CS480 HW #2

Introduction

Figure **??** 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.
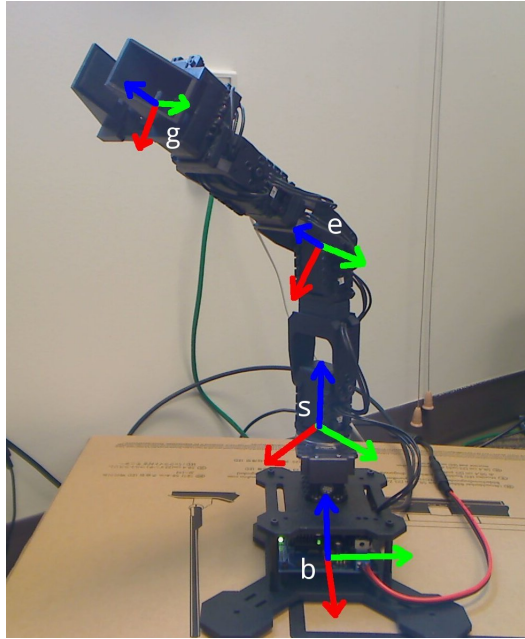

Figure 1: The Arm.

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 swivel at the "shoulder" joint, labeled "s" in the image, and rotate at 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 **??** $\Theta_s = -45°$ 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.

- Assuming that $\Theta_s = 0°$ 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 $\Theta_e = 0°$,

  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 $[.1\ 0\ 0]_g^T$ in coordinate frame b? _____

  What is the location of $[.1\ 0\ 0]_b^T$ 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:

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

This corresponds to the result presented in Figure 29.

- Show how to calculate T_b^g.

- Show how to calculate T_g^b.

Question 3

Download the file hw2.py from the course schedule page and complete the unfinished functions. Confirm that the output of the finished code corresponds to your answers from Question 1.