HW1: Search
CS4300: Artificial Intelligence **Prof. Alan Kuntz**
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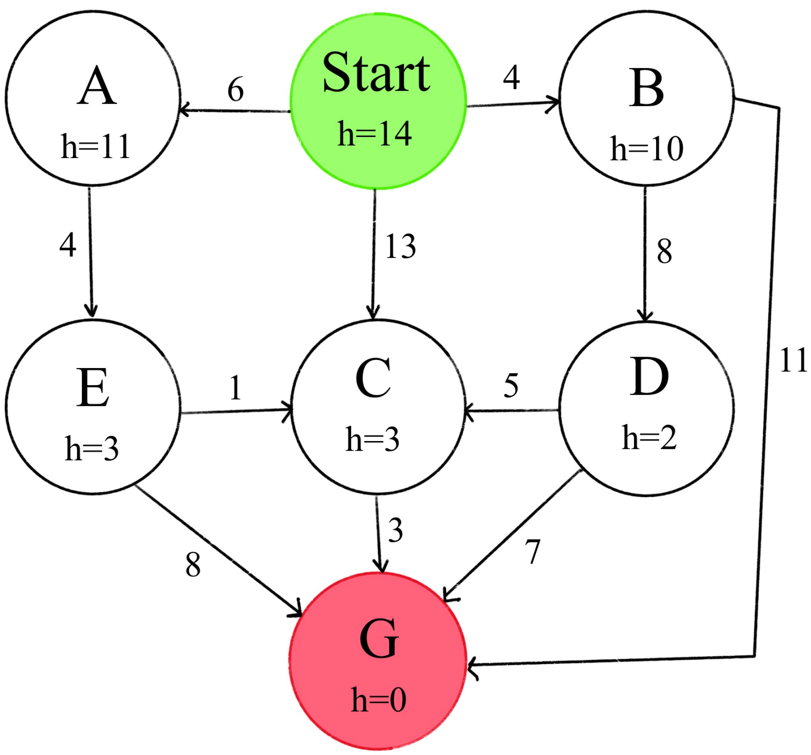
1 Graph Search

Alice the agent really wants to go skiing right after AI class is over. She starts in the lecture hall (the "start" state below) and wants to make it to Park City (the "goal" state) as soon as possible. There are several possible paths she can take denoted in the graph below:



The available actions at each state are denoted by arrows with an edge cost label next to each arrow. For each of the following graph search strategies, **describe the order in which states are expanded as well as the path returned by graph search. Show all work.** When expanding states *add their children to the data structure in alphabetical order* (i.e. when expanding from Start, put A into the data structure *before* B), using 'G' for the goal. Remember that in graph search, states are expanded only once.

1. Depth first search

   Answer: ______________________

2. Breadth first search

   Answer: ______________________

3. Uniform cost search

   Answer: ______________________

4. Greedy search with the heuristic values listed at each state

   Answer: ______________________

5. A* search with the heuristic values listed at each state

   Answer: ______________________

Answer the following questions based on the above graph:

6. Do the heuristic values above constitute a consistent heuristic? If not, which edge(s) is/are not consistent?

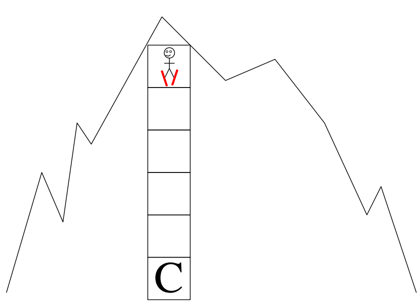
   Answer: ____________________

7. If necessary, fix the above heuristic to be consistent by decreasing its values as little as possible, i.e., minimizing the sum of the changes you make. Feel free to leave some values unchanged if changing them is not necessary.

