or directly type your solutions and save them as a PDF file. *Submission in any other format will not be graded.*

We highly recommend that you write down the derivation of your answers, and highlight your answers clearly!

Collaboration: You may discuss with your classmates. However, you should write and submit your own solutions.

1 Search [20 points]

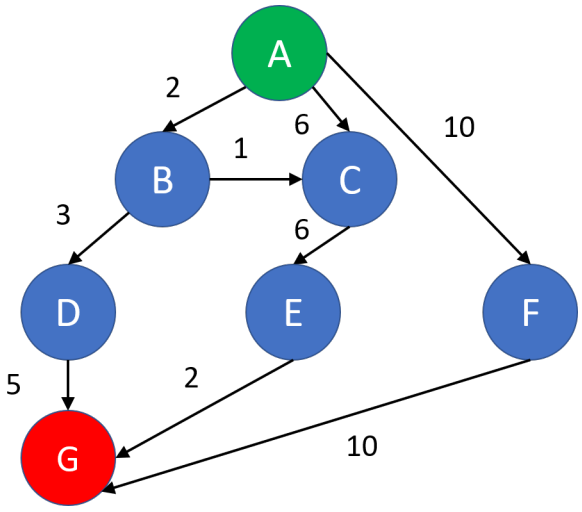

Figure 1: State space graph

Figure 1 shows a state space graph, in which state A is the start state and state G is the goal state. Each edge is directed and associated with a cost. You will apply tree search algorithms to this problem (i.e., no cycle checking).

Hints:

- Since you are working on tree searches, you may expand multiple nodes (i.e., partial paths) that have the same last states and you should count all of them. For example, you may expand A-B-C and then A-C and you should count both of them.
- As an example of how to count how many nodes you expand, if you expand "A", and then "F" (i.e., A-F), and then "B" (i.e., A-B), and then "G" (i.e., A-F-G) in the search process, then you expand 4 nodes. You expand a node (i.e., A-F) only when you check if its last state (i.e., "F") is a goal or not (if not, adding the successors into the fringe), not when you put that node (i.e., A-F) into your fringe.
- A solution is the state sequence (in the problem set) or action sequence (in the programming set) that can directly lead you from the start state to the goal state. It is NOT the sequence of nodes that you expand in your search process. For instance, in the above example, you expand 4 nodes, but your solution is A-F-G.

1. Apply DFS. Break ties on the fringe alphabetically, i.e., expand the state that comes earliest in the alphabet.

(a) How many nodes do you need to expand (including expanding A and and the node containing G) until you find the solution? **[1.5 points]**

(b) What is the solution (i.e., state sequence)? Your solution should contain both states A and G. **[1.5 points]**

2. Apply BFS. Break ties on the fringe alphabetically.

   (a) How many nodes do you need to expand (including expanding A and and the node containing G) until you find the solution? **[1.5 points]**

   (b) What is the solution (i.e., state sequence)? Your solution should contain both states A and G. **[1.5 points]**

3. Apply UCS. Break ties on the fringe alphabetically.

   (a) How many nodes do you need to expand (including expanding A and and the node containing G) until you find the solution? **[1.5 points]**

   (b) What is the solution (i.e., state sequence)? Your solution should contain both states A and G. **[1.5 points]**

4. Apply greedy search with the following heuristic h: the minimum number of edges to travel through to reach G. Break ties on the fringe alphabetically.

   (a) How many nodes do you need to expand (including expanding A and and the node containing G) until you find the solution? **[1.5 points]**

   (b) What is the solution (i.e., state sequence)? Your solution should contain both states A and G. **[1.5 points]**

5. Apply A* with the following heuristic h: the minimum number of edges to travel through to reach G. Break ties on the fringe alphabetically.

