Washington State University
School of Electrical Engineering and Computer Science
Fall 2018

CptS 440/540 Artificial Intelligence
Homework 3 Solution
Due: September 13, 2018 (11:59pm)

General Instructions: Put your answers to the following problems into a PDF document and submit as an attachment under Content → Homework 3 for the course CptS 440 Pullman (all sections of CptS 440 and 540 are merged under the CptS 440 Pullman section) on the Blackboard Learn system by the above deadline. Note that you may submit multiple times, but we will only grade the most recent entry submitted before the above deadline.

1. Consider the following initial and goal states for the 8-puzzle problem (same as Homework 1). In the search algorithms below, when iterating over possible actions (i.e., moving the blank tile), always consider the actions in the order: Left, Right, Up, Down. Also, be sure to use the search algorithms as defined in the lecture notes.

1	2	3
4		6
7	5	8

Initial State

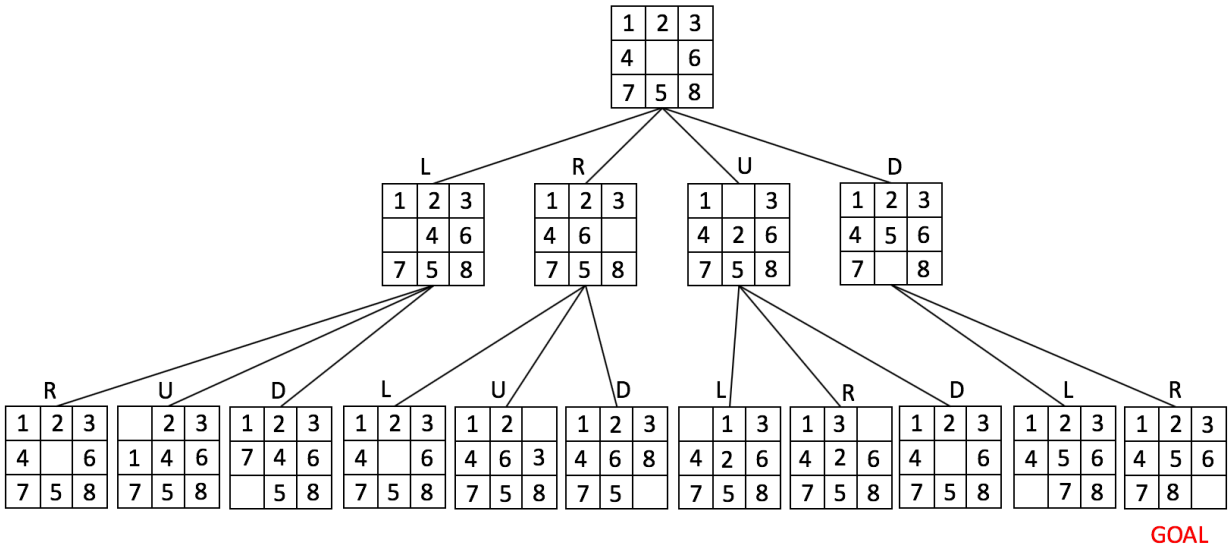
1	2	3
4	5	6
7	8	

Goal State

   a. Draw the search tree showing all nodes generated by the Breadth-First Search algorithm to solve this problem.
   b. Draw the search trees for each iteration of the Iterative-Deepening Search algorithm to solve this problem.
   c. Draw the search tree generated by the A* search algorithm to solve this problem using the city-block distance for the heuristic *h*. The city-block distance for an 8-puzzle state is the sum of the city-block distances of each tile in the puzzle (excluding the blank tile). Next to every node, show the values of *f*, *g* and *h*. If two nodes have the same *f* value, then prefer nodes farther to the right in the search tree.
   d. Draw the search tree generated by the Hill-Climbing search algorithm to solve this problem, where a state's Value = 1 / (*h* + 1), where *h* is the heuristic from part (c). Next to every node, show its Value. Finally, indicate which node is returned. Be careful; note that the Hill-Climbing algorithm does not employ the goal test, but stops only after none of the generated neighbor nodes has a strictly better Value.
   e. *CPTS 540 Students Only*: Consider changing the heuristic in part (c) such that you also include the city-block distance of the blank tile in the sum. Is this new heuristic admissible? Justify your answer.

