Department of Electrical and Computer Engineering
University of Illinois at Chicago

ECE 452 | Homework 5 | Date: 3/26/2018

Due date: 4/5/2018

1. A robot manipulator is used to assemble a car headlight. Tasks for the manipulator are described in a fixed frame A. A frame B is attached to the robot end-effector. The current configuration of the end-effector is described by the rigid-body transformation

$$g_{ab} = \begin{bmatrix} 0.528383 & 0.758351 & -0.381725 & 3.32152 \\ -0.150539 & 0.526175 & 0.836945 & 3.00205 \\ 0.835553 & -0.384763 & 0.392184 & 2.63034 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

   (a) Consider a **twist** described in the frame B by $T_b = \begin{bmatrix} -3 & 5 & -1 & -4 & 2 & 3 \end{bmatrix}^T$. Find the description of this twist in the frame A.

   (b) Assume the robot is asked to exert a **wrench** which is described in the frame B by $W_b = \begin{bmatrix} 4 & -3 & 5 & -1 & 3 & 2 \end{bmatrix}^T$. Find the description of this wrench in the frame A.

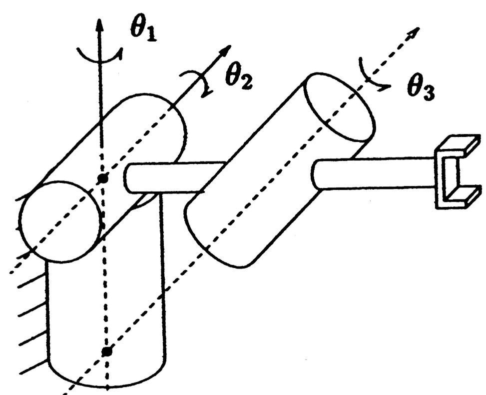

Figure 1: 3-DOF manipulator for Problem 2.

2. Consider the manipulator in Figure 1.

   (a) Conveniently choose frames S and T, the reference configuration, and identify all the joint twists. Define the kinematic parameters as you need them.

   (b) Compute the orientation of the tool frame as a function of the joint displacements and the kinematic parameters you chose.

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(c) Compute the position of the origin of the tool frame as a function of the joint displacements and the kinematic parameters you chose.

3. Consider the manipulator in Figure 2. Take the arrows on the joint axes as the indication of the direction of rotation (for joints 2 and 3 the direction of the arrow on the axis is not consistent with the direction of the rotation marking).

   (a) Conveniently choose frames S and T, the reference configuration, and identify all the joint twists. Define the kinematic parameters as you need them.

   (b) Compute the orientation of the tool frame as a function of the joint displacements and the kinematic parameters you chose.

   (c) Compute the position of the origin of the tool frame as a function of the joint displacements and the kinematic parameters you chose.

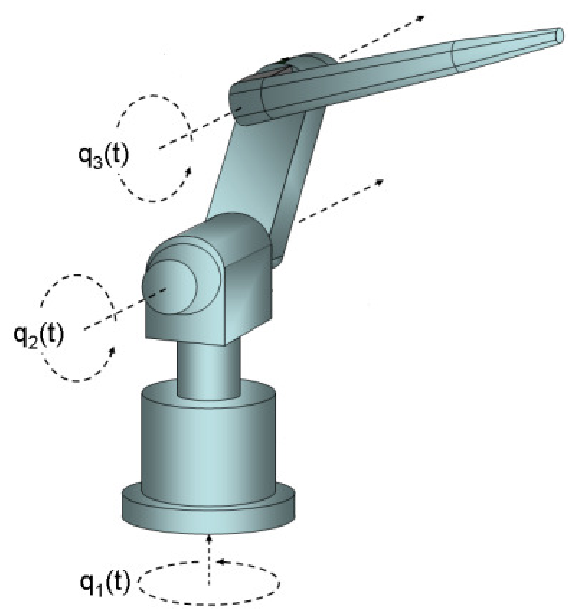

Figure 2: 3-DOF manipulator for Problem 3.

