Planning and Decision Making - Assignment 3

Global Path Planning

Due date: Monday, December 8, 11:59am
Submit by Brightspace before noon

Course: RO47005 Planning & Decision Making, TU Delft, CoR
Contact: Zuleika Redondo Garcia, email: Z.M.RedondoGarcia@student.tudelft.nl

Deliver a PDF (maximum 4 pages) with the answers to all questions in this assignment on Brightspace before the due date. Questions can be asked in the Q&A sessions or on the Brightspace forum. The solutions to this assignment will be discussed in the Q&A session in the week of the submission deadline.

1 Definition of the elements of RRT

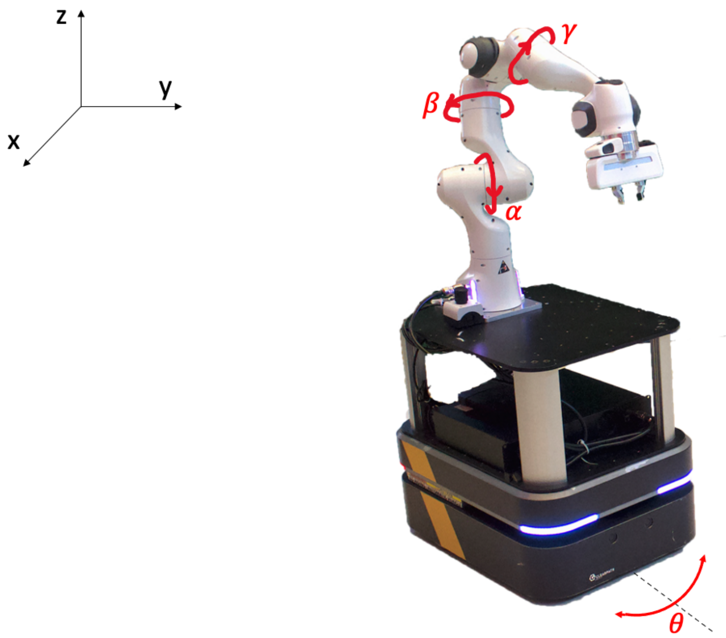

Figure 1: Mobile manipulator of AIRLab with α, β and γ indicating the DOF of the arm. θ is the orientation of the base, the other DOF of the base are the x and y [1].

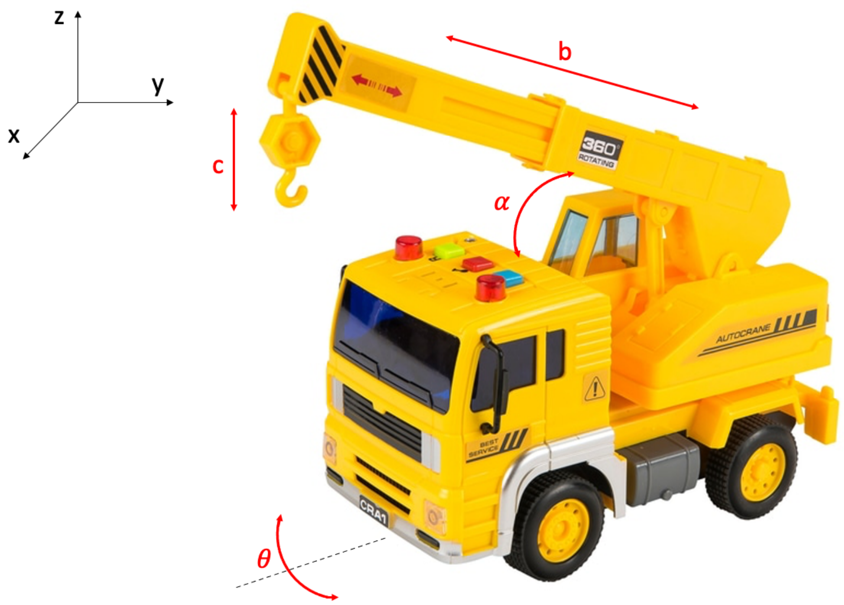

Figure 2: Toy crane with indicated DoF by α, b and c. θ is the orientation of the car, the other DOF of the car are the x and y [2].

Description of the 2 systems (6,0 pt)

In this part of the assignment, you will solve parts of the motion planning problem for two systems: the mobile manipulator of AIRLab Delft [1], which could be used for stacking shelves in supermarket stores, and a toy crane.
The mobile manipulator is visualized in Figure 1, where the base is to be considered as a unicycle (x, y, θ) and the rotational joints of the manipulator are defined by angles α, β and γ. Consider that the joints have no limits and can rotate both clockwise and anticlockwise. The angle θ is the orientation of the base. (This is a simplified representation of the manipulator of the real robot.)
The toy crane is visualized in Figure 2 with corresponding degrees of freedom. The base can be considered a car, with DOF (x, y, θ), with θ the orientation of the car in the plane. On top of the car is a crane mounted with a rotational joint $\alpha \in [0, \frac{1}{2}\pi]$, the arm of the crane can elongate with length b and the gripper can be moved up and down with length c.

All questions must be answered for both systems

Question 1.1 (1,0 pt - 0,5 pt per robot) Define the workspace and configuration space of the robot.

Question 1.2 (1,0 pt - 0,5 pt per robot) Is the system holonomic or nonholonomic? Provide a short explanation.

Question 1.3 (2,0 pt - 1,0 pt per robot) Given two configurations q_1 and q_2, define an appropriate metric to compute the distance (q_1,q_2).

Question 1.4 (2,0 pt - 1,0 pt per robot) Given q_1 and q_2 of the robot, define an appropriate steering function to connect them exactly. Assume an obstacle-free environment.

2 RRT (4,0 pt)

Description

Using the information of your system, you can define the RRT method (Rapidly Exploring Random Trees) for that particular system. Some steps are general, other steps specific to the system you use. We will now use the answers of the questions of part one to define the RRT method for the AIRLab Delft mobile manipulator.

Question 2.1 (2,0 pt) To compute a collision-free path in an environment with static obstacles, define and describe the steps of the RRT method for the mobile manipulator. Indicate where your answers of Question 1.3 and 1.4 are incorporated in this algorithm.

Question 2.2 (1,0 pt) Is this method optimal? If not, name a globally optimal alternative and compare it briefly to RRT.

Question 2.3 (1,0 pt) Is RRT complete, probabilistic complete or incomplete? Reason why.

[1] ICAI. AIRLab Delft. `https://icai.ai/airlab-delft`.

[2] Smyths Toys. Light and sounds crane truck. `https://www.smythstoys.com/uk/en-gb/toys/great-value-toys-/light-and-sounds-crane-truck-small/p/163665`.