   (a) How many nodes do you need to expand (including expanding A and and the node containing G) until you find the solution? **[1.5 points]**

   (b) What is the solution (i.e., state sequence)? Your solution should contain both states A and G. **[1.5 points]**

   (c) Is h admissible for the state space graph shown in Figure 1? **[1.5 points]**

   (d) Is h consistent for the state space graph shown in Figure 1? **[1.5 points]**

6. (a) What is the cost of the optimal solution? **[1 point]**

   (b) Which of the algorithms from the previous parts achieved it? **[1 point]**

2 Adversarial Search [20 points]

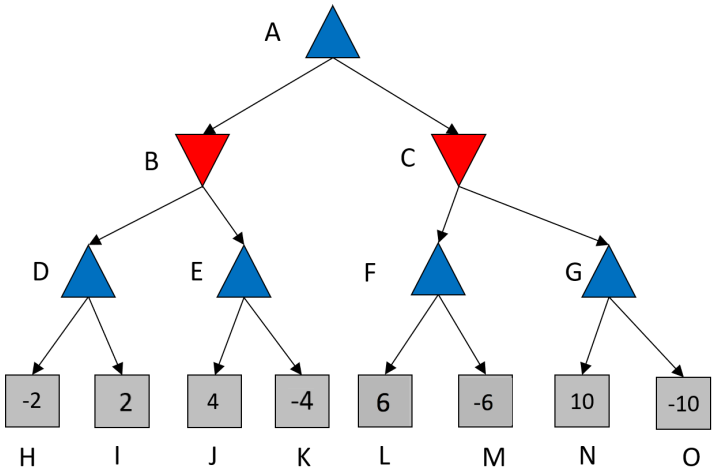

Figure 2: An adversarial search tree

Figure 2 shows an adversarial search tree, in which the blue nodes (i.e., "A", "D", "E", "F", "G") are max nodes and the red nodes (i.e., "B", "C") are min nodes. The gray nodes are the terminal states—each has its utility value. Each max or min node has two actions: "go left" or "go right". For example, if you are at "A", then you can go left to arrive at "B" or go right to arrive at "C".

Note that, you are provided with this entire adversarial search tree, which has not been traversed/expanded yet. Your job is to do minimax search, determining each node's value and finding out the minimax solution from "A" to the goal states.

1. Perform **(minimax) search** to

   (a) fill in the value of each node; **[3.5 points]**

A	B	C	D	E	F	G

   (b) find the minimax predicted strategy. A predicted strategy is a "path" from "A" to the gray (leaf) nodes. For example, "A"-"C"-"G"-"N" (or equivalently, right-right-left). **[2.5 points]**

2. Perform minimax search with α-β **pruning** . Expand the tree in DFS order fashion, breaking ties with the leftmost action first.

   (a) Fill in the value of each node. If a node is pruned (i.e., no need to visit according to α-β pruning), put X as the answer for that node. **[7.5 points]**

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O

   (b) State the predicted strategy. **[3 points]**

3. Now let us consider the **expectimax search** by changing each red min node to an expectation node. The probability for the left and right actions are 50% and 50%. Please fill in the value of each node. **[3.5 points]**

A	B	C	D	E	F	G

A	B	C	$\neg(A \wedge B \wedge \neg C)$	$\neg A \vee \neg B \vee C$
F	F	F		
F	F	T		
F	T	F		
F	T	T		
T	F	F		
T	F	T		
T	T	F		
T	T	T		

Table 1: The table for Question 3.

3 Logic-1 [4 points]

Show that $\neg(A \wedge B \wedge \neg C)$ is the same as $\neg A \vee \neg B \vee C$, by filling in the truth table in Figure 1. T: True; F: False. Please make sure that you answer all the 16 cells correctly. No partial grades will be given for this question.

4 Logic-2 [6 points]

Suppose that the following logical sentences are in your knowledge base.

$$\begin{aligned} C \wedge F &\Rightarrow \neg B \\ B &\Rightarrow F \\ B &\Rightarrow C \end{aligned} \tag{1}$$

Question: Is B True or False?