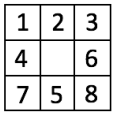
Solution:

a. Breadth-first search generates almost the entire depth=2 search tree. Only the last node to the right of the goal node is not generated.

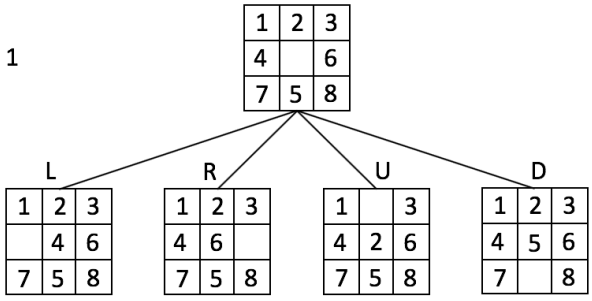


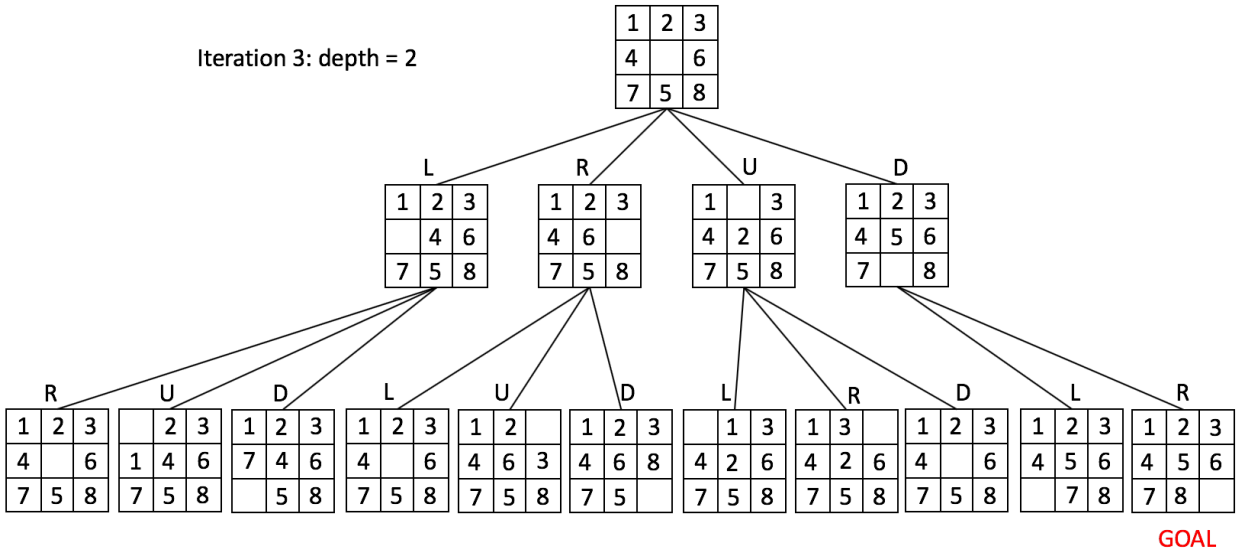
b. Iterative-deepening search. The last (3rd) iteration stops as soon as goal is generated. So, like BFS, the node just to the right of the goal is not generated.

