Write down your works on a PDF file and submit it to Moodle before June 11th, 2018

Problem 1. (3.0pts) (AIMA, Exercise 3.3) Suppose two friends live in different cities on a map, such as the Romania map shown in Figure 3.2. On every turn, we can simultaneously move each friend to a neighboring city on the map. The amount of time needed to move from city i to neighbor j is equal to the road distance $d(i, j)$ between the cities, but on each turn the friend that arrives first must wait until the other one arrives (and calls the first on his/her cell phone) before the next turn can begin. We want the two friends to meet as quickly as possible.

a) Write a detailed formulation for this search problem.

b) Let $D(i, j)$ be the straight-line distance between cities i and j. Which of the following heuristic functions are admissible? (i) $D(i, j)$; (ii) $2 \cdot D(i, j)$; (iii) $D(i, j)/2$.

c) Are there completely connected maps for which no solution exists?

d) Are there maps in which all solutions require one friend to visit the same city twice?

Problem 2. (1.0pt) You are given a graph as shown below. For each of the following graph search strategies, work out the order in which states are expanded, as well as the path returned by graph search.

a) Greedy best-first search

b) $A^*$

In all cases, assume ties resolve in such a way that states with earlier alphabetical order are expanded first. The start and goal state are S and G, respectively. Heuristic values are shown next to the states' symbols.

Problem 3. (1.0pt) Determine whether the heuristic in Problem 2. is admissible.
Problem 4. (3.0pts) You are given the initial state (a) and the goal state (b) of an 8-puzzle as shown below.

\[
\begin{array}{ccc}
2 & 8 & 3 \\
1 & 6 & 4 \\
7 & & 5 \\
\end{array}
\quad
\begin{array}{ccc}
1 & 2 & 3 \\
8 & & 4 \\
7 & 6 & 5 \\
\end{array}
\]

(a) (b)

a) Apply A* using Manhattan distance heuristic function. Draw the search tree including possible expanded states during the algorithm procedure. Compute the triple \((g, h, f)\) for each state. Describe the optimal strategy found.

b) Repeat a) with the misplaced tiles heuristic function instead of Manhattan distance.

How does an 8-puzzle search tree look like? For example,

Problem 5. (2.0pts) It has been shown that the 8-puzzle states are divided into two disjoint sets, such that any state is reachable from any other state in the same set, while no state is reachable from any state in the other set.

Write a procedure whose input parameters are two 2-dimensional arrays representing the two 8-puzzles states, A and B, and the only output parameter is a binary value indicating whether A is reachable from B.

Your procedure must be implemented in C++/Python/Java.