National University of Singapore
School of Computing
CS2109S: Introduction to AI and Machine Learning
Semester I, 2023/2024

Tutorial 1
Problem Formulation & Uninformed Search

These questions will be discussed during the tutorial session. Please be prepared to answer them.

Summary of Key Concepts

In this tutorial, we will discuss and explore the following key learning points/lessons from Lecture:

1. Describing the problem environment with PEAS.
2. Formulating a search problem:
   (a) State representation
   (b) Actions
   (c) Goal state(s)
3. Uniform-cost Search
4. Iterative Deepening Search

Problems

1. Determine the following environment properties of a Sudoku game.
   - Fully vs Partially Observable
   - Single vs Multi-Agent
   - Deterministic vs Stochastic
   - Episodic vs Sequential
   - Static vs Dynamic
   - Discrete vs Continuous
2. Determine the PEAS (Performance measure, Environment, Actuators, Sensors) for the SIRI function of iPhones.

3. The Tower of Hanoi is a famous problem in computer science, and is described as follows: You are given 3 pegs (arranged left, middle and right) and a set of n disks with holes in them (so they can slide into the pegs). Every disk has a different diameter.

   We start the problem with all the disks arranged on the left peg in order of size, with the smallest on the top. The objective is to move all the disks from the left peg to the right peg in the *minimum number of moves*. This is done by:

   - moving one disk at a time from one peg to another; and
   - never placing a disk on top of another disk with a smaller diameter.

   Figure 1 shows the intial state for $n = 3$. To get a better feel of the problem, you can try it here: https://www.mathsisfun.com/games/towerofhanoi.html.

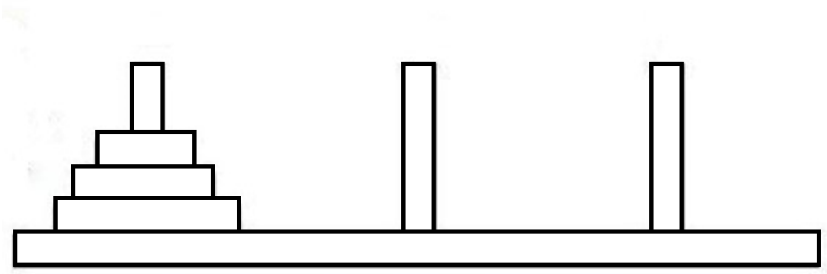

Figure 1: The initial state for $n = 3$

Complete the following:

(a) Give the representation of a state in this problem;

(b) Describe the representation invariant of your state (i.e., what condition(s) must a state satisfy to be considered valid). Compare the total number of possible configurations in the actual problem to that of your chosen state representation, with and without considering the representation invariant;

(c) Specify the initial and goal states of your state representation;

(d) Define the actions;

(e) Using the state representation and actions defined above, state the transition function T (i.e., upon applying each of the actions defined above to a current state, what is the resulting next state?).

4. Consider the undirected graph shown in Figure 2. Let S be the initial state and G be the goal state. The cost of each action is as indicated.

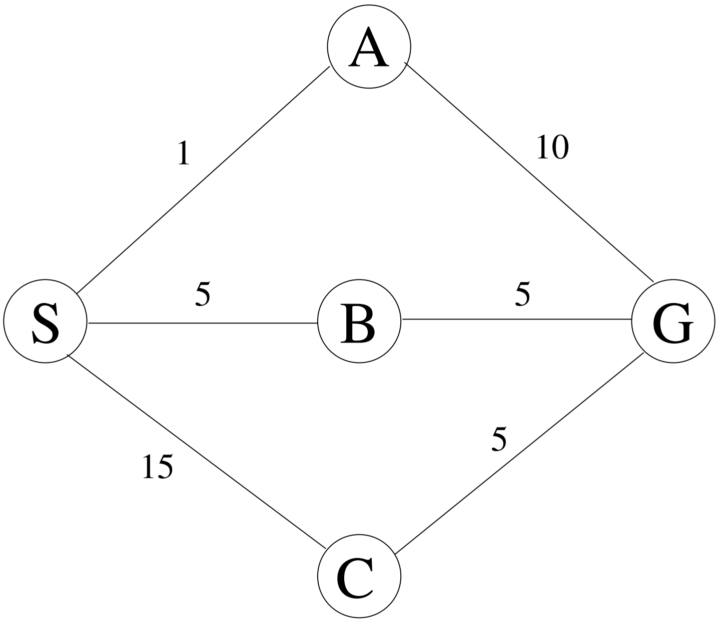

Figure 2: Graph of routes between S and G.

   (a) Give a trace of uniform-cost search using *tree* search

   (b) Give a trace of uniform-cost search using *graph* search

   (c) When A generates G, the goal state, with a path cost of 11 in (b), why doesn't the algorithm halt and return the search result since the goal has been found? With your observation, discuss how uniform-cost search ensures that the shortest path solution is selected.

   (d) What's the difference between uniform-cost search (using graph search) and Dijkstra's algorithm?

5. Describe a state space in which iterative deepening search performs much worse than depth-first search.