THE DEPARTMENT OF AUTOMOTIVE ENGINEERING

CLEMSON UNIVERSITY

AuE 8220: Robotic Mobility and Manipulation, Fall 2022

Comprehensive Project

Assigned on: Oct 27th Due: Dec. 6th 1:00 PM (in class presentation + upload)

Instructions:

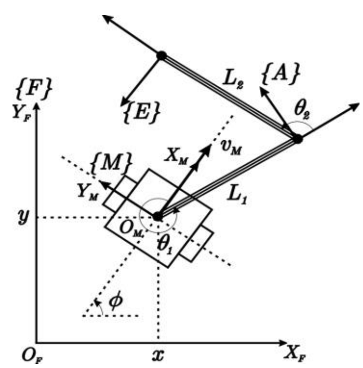
You will attempt this software project together with your selected team-member.

PPT file (15-20 comprehensive slides)

- PPTX contains: Motivation; Formulation (can be handwritten and scanned), Screenshots of critical code; Results (graphs and embedded videos)
- In-Class Presentation of PPT + Prerecorded Working Code (15 minutes + 5 minutes questions)
- Dr. Krovi will give an example of how past students have made a presentation (and show it in next class)
- Upload a single Zip file with PPTX + Full documented Source-Code Directory by the due date/time noted above.

Project

In this problem we will develop the open-loop control (redundancy-resolution) for a 2-link DD-WMM to track desired EE position trajectories. The **end-effector position** $\underset{\sim}{\mathbf{x}}^d = (x, y)^T$ will be the manipulation variables of interest. This end-effector traverses TWO desired trajectories (1 full cycle in 20 seconds): (A) an ellipse with semi-major axis=2.5 oriented at an angle 60^0 w.r.t the horizontal and a semi-minor axis = 0.5, center at (0.5,0.5); and (B) a square of side 3.5 centered at (1,1).



Phase 1: Formulate 2-link Differentially Driven WMM/setup for kinematic simulation

Make any necessary assumptions about various parameters such as Wheel radius, Arm-lengths (and document them)

Phase 2: Redundancy Resolution

Study the effects of different open-loop redundancy resolution methods to problem at hand.

(i) Using the traditional pseudo-inverse solution.

(ii) Adding auxiliary constraints (one at a time) on the joint space variables of the form to resolve redundancy:

a. $\dot{\theta}_1 + \dot{\theta}_2 = 0$

b. $\dot{q}_1 = 0$

(iii) Using the minimization of an artificial potential described on the joint space as a secondary manipulation criterion to the traditional pseudoinverse solution (where $V = q_1^2 + 0.25q_2^2 + 0.66q_3^2$)

Simulate and plot the results of these various schemes for 3 full traversals of the ellipse of interest

Phase 3: Joint-space control and Task-Space Control

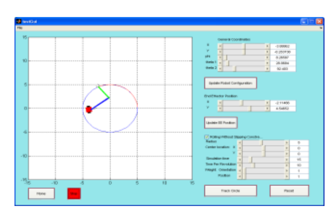
The desired manipulation rates can be achieved by the manipulator using (an appropriately modified closed-loop variant of) resolved motion-rate control. Hence you decide to create 2 types of controllers that allows the actual manipulation rates $\dot{\underset{\sim}{\mathbf{x}}}$ to track the desired manipulation rates $\dot{\underset{\sim}{\mathbf{x}}}^d$

(i) Design a joint-space controller (whose error-dynamics time-constants are 3 seconds).

(ii) Design a closed-loop task-space controller such that the pole of the error dynamics along the X-axis is -5 and Y axis is at -10.

Simulate and plot the results of these various schemes for 3 full traversals of the ellipse of interest – i.e. simulate for 60 seconds in total using MATLAB/Simulink.

Phase 4:



Develop an appropriate Graphical User Interface that will allow you to vary the various parameters of interest and study the effects

Phase 5:

Connect to a 2-link Differentially-Driven Wheeled Mobile Manipulator model (with MATLAB <--> CoppeliaSim)