CS354 HW #1

Introduction

Figure 1 shows an image of the PhantomX Pincher Arm manufactured by Trossen Robotics. This arm has five degrees of freedom: one gripper and four rotational joints. The goal of this assignment is to explore the kinematics of this arm.

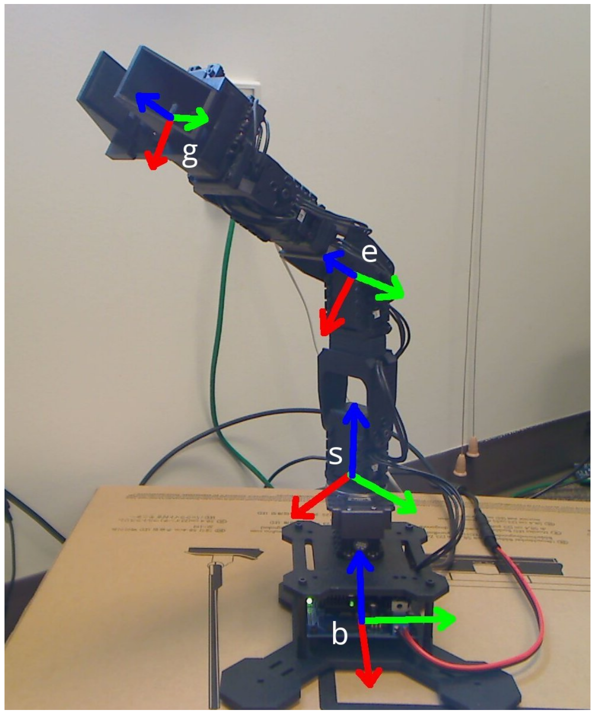

Figure 1: The Arm.

In order to simplify the analysis, we will consider only two of the arm's degrees of freedom and assume that the rest of the joints are frozen in place. The arm is allowed to rotate around the z-axis of the the "shoulder" joint, labeled "s" in the image, and around the y-axis of the "elbow" joint, labeled "e" in the image.

We will organize our analysis around the four different coordinate frames labeled in the figure. For each coordinate frame, the red arrow corresponds to the x-axis, the green arrow corresponds to the y-axis, and the blue arrow corresponds to the z-axis. We will express the rotation of the two joints as θ_s and θ_e. In Figure 1 $\theta_s = -45°$ and $\theta_e = 45°$.

The dimensions of the arm are as follows:

- The shoulder joint is 8cm above the base.
- The elbow joint is 15cm from the shoulder.
- The gripper is 18cm from the elbow.

Question 1

Perform the following coordinate transforms by hand. You should be able to work these out directly, without doing any matrix arithmetic. Throughout these exercises, I will use subscripts on position vectors to indicate which coordinate frame I am referring to. In other words $[0\ 0\ 1]_g^T$ refers the position $(0, 0, 1)$ in the gripper coordinate frame. Distances are in meters.

The first answer is provided for you.

- Assuming that $\theta_s = 0°$ and $\theta_e = 0°$,

  What is the location of $[0\ 0\ 0]_g^T$ in coordinate frame b? $\underline{(0, 0, .41)}$

  What is the location of $[0\ 0\ 0]_b^T$ in coordinate frame g? ________________

- Assuming that $\theta_s = 90°$ and $\theta_e = 0°$,

  What is the location of $[0\ 0\ 0]_g^T$ in coordinate frame b? ________________

  What is the location of $[0\ 0\ 0]_b^T$ in coordinate frame g? ________________

- Assuming that $\theta_s = 90°$ and $\theta_e = 90°$,

  What is the location of $[0\ 0\ 0]_g^T$ in coordinate frame b? ________________

  What is the location of $[0\ 0\ 0]_b^T$ in coordinate frame g? ________________

  What is the location of $[.4\ 0\ 0]_g^T$ in coordinate frame b? ________________

  What is the location of $[.4\ 0\ 0]_b^T$ in coordinate frame g? ________________

Question 2

For this question, feel free to use the matrix "nicknames" from Figure 22 of the Jennifer Kay paper. You don't need to actually calculate the matrix products. For example, The solution for the simple arm in Figure 27 could be written as:

$$T_g^w = \mathrm{Trans}(L1, 0, 0) \times \mathrm{Rotz}(\Psi) \times \mathrm{Trans}(L2, 0, 0).$$

This corresponds to the result presented in Figure 29.

- What is F_g^e?

  $F_g^e = \mathrm{Trans}(0, 0, -.18)$ (First answer provided for you.)

- What is F_e^s? (Requires both a rotation and a translation.)

- What is F_s^b?

- Show how to calculate T_b^g from F_g^e, F_e^s and F_s^b. (This will just be a matrix product.)

- What is F_b^s?

- What is F_s^e?

- What is F_e^g?

- Show how to calculate T_g^b from F_b^s, F_s^e and F_e^g.

Question 3

UNDER CONSTRUCTION

Question 4

- Consider the Euler angles $\alpha = 90.0^o$, $\beta = 0^o$, $\gamma = 0^o$ expressed as intrinsic rotations with the axis order $x - y - z$. How would this rotation be expressed using the following representations?
  - Euler angles with *extrinsic* rotations and the axis order $x - y - z$.
  - Axis-angle
  - Quaternion
  - Rotation Matrix
- Consider the Euler angles $\alpha = 90.0^o$, $\beta = 90^o$, $\gamma = 0^o$ expressed as extrinsic rotations with the axis order $z - y - x$. How would this rotation be expressed using the following representations?
  - Euler angles with *extrinsic* rotations and the axis order $x - y - z$.
  - Rotation Matrix