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MATH. - NATURWISS. FAKULTÄT
FACHBEREICH INFORMATIK
KOGNITIVE SYSTEME · PROF. A. ZELL

Mobile Robots

Summer Semester 2013
Assignment 11

due date: 16.07.2013, presentation: 23.07.2013
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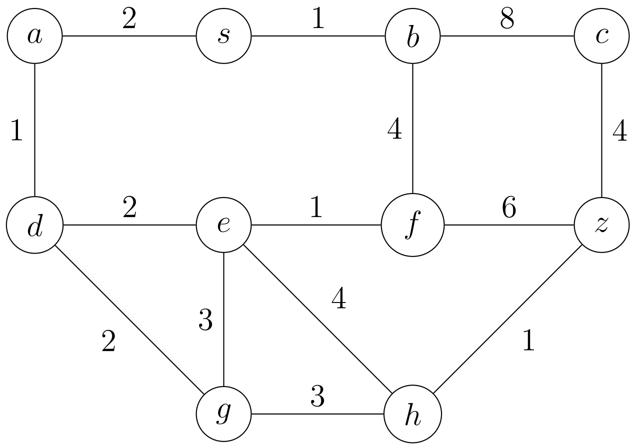
Exercise 1 Graph Search (10 points)



Let $s = (1, 2)$ be the start node and $z = (3, 1)$ be the goal node. Compute the shortest path from s to z using

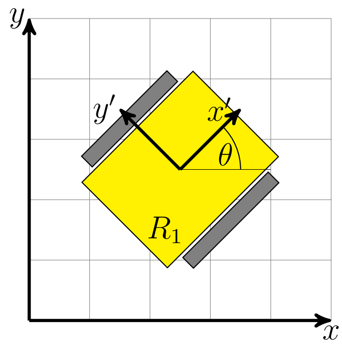
(a) Breadth-first search. Specify the content of the queue and the currently expanded node v for every step of the algorithm. Use the same termination criterion as presented on the slides.

(b) Dijkstra's Algorithm. Specify the currently expanded node v, the values $dist(u)$ for every node u and the set of all visited nodes for every step of the algorithm.

(c) A*. Specify the currently expanded node v and the content of the priority-queue (including and sorted by the key value) for every step of the algorithm. Please differentiate heuristic and distance values. Use the heuristic $h_1(v) = |z.x - v.x|$, which is clearly admissible.

In all cases specify the resulting path. If several nodes have the same priority, break the ambiguity using the lexicographical ordering of the nodes.

Exercise 2 Nonholonomic Constraints (5 points)

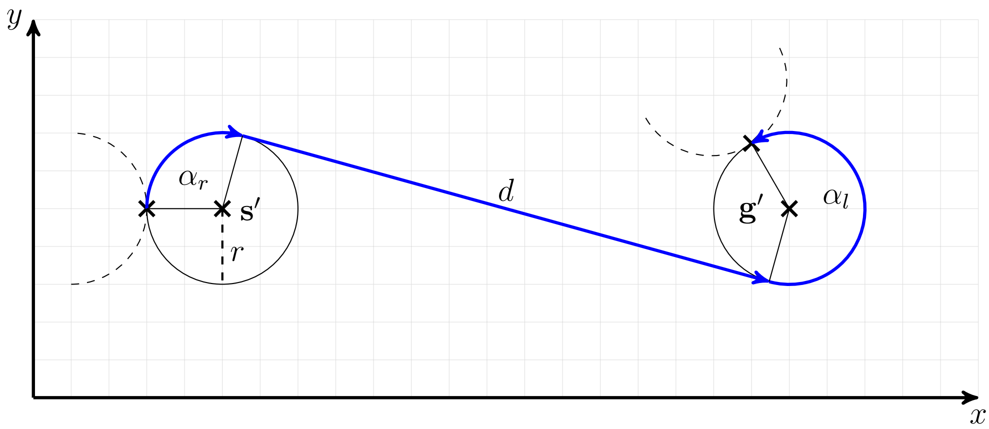


Assume a differential-drive robot R_1 and let R_1's state be given by $\mathbf{q} = (x, y, \theta)^T$.

(a) Formulate a constraint on R_1 that expresses its wheels inability to move along the local y'-axis. Use the global frame as the frame of reference, i.e. the constraint should be formulated in the configuration space and not in R_1's local coordinate frame. The resulting formula may only depend on $\mathbf{q}$ and possibly on derivatives of $\mathbf{q}$.
Hint: Start by calculating the vector $\mathbf{d}(\mathbf{q})$ which points in the heading direction.

(b) Is the constraint calculated in (a) holonomic or nonholonomic? Why?

Exercise 3 Reeds Shepp Curves (5 points)



Assume a car-like robot R_2. In the lecture we took a quick look at Reeds-Shepp curves. These are combinations of circular and straight motions that can connect arbitrary configurations, given there are no obstacles. To compute the shortest path, the algorithm calculates the lengths of all possible combinations. In this exercise you will calculate the length of the combination *right straight left*:

The robot first travels on an arc of radius r spanning an angle of α_r, then straight on a line of length d, then on another arc with angular span α_l.

(a) Calculate the distance d, the robot drives on the line. Simplify as far as possible. The result should only depend on $\mathbf{s}'$, $\mathbf{g}'$ and r

(b) Calculate the overall distance $\delta(\alpha_r, \mathbf{s}', \mathbf{g}', \alpha_l)$, assuming that α_r and α_l are given.