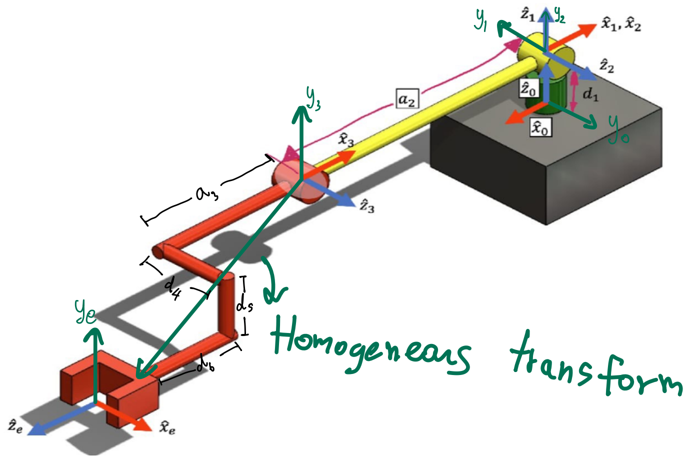


Homogeneous transformation

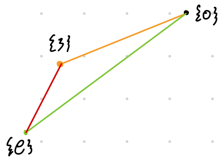
Find MDH-Parameter ; $d_1 = 0.0892$ m. , $a_2 = -0.425$, $r^n_{n,e} = \underbrace{[0, -\frac{\pi}{2}, 0]}_{\text{roll, pitch, yaw}}$ rad

	a	α	d	θ
0-1	0	0	d_1	$\pi + q_1$
1-2	0	$\frac{\pi}{2}$	0	q_2
2-3	-0.425	0	0	q_3

tool : $\{3\} \rightarrow \{e\}$ get transformation from (FKHW3)

$${}^3_eT = {}^3_0T\,{}^0_eT$$

$${}^3_eT = {}^0_3T^{-1}\,{}^0_eT$$



$${}^0_3T = \left[\begin{array}{c|c} {}^0R_3 & {}^0P_3 \\ 0\ 0\ 0 & 1 \end{array}\right]$$

$${}^0_eT = \left[\begin{array}{c|c} {}^0R_e & {}^0P_e \\ 0\ 0\ 0 & 1 \end{array}\right]$$

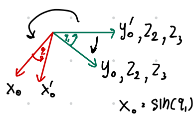
① Find Jacobian

$$J_i = \begin{bmatrix} J_{v_i}(q) \\ J_{w_i}(q) \end{bmatrix} = \begin{cases} \begin{bmatrix} \hat{z}_i \\ 0 \end{bmatrix} & ; \text{เมื่อข้อต่อที่ } i \text{ เป็นแบบ Prismatics} \\ \begin{bmatrix} \hat{z}_i \times ({}^0\hat{P}_e - {}^0\hat{P}_i) \\ \hat{z}_i \end{bmatrix} & ; \text{เมื่อข้อต่อที่ } i \text{ เป็น Revolute.} \end{cases}$$

$$J = \begin{bmatrix} \hat{z}_1 \times ({}^0\hat{P}_e - {}^0\hat{P}_1) & \hat{z}_2 \times ({}^0\hat{P}_e - {}^0\hat{P}_2) & \hat{z}_3 \times ({}^0\hat{P}_e - {}^0\hat{P}_3) \\ \hat{z}_1 & \hat{z}_2 & \hat{z}_3 \end{bmatrix}$$

$$\hat{z}_1 = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$ เพราะ $\hat{z}_1 = \hat{z}_0$

$$\hat{z}_2, \hat{z}_3 = \begin{bmatrix} s_1 \\ c_1 \\ 0 \end{bmatrix}$$



$x_0 = \sin(q_1)$

$y_0 = \cos(q_1)$

map frame of Jacobian

$$J^e = \begin{bmatrix} R^e_0 & 0 \\ 0 & R^e_0 \end{bmatrix} J^0$$

$$R^e_0 = R^{0\,T}_e$$

2. Check singularity

$$\det(J) = 0$$

$$J = \begin{bmatrix} \hat{z}_1 \times ({}^0\hat{P}_e - {}^0\hat{P}_1) & \hat{z}_2 \times ({}^0\hat{P}_e - {}^0\hat{P}_2) & \hat{z}_3 \times ({}^0\hat{P}_e - {}^0\hat{P}_3) \\ \cancel{\hat{z}_1} & \cancel{\hat{z}_2} & \cancel{\hat{z}_3} \end{bmatrix}$$

$$J = \left[\hat{z}_1 \times ({}^0\hat{P}_e - {}^0\hat{P}_1) \quad \hat{z}_2 \times ({}^0\hat{P}_e - {}^0\hat{P}_2) \quad \hat{z}_3 \times ({}^0\hat{P}_e - {}^0\hat{P}_3) \right]$$

↳ 3x3 matrix

③ Calculate effort

w reference at frame e ; so we need to change it via rotation matrix

Let $${}^eW = \begin{bmatrix} \text{force}(f^e) \\ \text{momen tum}(n^e) \end{bmatrix} \rightarrow {}^0W = \begin{bmatrix} f^0 = {}^0R_e f^e \\ n^0 = {}^0R_e n^e \end{bmatrix}$$

$$f^0 = {}^0R_e f^e$$

$$n^0 = {}^0R_e n^e$$

$$\boxed{\tau = {}^0J^T\,{}^0W}$$