Department of Electrical and Computer Engineering
University of Illinois at Chicago

ECE 452 Homework 6 Date: 4/9/2018

Due date: 4/19/2018

1. Conveniently choose frames S and T, define the necessary kinematic parameters, and compute the **body manipulator Jacobian** for the 3-DOF manipulator in Figure 1.

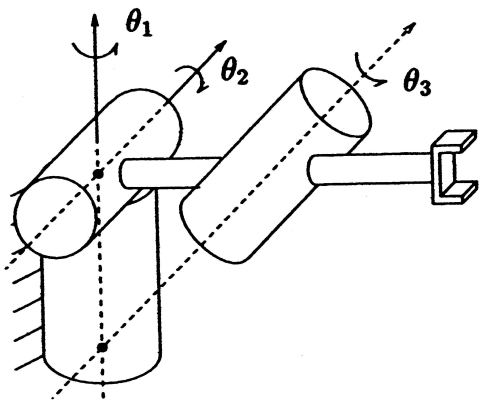

Figure 1: 3-DOF manipulator for Problem 1.

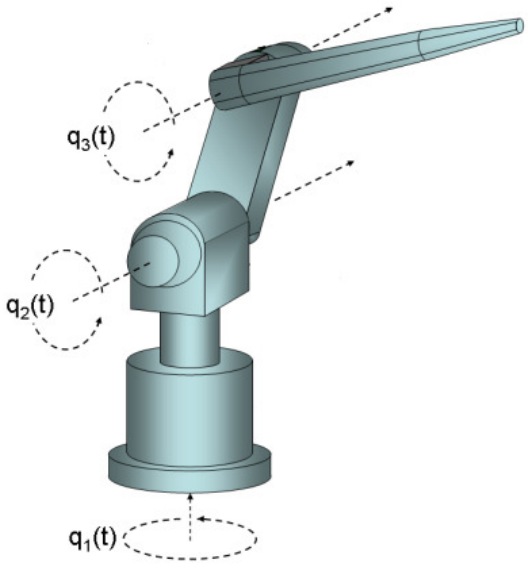

Figure 2: 3-DOF manipulator for Problem 2.

2. Consider the manipulator in Figure 2. Conveniently choose frames S and T, define the necessary kinematic parameters, and compute the **spatial manipulator Jacobian** for the manipulator.

3. Consider again the manipulator in Figure 2. Identify all the singular configurations of the manipulator.

   Hint: For real matrices, the following identities hold:

$$\text{rank}(A^T A) = \text{rank}(AA^T) = \text{rank}(A) = \text{rank}(A^T).$$

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4. Compute the *first three columns* of the **spatial manipulator Jacobian** of the manipulator in Figure 3. Note that joint 3 is prismatic.

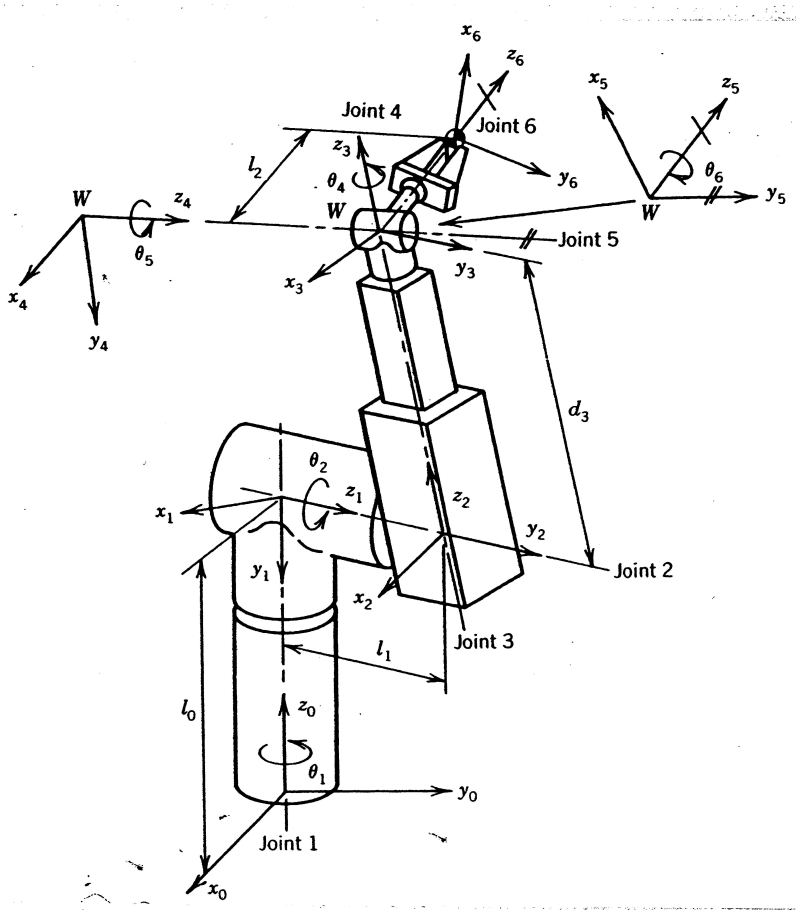

Figure 3: 6-DOF manipulator for Problem 2.

5. Many robots have a wrist mechanism to simplify their analysis and control. An example is the Elbow Manipulator depicted in Figure 3.4 of the Murray, Li and Sastry (MLS) book. However, the wrist mechanism introduces singular configurations that need to be avoided while operating the robot.

   Determine the singularities of the wrist mechanism of the Elbow Manipulator (refer to Figure 3.4 of the MLS book). Ignore the first three joints and place both the S and the T frames at the base of the wrist (the intersection of the three wrist axes). Can you identify the singularities with those described in Section 4.3 of Chapter 3 of the MLS book?