Heuristic Practice

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Overview

Practice 1 - Car in maze

Imagine a car-like agent wishes to exit a maze like the one shown below:

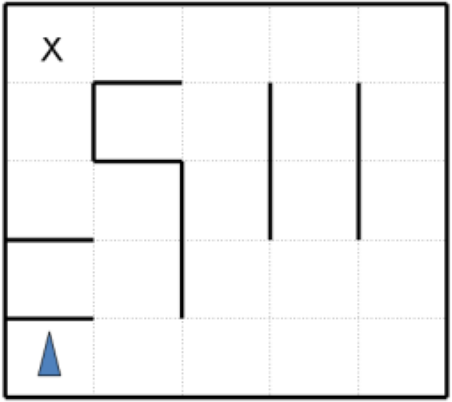

Figure: A car in maze

Description of problem I

The agent is directional and at all times faces some direction $d \in (N, S, E, W)$. With a single action, the agent can either move forward at an adjustable velocity v or turn. The turning actions are *left* and *right*, which change the agent's direction by 90 degrees. Turning is only permitted when the velocity is zero (and leaves it at zero).

- The moving actions are *fast* and *slow*. *fast* increments the velocity by 1 and *slow* decrements the velocity by 1; in both cases the agent then moves a number of squares equal to its NEW adjusted velocity.
- Any action that would result in a collision with a wall crashes the agent and is illegal.
- Any action that would reduce v below 0 or above a maximum speed V_{max} is also illegal.
- The agent's goal is to find a plan which parks it (stationary) on the exit square using as few actions (time steps) as possible.

Description of problem II

As an example: if the agent shown were initially stationary, it might first turn to the east using (*right*), then move one square east using *fast*, then two more squares east using *fast* again. The agent will of course have to slow to turn.

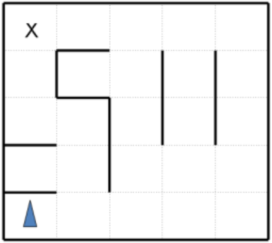

Figure: A car in maze

Question 1

If the grid is M by N, what is the size of the state space? Justify your answer. You should assume that all configurations are reachable from the start state.

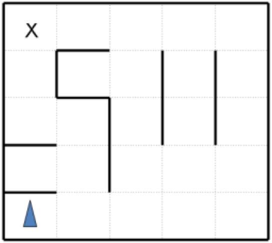

Figure: A car in maze

Question 2

What is the maximum branching factor of this problem? You may assume that illegal actions are simply not returned by the successor function. Briefly justify your answer.

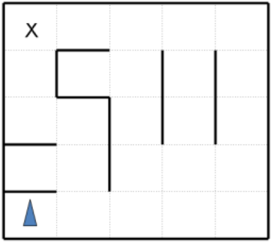

Figure: A car in maze

Question 3

Is the Manhattan distance from the agent's location to the exit's location admissible? Why or why not?

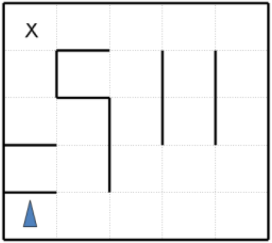

Figure: A car in maze

Question 4

State and justify a non-trivial admissible heuristic for this problem which is not the Manhattan distance to the exit.

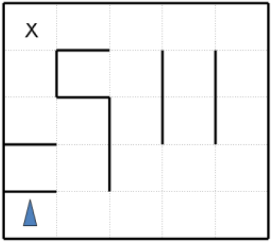

Figure: A car in maze

Question 5

If we used an inadmissible heuristic in A* tree search, could it change the **completeness** of the search?

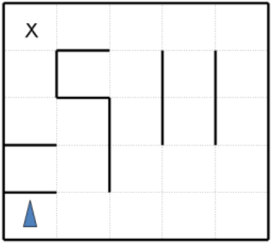

Figure: A car in maze

Question 6

If we used an inadmissible heuristic in A* tree search, could it change the **optimality** of the search?