Node	Old Heuristic Value	New Heuristic Value
Start	14	
A	11	
B	10	
C	3	
D	2	
E	3	
Goal	0	

2 Downhill Skiing

After getting to Park City, Alice takes the lift up to the top of the mountain. Now she wants to ski down, so her only option is to go straight downhill. She begins with a velocity of 0 and can safely maintain a maximum velocity of V. At any state, she has three actions she can take: accelerate, decelerate or coast. If the accelerates, her velocity increases by 1; if she decelerates, it decreases by 1; if she coasts, it stays the same. *After* her velocity is adjusted by her action, she moves downhill an equal number of squares to her current velocity.



Consider the above figure. If Alice's first action is "accelerate" then she will end up in the second square down with a velocity of 1. If she then "coasts" then she will end up in the third square down with a velocity of 1. If she "accelerates" again, she will end up in the fifth square down with a velocity of 2.

Alice's goal is to reach the chair lift (marked "C") with a velocity of zero. (No, Alice cannot have negative velocities). She would like to get there as quickly as possible. However, if she ends her time at the chair lift square with a non-zero velocity, she skies into the parking lot and destroys her skis.

1. Describe the components that need to be included in the state definition. Justify your answer. What are the start/goal states?

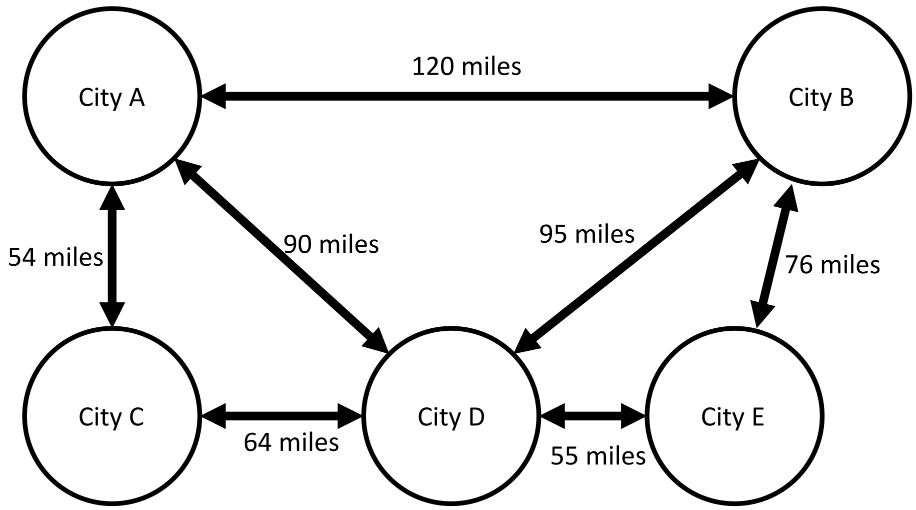
2. Give an example of a state that is not reachable and explain why it is not reachable.

3. Assuming all actions have a cost of 1, is Alice's current velocity an admissible heuristic? Why or why not?

4. Suppose that Alice cannot accelerate after she has decelerated (i.e. *all* accelerations must occur before *all* decelerations, but she can coast whenever she wants): does this yield *more* unreachable states? If so, give an example of one. Justify your answer either way.

3 Human-Centric Factors

Consider the following graph, which shows the connectivity via roads between five cities. The edges and their labels represent the existence and length of the roadways in between the cities.



Jessie, who resides in City A, needs to travel to City B. Jessie has a medical condition that frequently produces life-threatening symptoms at unpredictable times that requires treatment in an emergency room. There are emergency rooms in each of the five cities, but medical care is non-existent on the roads themselves.

Please consider and thoughtfully answer the following questions:

1. From just looking at the graph, what path do you think Jessie should take to get from City A to City B? Explain your choice.

2. (a) Using the edge costs given in the graph, what path is returned using the UCS algorithm with the traditional objective function (shortest cumulative distance)?

(b) Based on your answer to question 1 and (2a), do you think that the shortest cumulative distance on the path from City A to City B is the right objective function to use when considering the optimal route for Jessie? Why or why not?

