CSC505 Jennings
Homework 6, Spring 2020
Please read, research, and answer all 4 questions below.

This assignment MUST be done alone, NOT in a group. You may NOT discuss the questions with other students. If you use any resources (e.g. websites) to answer a question, you MUST cite it there. Turn in the assignment on Gradescope.

I. Overview:

This is an INDIVIDUAL assignment. Do not discuss it at all or share information about the questions or answers with anyone.

In this assignment, you will demonstrate your understanding of how *search* is generalized from searching a simple data structure to searching a *solution space* for an optimal, or at least acceptable, solution.

For this assignment, you can turn in a PDF in almost any format – there is no template to follow. On Gradescope, you will have to indicate where in your PDF we will find the answer to each question.

Do not forget to cite any resources you used, including our textbook.

II. Questions:

The heuristic function used by the A* algorithm[1] is an argument supplied by the program using A*, and the heuristic must be *admissible* in order to guarantee that a least-cost path is found. Answer the questions below, which are about different problems we can solve with A* and a suitable heuristic.

1. $h(x) = d(x, g)$ where d is the Euclidean distance[2] function, g is the goal, and the problem is to find a path in 3 dimensions from a (fixed) start point, s, to the (fixed) goal. We can use A* if we convert the problem of searching for a path in 3-d space into a graph problem. Suppose we use a grid, and turn each intersection of grid lines into a node in the graph.

    a. Is $h(x)$ admissible or not? Give a 1-sentence justification.

    b. The grid imposes a maximum number of edges that any node can have. What is this number? State any assumptions.

[1] https://en.wikipedia.org/wiki/A*_search_algorithm

[2] In 3 dimensions, $d(x, y) = \sqrt{(x_0 - y_0)^2 + (x_1 - y_1)^2 + (x_2 - y_2)^2}$

2. $h(x) = 1\ coin$ (a constant function) in the problem of finding the least number of coins that make change[3] for a given amount, n, using a multi-set of coins with denominations $\{x_1, x_2, \ldots, x_j\}$.

a. This heuristic makes an estimate that a solution can be found from the current node by adding one more coin. Is it admissible?

b. Describe a graph structure that would allow the change making problem to be solved using A* search.

[3] https://en.wikipedia.org/wiki/Change-making_problem

3. $h(x) =$ cost of direct flight from x to the goal city, where the problem is to find the cheapest way to fly from a start city to a goal city. When there is a direct flight, it may be cheaper to fly through 1 or more cities. Whenever there is not a direct flight from city x to city y, the cost is ∞.

a. Is $h(x)$ admissible? Give a 1-sentence justification; also, state any assumptions.

b. Is $h(x)$ consistent? Give a 1-sentence justification; also, state any assumptions.

4. Solve this instance of the 8-puzzle, either by hand or by writing a program. If you use any existing programs or libraries, cite them of course. Your answer must show:

- Use of A* search (each step of execution)
- The relevant part of the graph that would be used by A*
- The heuristic chosen
- Value of the heuristic, h(n), and current cost, g(n) at each expanded node