Homework 1

Intro to Robotics, 2022

(Due 11:59 pm 9/9/2020)

Submission Instruction: Create a directory called HW1. Then create two subdirectories called Q1, Q2 and so on. Place the answers of each question in the corresponding directories. Finally, zip the HW1 directory and submit.

1. (~~50~~ 30 pts) As A = $\begin{bmatrix} \cos\alpha & -\sin\alpha & 0 \\ \sin\alpha & \cos\alpha & 0 \\ 0 & 0 & 1 \end{bmatrix}$, B = $\begin{bmatrix} \cos\beta & -\sin\beta & 0 \\ \sin\beta & \cos\beta & 0 \\ 0 & 0 & 1 \end{bmatrix}$, p = $\begin{bmatrix} 0 \\ 1 \\ 2 \end{bmatrix}$,
   (a) (10 pts) compute AB, Ap, ABp, ABp+p; draw vectors Ap, ABp, ABp+p in 3D coordinate system
   (b) (~~10~~ 5pts) If $\alpha = 30, \beta = 15$, compute AB, Ap, ABp; draw vectors Ap, ABp in 3D coordinate system
   (c) (5 pts) If $\alpha = 45, \beta = -15$, compute AB, Ap, ABp; draw vectors Ap, ABp in 3D coordinate system
   (d) (~~15~~ 5 pts) If $\alpha = 45, \beta = 15$, compute AB^{-1}, AB^T, $A^{-1}p$, A^Tp, $AB^{-1}p$, AB^Tp; draw vectors $A^{-1}p$, A^Tp, $AB^{-1}p$, AB^Tp in 3D coordinate system
   (e) (~~10~~ 5 pts) If $\alpha = 45, \beta = -45$, compute (Ap)x(Bp), ||(Ap)x(Bp)||; draw vector (Ap)x(Bp) in 3D coordinate system

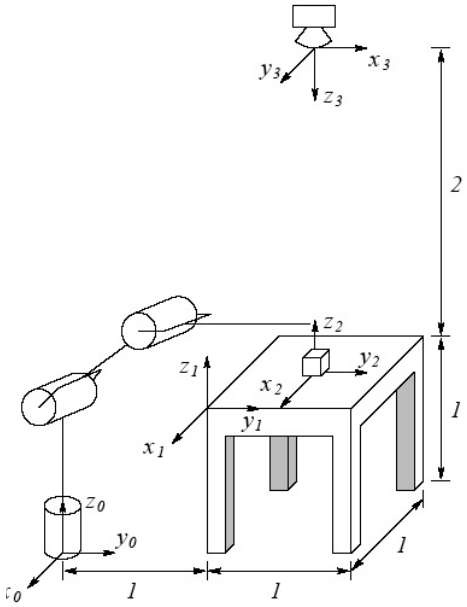
   You can write it on paper, scan and save as a PDF file.

2. (30 pts) Please write Python functions to compute AB, Ap, A^Tp, $A^{-1}p$, p_1xp_2, $p_1^Tp_2$, A_1 A_2A_3 A_4 A_5 A_6 A_7. (Upper case characters are matrixes, lower case characters are vectors).
   (a) (30 pts) The functions work for all reasonable size matrixes and vectors
   (b) (-10 pts) if the functions doesnot check dimension matching
   (c) (-10 pts) if the functions are not properly commented

   Your submission should include test code. Feel free to use Python packages.

3. (20 pts) A robot is set up 1 meter from a table. The table top is 1 meter high and 1 meter square. A frame $o_1x_1y_1z_1$ is fixed to the edge of the table as shown. A cube measuring 20 cm on a side is placed in the center of the table with frame $o_2x_2y_2z_2$ established at the center of the cube as shown. A camera is situated directly above the center of the block 2m above the table top with frame $o_3x_3y_3z_3$ attached as shown.

   Compute the following transformation matrices: H_1^0, H_2^0, H_3^0, H_3^2, and H_3^1,



You can write it on paper, scan and save as a PDF file.

4. (20 pts) Download and install the robot simulator CoppeliaSim from https://www.coppeliarobotics.com/ . Create a scene with one table and one UR5 robotic arm. Take a screen shot and submit it.