3. Imagine you are working with a team that is trying to train assistive AI to help Jessie decide on routes to travel safely between cities. Your teammates propose the following objective functions and you need to decide whether these objective functions will enable good outcomes for Jessie. Carefully critique each objective function by answering the questions provided *(note: some of these algorithms require additional information to solve - your team has only proposed the objective function)*.

   Objective function 1: Since we do not want Jessie to take longer roads, an objective function could be to minimize the sum of the cube of each distance between cities to punish longer edge traversals, i.e.,
   Edge Cost = Distance^3.

   (a) Do you think this objective function is appropriate for this context when considering your answer to question 1?

   (b) Given just the information provided by your teammate, can we use UCS with this objective function? If so, what path is returned? If not, explain why not.

   (c) Given just the information provided by your teammate, can we use A* with this objective function? If so, what path is returned? If not, explain why not.

(d) Using your answers above, which, if any, of the search algorithms above will return the route you think is best for Jessie for this objective function for this specific graph? Justify your answer.

Objective function 2: An objective function could be to minimize the maximum distance between any two adjacent cities on the path (i.e., we define the total cost of each path to be the longest edge on that path, and the objective is to minimize this value).

(e) Do you think this objective function is appropriate for this context when considering your answer to question 1?

(f) Given just the information provided by your teammate, can we use UCS with this objective function? If so, what path is returned? If not, explain why not.

(g) Given just the information provided by your teammate, can we use A* with this objective function? If so, what path is returned? If not, explain why not.

(h) Using your answers above, which, if any, of the search algorithms above will return the route you think is best for Jessie for this objective function for this specific graph? Justify your answer.

4. So far, we've been considering a *specific* graph. However we want our algorithms to work for any arbitrary graph.

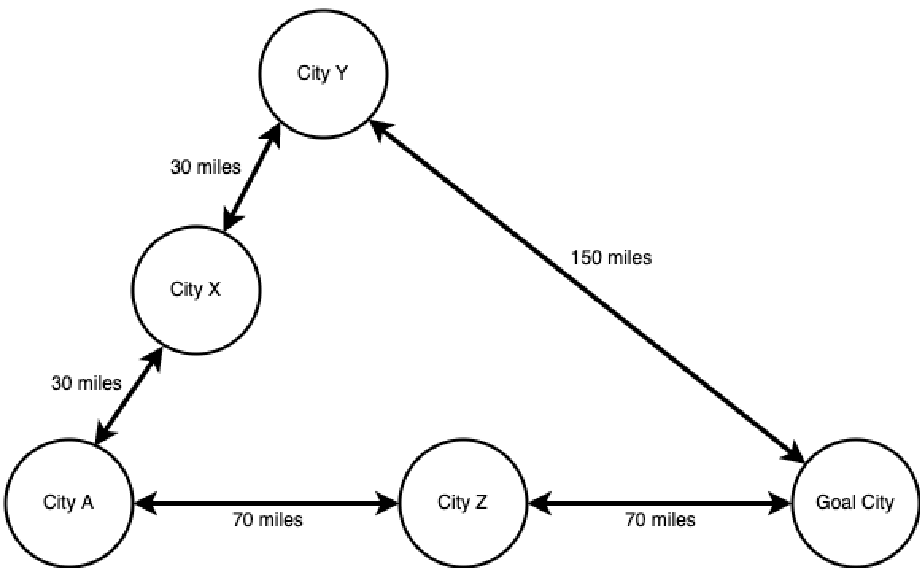
   (a) Describe an objective function that you think is most appropriate for this scenario (use or modify one of the objective functions given above or come up with your own).

