Homework 3

Assigned on March 4, 2024
Due on March 11, 2024

Learning Outcomes:

After this homework, you should be able to:

(a) Appreciate the existence of multiple solutions for inverse kinematics problem;

(b) Determine the inverse kinematics mapping of manipulators.

Tasks

Problem 1
CLO2-C4

2×5+15+5 points

(a) Given a desired (x, y), how many solutions are there to the inverse kinematics of the arm shown in Figure 1? Treat the cases of position at boundary of workspace and in the interior of workspace separately.

(b) If an orientation of the end effector is also specified, how many solutions are there? Treat the cases of position at boundary of workspace and in the interior of workspace separately.

(c) Use the geometric approach to find solutions for both cases, i.e. (i) only (x, y) is provided, and (ii) (x, y, ϕ) is provided.

(d) The manipulator of this question is installed on a bomb-disposal robot as shown in Figure 2. Your task is to move the bomb, the red box, from its present location to the containment unit, the container in black, safely, i.e. it is required that the bomb remains in its current orientation throughout the motion. The motion will be carried out in three steps - move straight up, move left, and move straight down.

The provided script `bombDisposal.m` requires you to provide it values of the joint variables at different instants in time for the entire motion. It will then set up the display of the robot and play the motion corresponding to the provided joint variables. The required motion is captured in `bombDisposal.mp4`

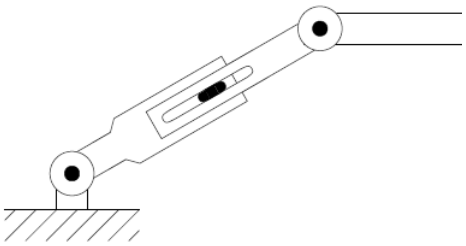

Figure 1: Three link planar robot

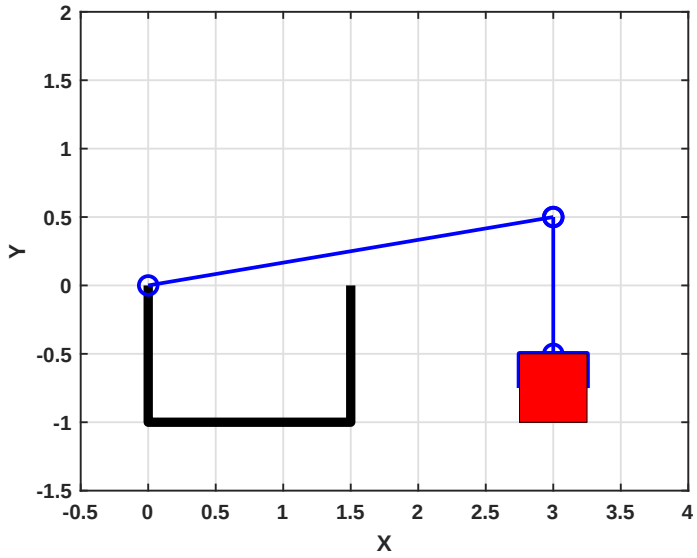

Figure 2: The Bomb Disposal Robot

Problem 2
CLO2-C3

25 points

Gen3 robots, shown in Figure 3, are a popular series of industrial robots from Kinova Robotics. They offer two robotic manipulators - a 6 dof and 7 dof one, under this title. In this task, you'll obtain closed-form expressions for all possible inverse kinematics solutions of the 6 DOF Kinova Gen3 robot. You can use either the algebraic or geometric approach. The schematics and dimensions of this robot can be located on page 62 of its user guide.

A second part to this question will be added soon.

Problem 3
CLO2-C4

30 points

In this task, you'll find closed-form expressions for all the inverse kinematics solutions for the Universal Robotics' UR5e arm, introduced to you in the previous homework and being utilized for RoboCup ARM Challenge 2024. As you've determined in the previous homework, this arm does not employ a spherical wrist thereby eliminating the possibility of decoupling the kinematics as shown in class. You'll have to explore yourself the possibilities of any decoupling and strategies for solving inverse kinematics problem.

Figure 3: Kinova Gen3 6 DOF Arm

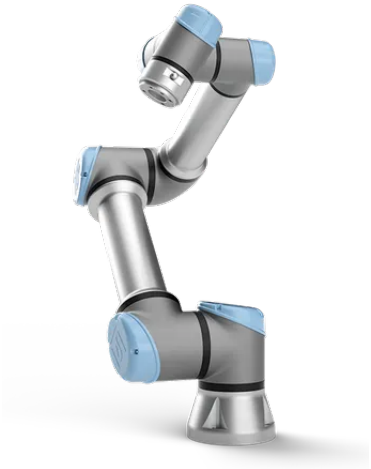

Figure 4: Universal Robotics UR5E Arm

Answer the following questions individually:

Problem 4
CLO2-C2

5+10 points

(a) How many hours did each of you spend on this homework and specifically state your contribution in this homework assignment? Answer as accurately as you can, as this

will be used to structure next year's class.

(b) Do you have any specific advice for students attempting this homework next year?

(c) **This question has been revised compared to the previous homework assignments.** Each group member is to provide their reflections as answers to each of the following questions. You are expected to be precise in your responses.

1. Explain each of the outcomes, stated at the beginning of this document, in your own words.
2. Why is it important for you to achieve each of the outcomes in relation to understanding or building any robot?
3. What do you currently understand about content related to these outcomes? Do you have unanswered questions?
4. Have you achieved these outcomes? What went wrong? How will you enable yourself to achieve these outcomes? What could you do to know more or enhance your skills in this context?