4. Consider again the manipulator in Figure 2. Place the frame S at the base of the manipulator, with its z axis corresponding to the axis of Joint 1 and its x axis parallel to the axis of Joint 2. Further, assume that Link 3 lies in the y-z plane of frame S and that the end-effector frame T is located at the very end of the link 3. Also, assume that the lengths l_1, l_2, and l_3 of the links 1, 2 and 3, respectively, satisfy $l_1 > l_2 > l_3$. Sketch or describe the **reachable workspace** of the manipulator. Ignore possible collisions between links and assume every joint can rotate for full 360°.

5. Consider the Kraft Viper manipulator in Figure 3.

   (a) Conveniently choose frames S and T, the reference configuration, and identify all the joint twists. Ignore the gripper jaw motion and define the kinematic parameters as you need them.

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(b) Compute the position of the origin of the tool frame as a function of the joint displacements (and the kinematic parameters you chose).

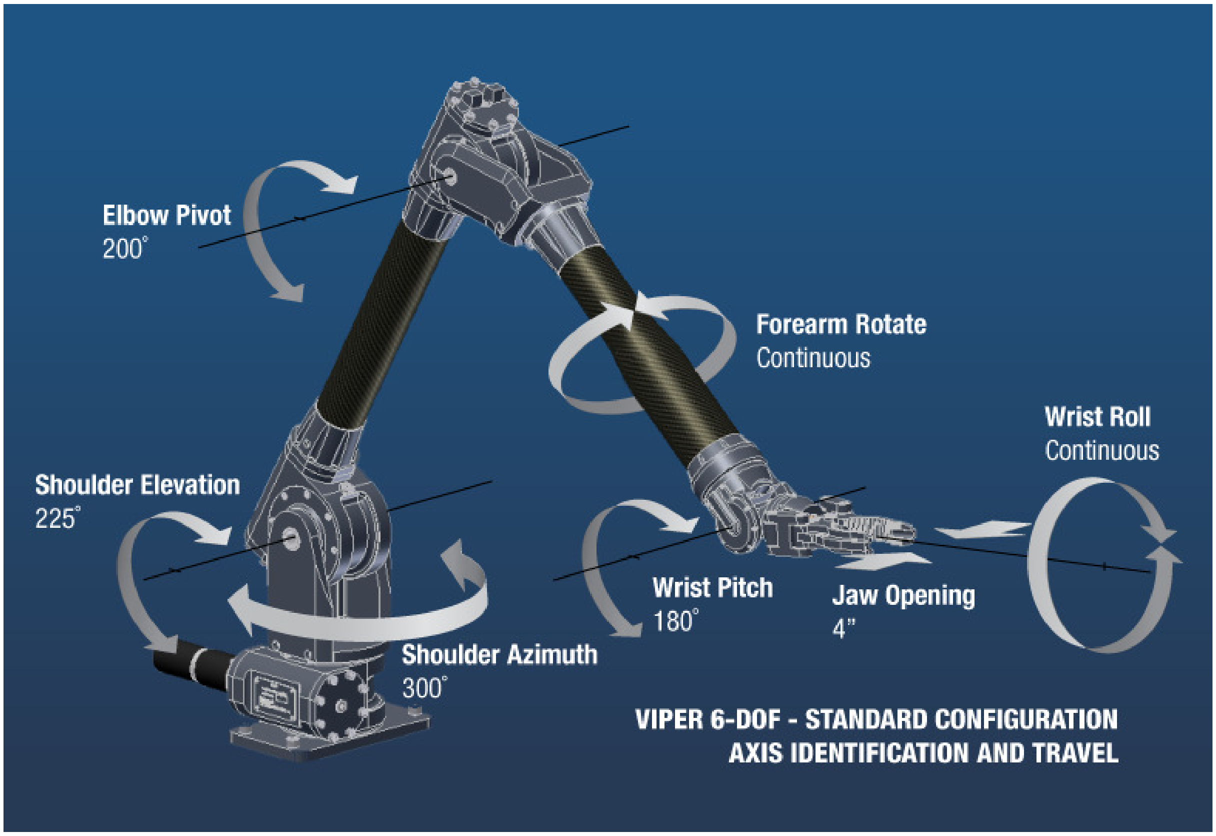

Figure 3: Kraft Viper manipulator for Problem 5.