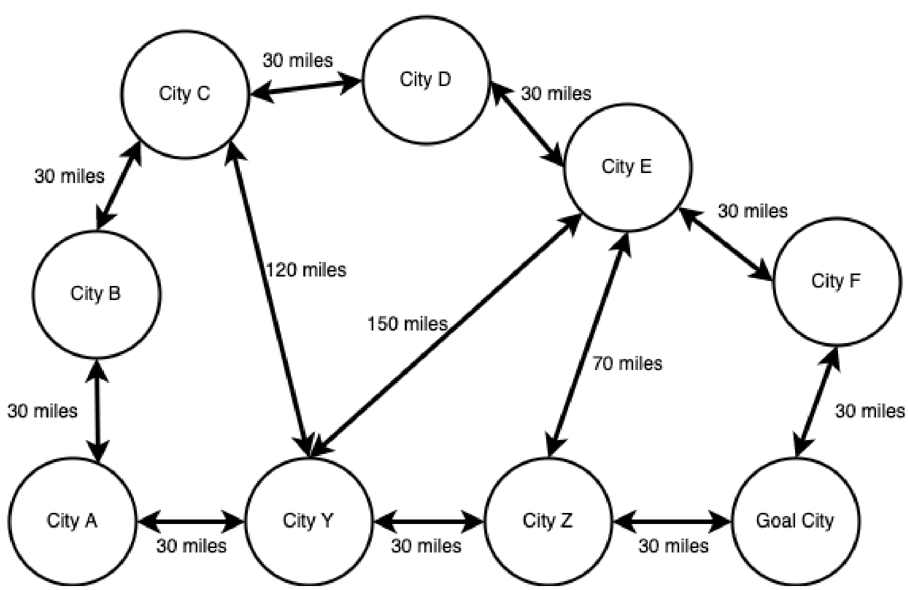
   (b) Determine which, if any, of the search algorithms we've covered will still be optimal for this objective for any arbitrary graph.

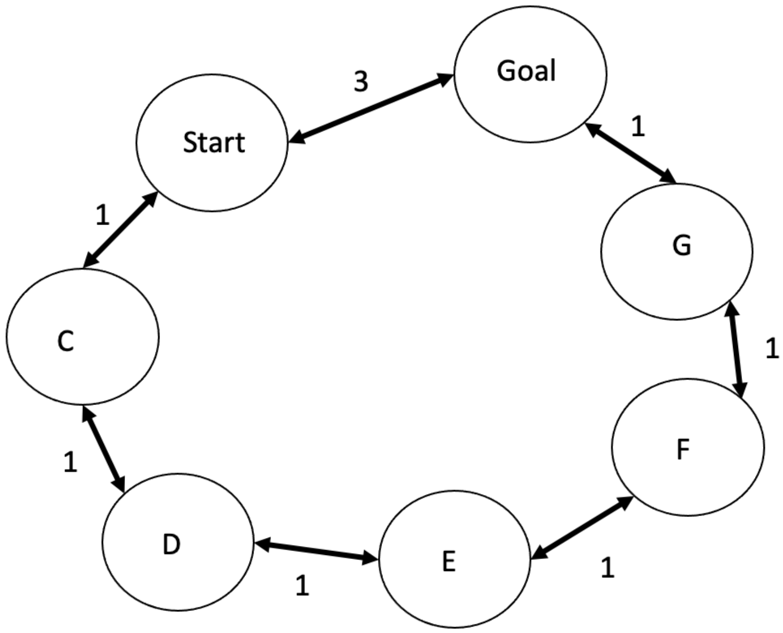
   (c) Justify your answer with a discussion of the kinds of paths the algorithm might choose between in an unknown, arbitrary graph.

Optional: you may find it helpful to consider a few specific graphs when considering all arbitrary graphs. I've included a few such graphs at the end of this document to help you think about this.

5. In this problem, we are modeling this situation solely based on distances between cities and locations of emergency rooms. What is another example of a human-centric factor that we would need to consider when modeling the optimal path for Jessie that demonstrates the complex nature of defining an "optimal" path in real life?






3
Goal
Start
1
1
G
1
C
F
1
D
E
1
1