MCE/EEC 647/747
Homework 2 - Spring 2015
Due 2/5/15

Preliminary steps

1. Solve problems 2-14 (numerically) and 2-22 (symbolically, Matlab's Symbolic Toolbox highly suggested).
2. Determine the slight difference between Matlab's `atan2` and the function shown in Appendix A of SHV.
3. Read Sections 2.5.1 and 2.5.2 of SHV to develop a detailed understanding of the inverse orientation solutions using Euler and Roll/Pitch/Yaw.
4. Examine Examples 3.3 and 3.4 in preparation for the main problem in this homework.
5. Read Section 3.3 to understand the geometric approach to the inverse position solutions for common robot configurations.
6. Solve Problem 3.13

Main problem:
A cylindrical manipulator similar to the one in Prob. 3-13 is fitted with a spherical wrist, as shown in Fig. 1 The base of the manipulator is placed at the world origin and there is a flat wall parallel to the x_0z_0 axis, as sketched. The wall is d_w units away from the world origin. The robot needs to draw an "eight figure" on the wall. To do this, point o must be on the wall surface at all times, and the pen (aligned with the z_6 axis) must remain perpendicular to the wall.

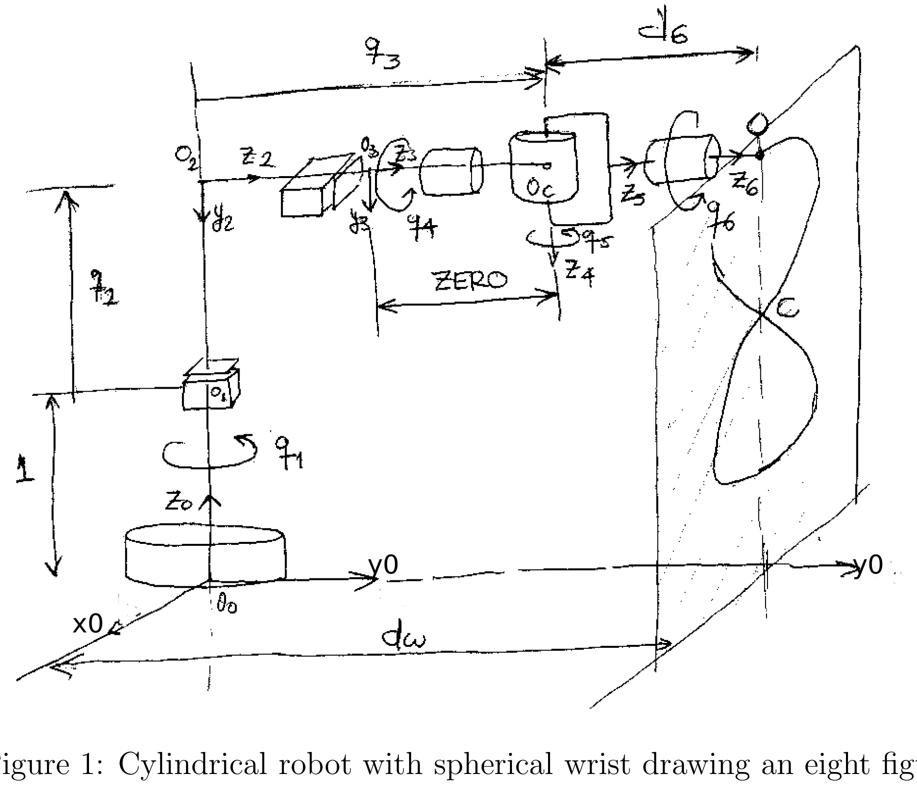

Figure 1: Cylindrical robot with spherical wrist drawing an eight figure

The eight figure can be taken as Bernoulli's lemniscate, described in polar coordinates as

$$r = \pm\sqrt{\cos(2\theta)}$$

where θ varies between $-\pi/4$ and $\pi/4$. Figure 2 shows the lemniscate drawn on a generic x_1, x_2 plane. The rectangular coordinates are found according to

$$x_1 = r\sin(\theta), \quad x_2 = r\cos(\theta)$$

Take the x_2 axis of the lemniscate parallel to the z_0 axis and center the figure at $(0, d_w, 1)$.

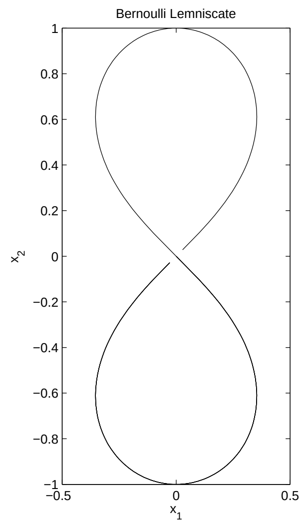

Figure 2: Bernoulli's Lemniscate

1. Generate the set of world coordinates for the figure, using θ from $-\pi/4$ to $\pi/4$ at a 0.01 spacing.

2. Determine the required world orientation of the end effector frame.

3. Write Matlab code to solve the required inverse kinematics problem. Consider unlimited ranges for q_1, q_2 and q_3.

4. Plot all joint variables as a function of figure parameter θ, for both halves of the figure.

5. Verify that the inverse solution works by calculating the forward position kinematics and plotting in 3D (use `plot3` and a suitable marker)

6. Write Matlab code to attempt a solution using Corke's Robotics Toolbox. Compare solutions.

Doctoral students only (747):
Repeat the problem, but consider that the figure must be drawn on the plane

$$\frac{x_0}{2} + \frac{y_0}{2} + \frac{z_0}{2} = 1$$

The proportions of the figure must be the same as in the original case. Choose your own center for the figure.