Iteration 1: depth = 0

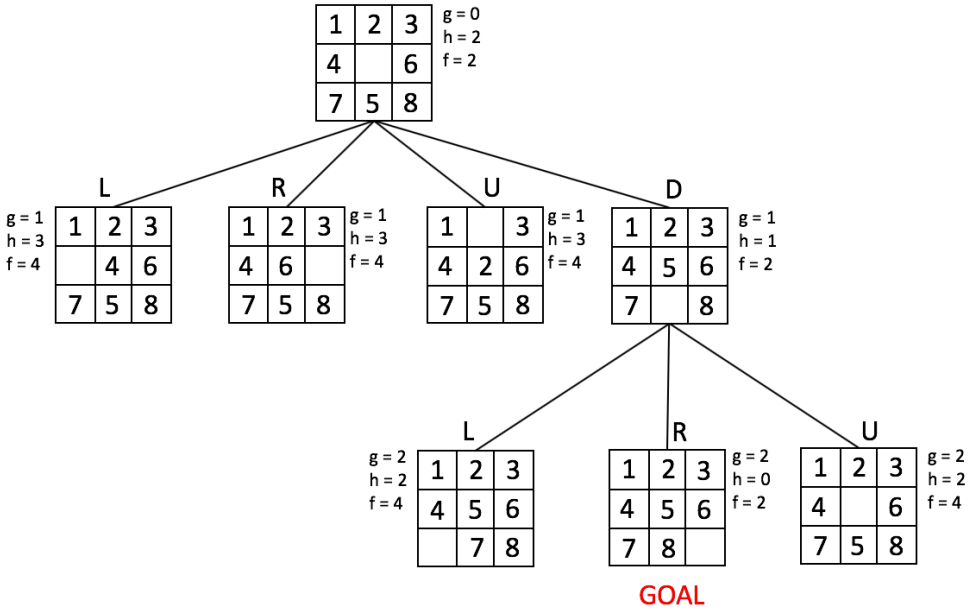


Iteration 2: depth = 1

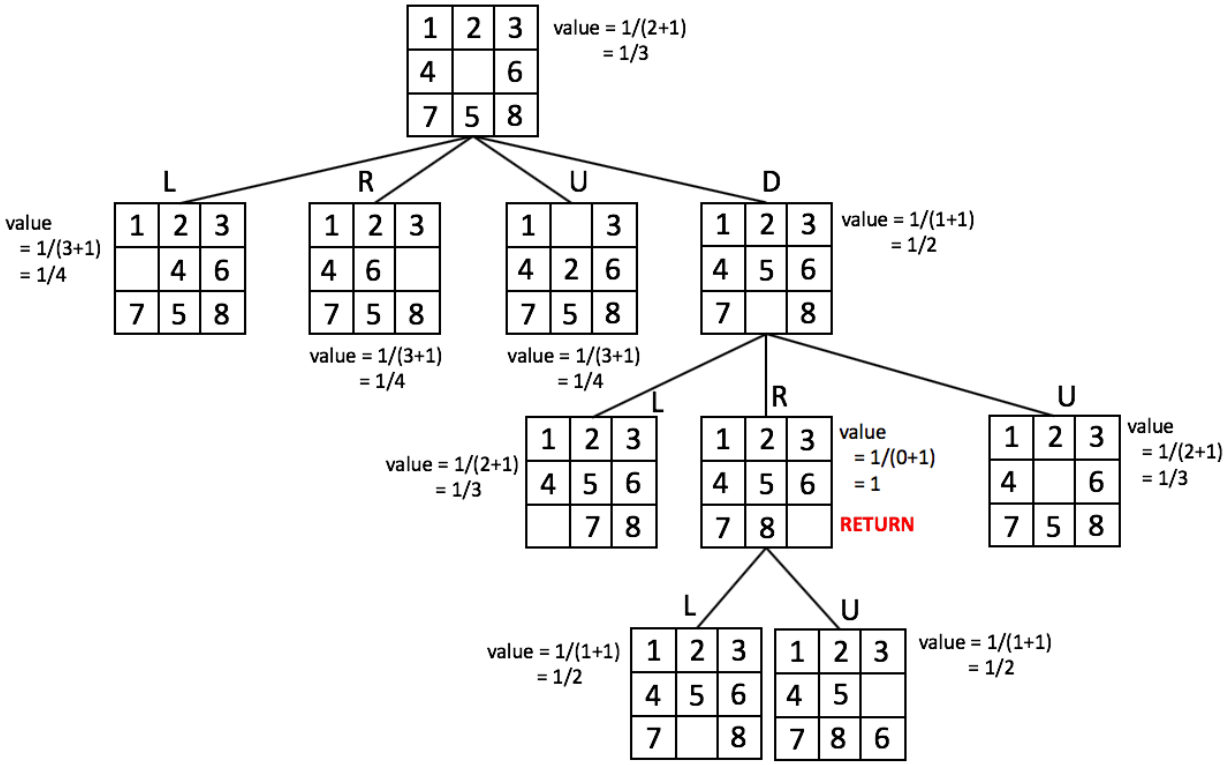




c. Note that A* search does generate the node to the right of the goal node, since A* performs the goal test only when nodes are removed from the frontier.



d. Note that hill-climbing search does not know the maximum value, so it generates nodes beyond the goal node; stopping and returning the goal node only after none of its children have a better value.



e. No, this heuristic is not admissible, because it may over-estimate the cost to the goal. For example, the heuristic value for the state below is 2, but the cost to the goal is 1.