COMP7015 Artificial Intelligence **Semester 1, 2022/23**

Written Assignment 1

Instructor: Dr. Kejing Yin Sep. 22, 2022

Problem 1: Formulating a Search Problem (20 marks)

Consider a famous problem in AI, *the missionaries and cannibals problem*, which is stated as follows. Three missionaries and three cannibals are on one side of a river, along with a boat that can hold one or two people. The task is to get everyone to the other side of the rivier, but you cannot leave a group of missionaries in one place outnumbered by the cannibals in the same place.

Q1. Formulate the problem into a search problem. Define precisely its state space, the initial state, the goal state, and all possible actions.

Q2. Draw the complete state space according to your formulation.

Q3. Which search algorithm is the best one to solve for problem? Explain your choice.

Remarks: you can define some notations to help you formulate the problem, like we did in the wolf, goat and cabbage problem. If you intend to use any self-defined notations, explain the meaning of your notations clearly and precisely at the begining of your solution.

Problem 2: Uninformed Search (40 marks)

Consider a state space, where each state is a number. The initial state is 1. For each state, there are two successors: numbers $2k$ and $2k + 1$.

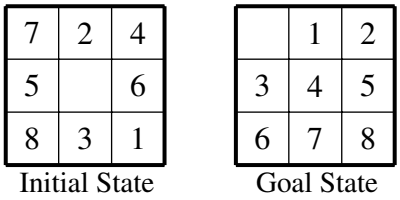
Q1. Draw the portion of the state space for states 1 to 15.

Q2. Suppose the goal state is 11. List the order in which nodes will be visited for breadth-first search, depth-first search, depth-limited search with limit 3, and iterative deepening search.

Q3. Suppose the goal state is a large number, for example, 32768 or 2^{50}, and you only have limited memory. Which of BFS, tree-like DFS, and graph DFS would you use to solve this problem? Explain your choice.

Problem 3: Heuristic Search (40 marks)

Consider the following 8-puzzle problem.



The objective of the puzzle is to slide the tiles horizontally or vertically into the blank space until the configuration matches the goal state. The search space is quite large in 8-puzzle or 16-puzzle

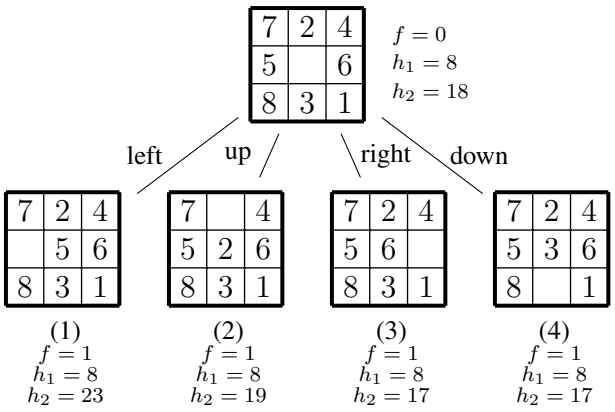
- h_1 = the number of misplaced tiles (blank not included).

  For the example above, all eight tiles are out of position, so the initial state has $h_1 = 8$.

- h_2 = the sum of the distances of the tiles from their goal positions.

  Because tiles cannot move along diagonals, the distance is the sum of the horizontal and vertical distances — called **Manhattan distance**. For the example above, moving 7 in the initial state to the correct location in the goal state requires 3 moves (right, down, and down), moving 2 in the initial state to the correct location in the goal state requires 1 move (right). Tiles 1 to 8 in the initial state of the above example give a Manhattan distance of $h_2 = 3+1+2+2+2+3+3+2 = 18$.

The possible actions include moving the blank tile left, up, right, and down. The cost of moving left, up, right, and down are 1, 2, 3, and 4, respectively. The first step of search expands the initial state and results in the following search tree:



Q1. Are h_1 and h_2 admissible? Briefly explain your answer.

Q2. Which of h_1 and h_2 is a better heuristic function to use? Briefly explain the reasons.

Q3. Perform greedy search with the heuristic function h_2 to solve for this problem. Draw the portion of the search tree after the first four steps (including the first step shown above). Show which state you expand in each step and briefly explain the reason.

Q4. Perform A* search with the heuristic function h_2 to solve for this problem. Draw the portion of the search tree after the first four steps (including the first step shown above). Show which state you expand in each step and briefly explain the reason.