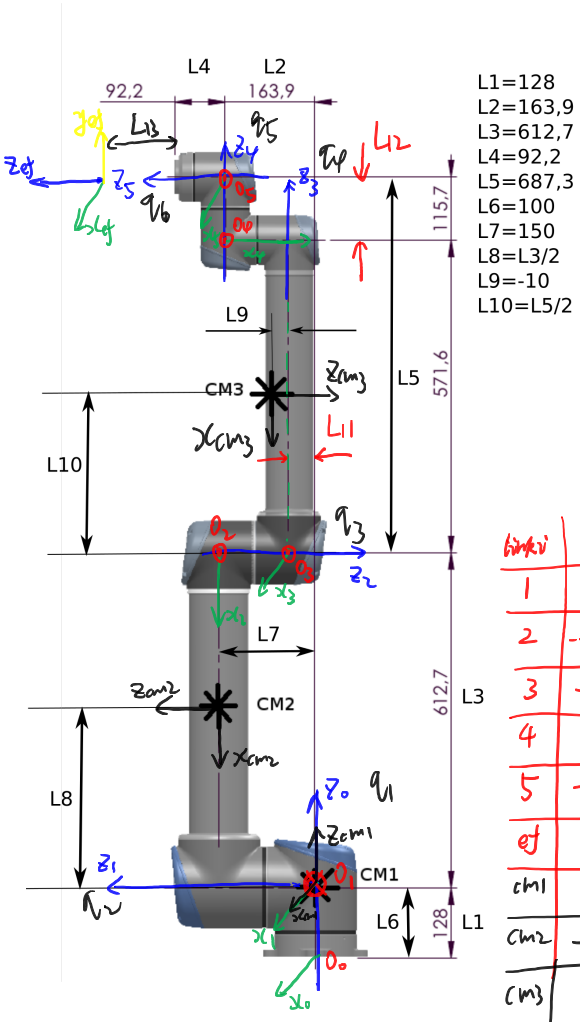

link i	θ_i	d_i	a_i	α_i
1	q_1	L_1	0	$\frac{\pi}{2}$
2	$-\frac{\pi}{2}+q_2$	L_7	L_3	$-\pi$
3	$-\frac{\pi}{2}+q_3$	L_7-L_{11}	0	$\frac{\pi}{2}$
4	$\frac{\pi}{2}+q_4$	L_5-L_{12}	L_2-L_{11}	0
5	$-\frac{\pi}{2}+q_5$	L_{12}	0	$\frac{\pi}{2}$
ef	$0+q_6$	L_4+L_{13}	0	0
cm1	$0+q_1$	0	0	0
cm2	$-\frac{\pi}{2}+q_2$	L_7	L_8	0
cm3	$0+q_3$	$L_7-L_{11}-L_9$	L_{10}	0

Figure 3.1: 3DOF robot.

3 DOF Jacobian

$$J_{am_1} = \begin{bmatrix} 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 1 & \end{bmatrix}$$

其中
$$\begin{cases} x_{cm_2} = L_7 \cdot \sin q_1 - L_8 \sin q_2 \cdot \cos q_1 \\ y_{cm_2} = -\left(L_7 \cdot \cos q_1 + L_8 \sin q_2 \cdot \sin q_1\right) \\ z_{cm_2} = L_6 + L_8 \cos q_2 \end{cases}$$

$$\begin{cases} x_{cm_3} = L_{11} \sin q_1 - L_3 \sin q_2 \cos q_1 + L_{10} \sin q_3 \cdot \cos q_1 \\ y_{am_3} = -L_3 \sin q_2 \cdot \sin q_1 - L_{11} \cos q_1 + L_{10} \sin q_3 \sin q_1 \\ z_{cm_3} = L_6 + L_3 \cos q_2 + L_{10} \cos q_3 \end{cases}$$

$$J_{cm_2} = \begin{bmatrix} -y_{cm_2} & -\cos q_1 \cdot (z_{cm_2} - L_6) \\ -x_{cm_2} & \sin q_1 \cdot (z_{cm_2} - L_6) \\ 0 & \sin q_1 \cdot y_{cm_2} + \cos q_1 \cdot x_{cm_2} \quad 0 \\ 0 & \sin q_1 \\ 0 & -\cos q_1 \\ 1 & 0 \end{bmatrix}$$

$$J_{cm_3} = \begin{bmatrix} -y_{am_3} & -\cos q_1 \cdot (z_{cm_3} - L_6) & \cos q_1 \cdot L_{10} \cdot \cos q_3 \\ -x_{cm_3} & \sin q_1 (z_{cm_3} - L_6) & -\sin q_1 \cdot L_{10} \cdot \cos q_3 \\ 0 & \sin q_1 \cdot y_{cm_3} + \cos q_1 \cdot x_{cm_3} & -\sin q_1 \cdot \left[(L_7 - L_{11}) \cos q_1 + L_{10} \sin q_3 \cdot \sin q_1\right] - \cos q_1 \cdot \left[L_{10} \sin q_3 \cdot \cos q_1 - (L_7 - L_{11}) \sin q_1\right] \\ 0 & \sin q_1 & -\sin q_1 \\ 0 & -\cos q_1 & \cos q_1 \\ 1 & 0 & 0 \end{bmatrix}$$