Foundations of Artificial Intelligence

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Exercise Sheet 2

Due: Monday, May 25, 2020

Exercise 2.1 (Formalizing problems)

Formalize the following problems as precisely as possible, by defining the initial state, the state space, the set of actions, the goal test and the path cost function:

- You want to solve Rubik's Cube.
  `http://en.wikipedia.org/wiki/Rubik%27s_Cube`
- You have to color a map of Europe with only four colors. In order for the national borders to be recognizable, no two neighboring countries may be assigned the same color.

Exercise 2.2 (Search algorithms)

Prove each of the following statements:

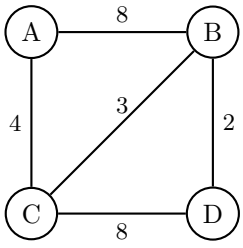
(a) Breadth-first search is a special case of uniform-cost search.

(b) Breadth-first search, depth-first search, and uniform-cost search are special cases of best-first search.

(c) Uniform-cost search is a special case of A* search.

Exercise 2.3 (Search)

Consider the graph depicted below. We are interested in a path from node **A** to node **D**. The cost of moving between two nodes is given by the respective edge weight. In the following, we refer to instances of the general Tree-Search algorithm (not Graph-Search).



	$h(x)$
A	8
B	3
C	4
D	0

(a) Perform a *Greedy Best-First Search* using heuristic h. In which order are the nodes expanded?

(b) Perform a $A^\star$ search using heuristic h. In which order are the nodes expanded?

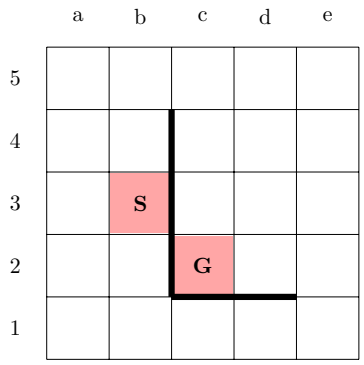
(c) Perform a *Uniform Cost Search*. In which order are the nodes expanded?

(d) Complete the following definition:

A heuristic h is *consistent* iff ...

Exercise 2.4 (A*)

A house cleaning robot tries to find the shortest path from S (start) to G (goal). The robot can move between horizontally or vertically connected grid cells, one cell in each step. If a wall (thick black line) lies in between two cells, the robot cannot move between them. Each step incurs a uniform cost of 1. Figure (a) shows the initial state, Figure (b) the heuristic value estimates of each cell.



(a) Initial state

	a	b	c	d	e
5	5	4	3	4	5
4	4	3	2	3	4
3	3	2	1	2	3
2	2	1	0	1	2
1	3	2	1	2	3

(b) Heuristic values

(a) Perform an A* search to find the shortest path from S to G. For all generated nodes, write down the respective g- and f-values in the corresponding grid cell. All other cells should be left blank. Use the graph-based variant of A* and re-open explored nodes when a better estimate becomes known (see slide 19 of 4-Informed-search-methods.pdf).

(b) Is the heuristic from Figure (b) admissible?

(c) Let $h^*(n)$ be the actual cost of the optimal path from n to the goal G. How many nodes does A* expand when using the h^* heuristic?

Note: The exercise sheets may be worked on in groups of up to three students.