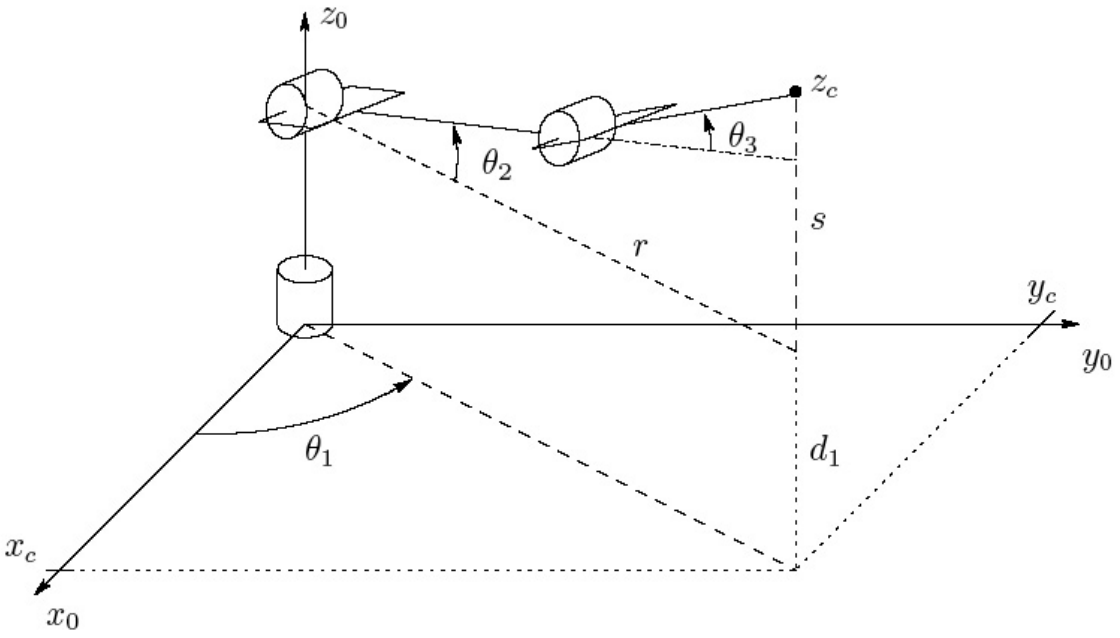
ECE 5397/6397: Intro to Robotics

HW 4, Due March 3 The manipulator Jacobian

1. Calculate the manipulator Jacobian of the anthropomorphic manipulator at the position z_c.
   a. Write out the J matrix in terms of z_i and o_i.
   b. Write out the z_i and o_i values.
   c. Write out the J values. Calculate the cross products. You may use your previous calculations for the A and T matrices.



