Foundations of Artificial Intelligence

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Exercise Sheet 2

Due: Wednesday, May 20, 2015, before the lecture

Exercise 2.1 (A* search (8-Puzzle))

(a) Trace the operation of A* search in the following 8-puzzle configuration:

2	8	3
1	6	4
7		5

Goal State:

1	2	3
8		4
7	6	5

Show the sequence of search nodes the algorithm will consider and the f, g, and h score for each node when used with the Manhattan distance heuristics.

(b) Calculate the h and f values for each search state from part (a) but using the "Misplaced Tiles" heuristics. How could the use of this heuristics influence the search?

Exercise 2.2 (A* Search (Path Planning))

Consider the problem of finding the shortest path between two points on a plane that has convex polygonal obstacles (see Fig. 1). This is an idealization of the problem a robot has to solve to navigate its way around in a crowded environment.

(a) Suppose the state space consists of all positions (x, y) in the plane. How many states exist? How many paths are there to the goal?

(b) We are interested in the shortest path to the goal. This runs along the corners of the polygons and therefore consists of line segments that connect the polygon's corners. We formulate the state space to contain the corners of all polygons as well as the start and goal coordinates. State the full successor function for the states $(1, 5)$ (start) and $(3, 4)$ in the problem in Fig. 1.

(c) Suggest a suitable heuristic for A* search.

(d) Execute the first step of A* Search. Show the search nodes and the $f-$, $g-$ and $h-$ values. Which state is expanded next after the start state?

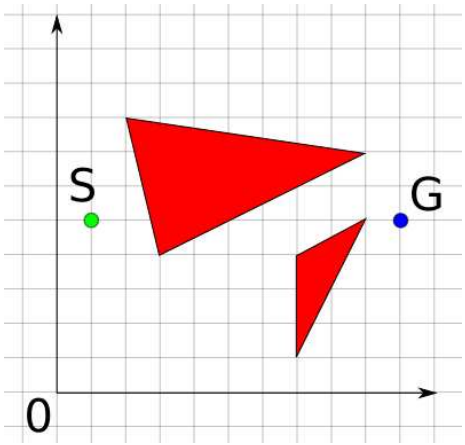


Figure 1: Robot navigation among polygons. The origin O is at coordinates $(0, 0)$. The start state is at $(1, 5)$. The goal is at $(10, 5)$.

Exercise 2.3 (Search algorithms)

Prove each of the following statements:

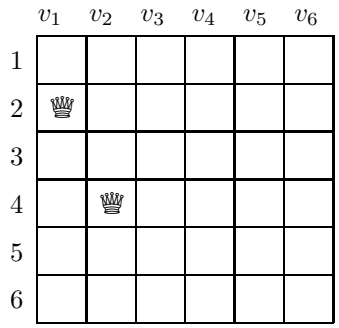
(a) Breadth-first search is a special case of uniform-cost search.

(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 2.4 (Forward Checking / Arc consistency)

Consider the 6-queens problem, where 6 pieces have to be placed on a size 6×6 board in such a way that no two queens are on the same horizontal, vertical or diagonal line. Let the domains be $dom(v_i) = 1, \ldots, 6$ for all variables $v_i \in V$. Consider now state $\alpha = \{v_1 \mapsto 2, v_2 \mapsto 4\}$.



(a) Enforce arc consistency in α. Specify in particular the domains of the variables before and after applying arc consistency. You may assume that the domain of variables with allocated values only consists of that value, while the values of unassigned variables still range over the complete domain.

(b) Apply forward-checking in α. Compare with the result of (a).

Exercise 2.5 (Searching under Unobservability and Nondeterminism)

Consider the sensorless two-location vacuum cleaner world from the lecture for the case in which the cleaning action can nondeterministically soil the current location if it was already clean.
Draw the belief space reachable from the initial belief state in which the robot considers all world states possible. Explain why the problem of cleaning both locations with certainty is unsolvable in this case.

The exercise sheets may and should be worked on in groups of three (3) students. Please write all your names and the number of your exercise group on your solution.