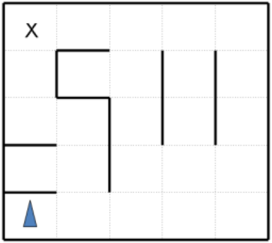

Figure: A car in maze

Question 7

Give a general advantage that an inadmissible heuristic might have over an admissible one.

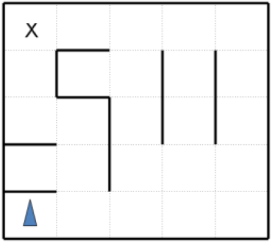

Figure: A car in maze

Suppose two friends live in different cities on a map, such as the Romania map shown in Figure . 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.

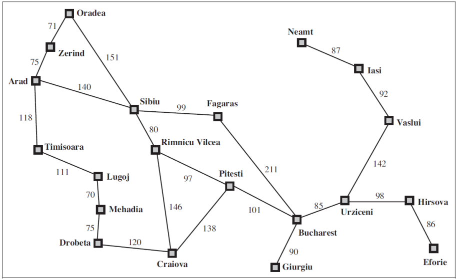

Figure: Cities of Romania

Write a detailed formulation for this search problem. (You will find it helpful to define some formal notation here.)

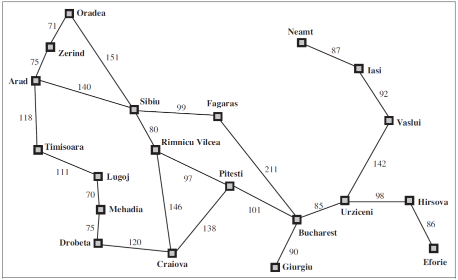

Figure: Cities of Romania

Question 2

Let $D(i,j)$ be the straight-line distance between cities i and j. Which of the following heuristic functions are admissible?

- $D(i,j)$;
- $2 \times D(i,j)$;
- $D(i,j)/2$.

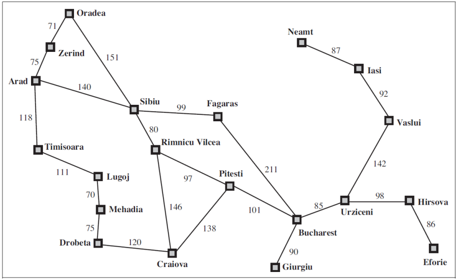

Figure: Cities of Romania

Practice 3 - Moving Vehicles

n vehicles occupy squares $(1, 1)$ through $(n, 1)$ (i.e., the bottom row) of an $n \times n$ grid. The vehicles must be moved to the top row but in reverse order; so the vehicle i that starts in $(i, 1)$ must end up in $(n - i + 1, n)$. On each time step, every one of the n vehicles can move one square up, down, left, or right, or stay put; but if a vehicle stays put, one other adjacent vehicle (but not more than one) can hop over it. Two vehicles cannot occupy the same square.

Question 1

Calculate the size of the state space as a function of n.

Question 2

Calculate the branching factor as a function of n.

Question 3

Suppose that vehicle i is at (x_i, y_i); write a nontrivial admissible heuristic h_i for the number of moves it will require to get to its goal location $(n - i + 1, n)$, assuming no other vehicles are on the grid.

Question 4

Which of the following heuristics are admissible for the problem of moving all n vehicles to their destinations? Explain.

- $\sum_{i=1}^{n} h_i$
- $max\{h_1, \cdots, h_n\}$
- $min\{h_1, \cdots, h_n\}$

Practice 4 - 8-puzzle

Invent a heuristic function for the 8-puzzle that sometimes overestimates, and show how it can lead to a suboptimal solution on a particular problem. (You can use a computer to help if you want.) Prove that if h never overestimates by more than c, A using h returns a solution whose cost exceeds that of the optimal solution by no more than c.

The End