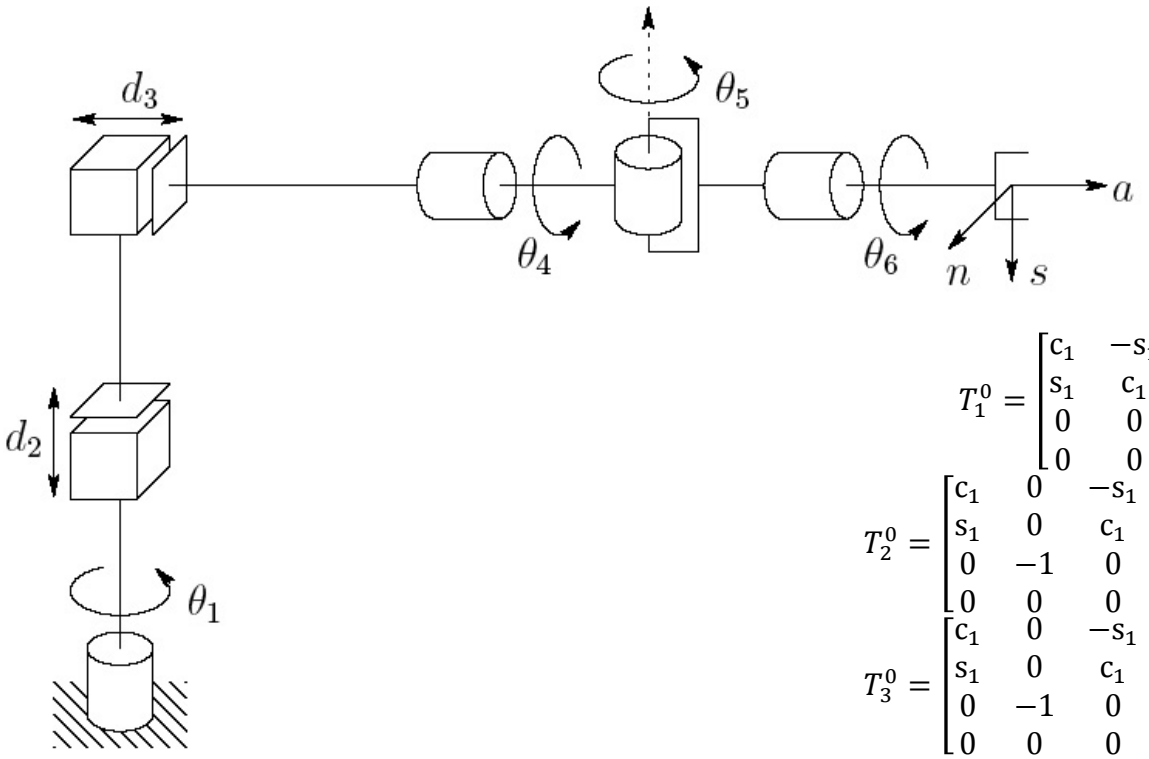
$$T_1^0 = \begin{bmatrix} c_1 & 0 & s_1 & 0 \\ s_1 & 0 & -c_1 & 0 \\ 0 & 1 & 0 & d1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T_2^0 = \begin{bmatrix} c_1c_2 & -c_1s_2 & s_1 & r2c_1c_2 \\ c_2s_1 & -s_1s_2 & -c_1 & r2c_2s_1 \\ s_2 & c_2 & 0 & d1 + r2s_2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T_3^0 = \begin{bmatrix} c_1c_{23} & -c_1s_{23} & s_1 & c_1(r2c_2 + r3c_{23}) \\ c_{23}s_1 & -s_1s_{23} & -c_1 & (r2c_2 + r3c_{23})s_1 \\ s_{23} & c_{23} & 0 & d1 + r2s_2 + r3s_{23} \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

2. Calculate the manipulator Jacobian of the cylindrical robot with spherical wrist manipulator at the position z_6.

a. Write out the J matrix in terms of z_i and o_i.
b. Write out the z_i and o_i values.
c. Calculate the cross products. You may use your previous calculations for the A and T matrices.



$$T_1^0 = \begin{bmatrix} c_1 & -s_1 & 0 & 0 \\ s_1 & c_1 & 0 & 0 \\ 0 & 0 & 1 & d_1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T_2^0 = \begin{bmatrix} c_1 & 0 & -s_1 & 0 \\ s_1 & 0 & c_1 & 0 \\ 0 & -1 & 0 & d_1 + q_2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T_3^0 = \begin{bmatrix} c_1 & 0 & -s_1 & -q_3 s_1 \\ s_1 & 0 & c_1 & q_3 c_1 \\ 0 & -1 & 0 & d_1 + q_2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T_4^0 = \begin{bmatrix} c_1 c_4 & s_1 & -c_1 s_4 & -q_3 s_1 \\ c_4 s_1 & -c_1 & -s_1 s_4 & q_3 c_1 \\ -s_4 & 0 & -c_4 & d_1 + q_2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T_5^0 = \begin{bmatrix} c_1 c_4 c_5 + s_1 s_5 & -c_1 s_4 & -c_5 s_1 + c_1 c_4 s_5 & -q_3 s_1 \\ c_4 c_5 s_1 - c_1 s_5 & -s_1 s_4 & c_1 c_5 + c_4 s_1 s_5 & q_3 c_1 \\ -c_5 s_4 & -c_4 & -s_4 s_5 & d_1 + q_2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T_6^0 = \begin{bmatrix} c_6 s_1 s_5 + c_1(c_4 c_5 c_6 - s_4 s_6) & -s_1 s_5 s_6 - c_1(c_6 s_4 + c_4 c_5 s_6) & -c_5 s_1 + c_1 c_4 s_5 & -q_3 s_1 \\ c_4 c_5 c_6 s_1 - c_1 c_6 s_5 - s_1 s_4 s_6 & -c_6 s_1 s_4 + (-c_4 c_5 s_1 + c_1 s_5) s_6 & c_1 c_5 + c_4 s_1 s_5 & q_3 c_1 \\ -c_5 c_6 s_4 - c_4 s_6 & -c_4 c_6 + c_5 s_4 s_6 & -s_4 s_5 & d_1 + q_2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$