CMP755 - Robotics - 2021

Homework #1

Due: 19.10.2021

You can submit the functions in a single .py file to ozgurerkent@hacettepe.edu.tr. For Questions 2, 4, write your results as comment in the file. For 8, 9; you can submit your files as softcopy (scans, readable proper images, etc.) or bring as hardcopies to the class.

1. (10 pts) Write a function in python (3.x) that will rotate a given 3D point ${}^{B}P = [x, y, z]$ by angle θ. (${}^{A}P = f1({}^{B}P, \theta)$, where $f1$ is your function) around
   (a) X-axis
   (b) Y-axis
   (c) Z-axis
2. (5 pts) Test your $f1$ with ${}^{B}P = [3, 5, 0]$ and $\theta = 90^{o}$ for all axes.
3. (10 pts) Write a function for XYZ fixed angles by using your written functions. (${}^{A}P = f2(\alpha, \beta, \gamma, {}^{B}P)$, where α, β, γ are rotations around X, Y, Z respectively.)
4. (5 pts) Test your $f2$ with ${}^{B}P = [2, 5, 0]$ and $\alpha = 30, \beta = 90, \gamma = 60$.
5. (10 pts) Write a function that will output quaternion for XYZ - fixed angle rotations with α, β, γ. ($Q = [qx, qy, qz, qw] = f3(\alpha, \beta, \gamma)$)
6. (10 pts) Write a function for transforming a 3D point ${}^{B}P = [x, y, z]$ to a new location after XYZ fixed angle rotation with α, β, γ and translation with amount of x, y, z. (${}^{A}P = f4([\alpha, \beta, \gamma], [x, y, z], {}^{B}P)$).
7. (10 pts) Write the same function for quaternions. (${}^{A}P = f5([qx, qy, qz, qw], [x, y, z], {}^{B}P)$)
8. (10 pts) (Question from book, 2.13.)
9. (30 pts) (Questions from book, 2.32-2.34, you can use the functions you implemented for the results.)

2.13 [21] The following frame definitions are given as known:

$$
{}^{U}_{A}T = \begin{bmatrix} 0.866 & -0.500 & 0.000 & 11.0 \\ 0.500 & 0.866 & 0.000 & -1.0 \\ 0.000 & 0.000 & 1.000 & 8.0 \\ 0 & 0 & 0 & 1 \end{bmatrix},
$$

$$
{}^{B}_{A}T = \begin{bmatrix} 1.000 & 0.000 & 0.000 & 0.0 \\ 0.000 & 0.866 & -0.500 & 10.0 \\ 0.000 & 0.500 & 0.866 & -20.0 \\ 0 & 0 & 0 & 1 \end{bmatrix},
$$

$$
{}^{C}_{U}T = \begin{bmatrix} 0.866 & -0.500 & 0.000 & -3.0 \\ 0.433 & 0.750 & -0.500 & -3.0 \\ 0.250 & 0.433 & 0.866 & 3.0 \\ 0 & 0 & 0 & 1 \end{bmatrix}.
$$

Draw a frame diagram (like that of Fig. 2.15) to show their arrangement qualitatively, and solve for ${}^{B}_{C}T$.

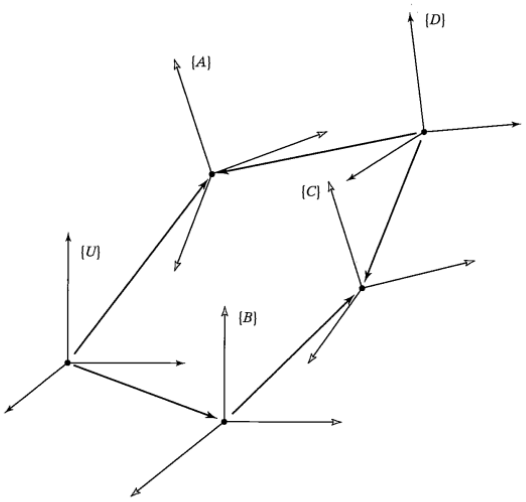

FIGURE 2.15: Example of a transform equation.

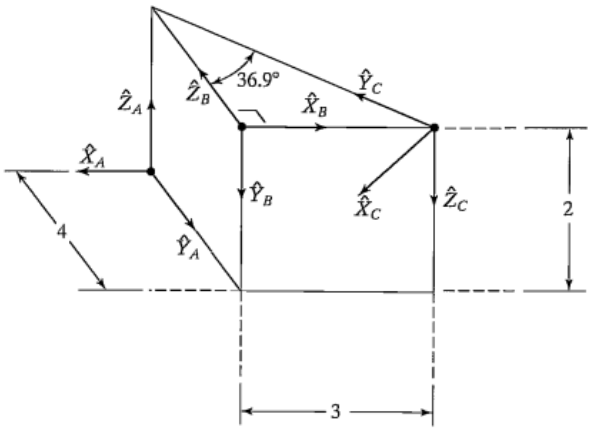

FIGURE 2.26: Frames at the corners of a wedge.

2.32 [15] Referring to Fig. 2.26, give the value of ${}^{A}_{C}T$.

2.33 [15] Referring to Fig. 2.26, give the value of ${}^{B}_{C}T$.

2.34 [15] Referring to Fig. 2.26, give the value of ${}^{C}_{A}T$.