ENPM-662- HW3

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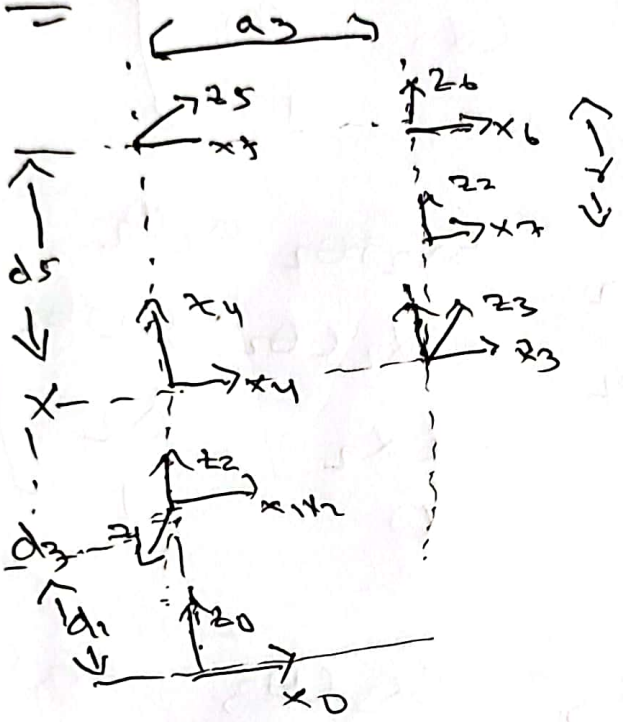
1) Position kinematics

1.1) Draw all D-H Parameters



1.2) D-H Parameters

link	θ_i	a_i	d_i	α_i
1	θ_1	0	d_1	$\pi/2$
2	θ_2	0	0	$-\pi/2$
3	θ_3	a_3	d_3	$-\pi/2$
4	θ_4	$-a_3$	0	$\pi/2$
5	θ_5	0	d_5	$\pi/2$
6	θ_6	a_3	0	$-\pi/2$
7	θ_7	0	d_7	0

1.3) Successive transformation matrix

$$T_1^0 = \begin{bmatrix} C\theta_1 & -S\theta_1 C\alpha_1 & S\alpha_1 S\theta_1 & a_1 C\theta_1 \\ S\theta_1 & C\alpha_1 C\theta_1 & -S\alpha_1 C\theta_1 & a_1 S\theta_1 \\ 0 & S\alpha_1 & C\alpha_1 & d_1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T_2^1 = \begin{bmatrix} C\theta_2 & -S\theta_2 C\alpha_2 & S\alpha_2 S\theta_2 & a_2 C\theta_2 \\ S\theta_2 & C\alpha_2 C\theta_2 & -S\alpha_2 C\theta_2 & a_2 S\theta_2 \\ 0 & S\alpha_2 & C\alpha_2 & d_2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T_3^2 = \begin{bmatrix} C\theta_3 & -S\theta_3 C\alpha_3 & S\alpha_3 C\theta_3 & a_3 C\theta_3 \\ S\theta_3 & C\alpha_3 C\theta_3 & -S\alpha_3 C\theta_3 & a_3 S\theta_3 \\ 0 & S\alpha_3 & C\alpha_3 & d_3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T_4^3 = \begin{bmatrix} C\theta_4 & -S\theta_4 C\alpha_4 & S\alpha_4 S\theta_4 & a_4 C\theta_4 \\ S\theta_4 & C\alpha_4 C\theta_4 & -S\alpha_4 C\theta_4 & a_4 S\theta_4 \\ 0 & S\alpha_4 & C\alpha_4 & d_4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T_5^4 = \begin{bmatrix} c\theta_5 & -s\theta_5 c\theta_5 & s\alpha_5 s\theta_5 & a_5 c\theta_5 \\ s\theta_5 & c\alpha_5 c\theta_5 & -s\alpha_5 c\theta_5 & a_5 s\theta_5 \\ 0 & s\alpha_5 & c\alpha_5 & d_5 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T_6^5 = \begin{bmatrix} c\theta_6 & -s\theta_6 c\theta_6 & s\alpha_6 c\theta_6 & a_6 c\theta_6 \\ s\theta_6 & c\theta_6 c\alpha_6 c\theta_6 & -s\alpha_6 c\theta_6 & a_6 s\theta_6 \\ 0 & s\alpha_6 & c\alpha_6 & d_6 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T_7^6 = \begin{bmatrix} c\theta_7 & -s\theta_7 c\theta_7 & s\alpha_7 c\theta_7 & a_7 c\theta_7 \\ s\theta_7 & c\alpha_7 c\theta_7 & -s\alpha_7 c\theta_7 & a_7 s\theta_7 \\ 0 & s\alpha_7 & c\alpha_7 & d_7 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

we get succesive matrices from the eqd.

14) final transformation matrix

$$T_7^0 = T_1^0 \times T_2^1 \times T_3^2 \times T_4^3 \times T_5^4 \times T_6^5 \times T_7^6$$

Parametric validation:

Case(1) All θ values are zeros

$$(x, z) = (a_3 + d_1 + d_3 + d_5 + d_6)$$

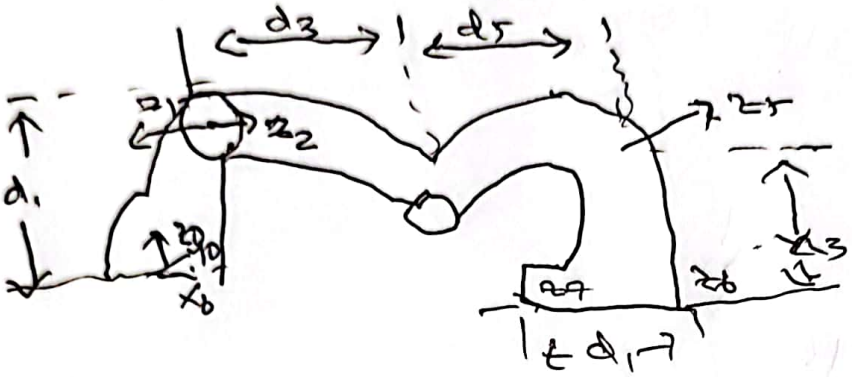
$$= (0.0880, 0.926)$$

Case(2): $\theta_1 = 90$, all other values are zero

$$(y, z) = (a_3, d_1 + d_3 + d_5 - d_4)$$

$$= (0.0880, 0926)$$

Case ③: $\theta_2 = 90$ & other all theta are zero



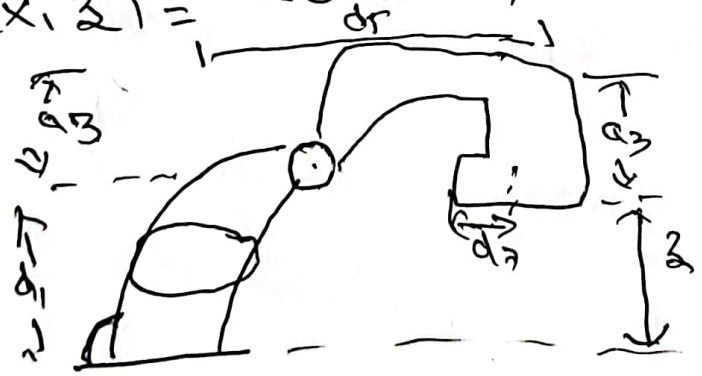
$$(x, z) = (d_3 + d_5 - d_7,\ d_1 - d_3)$$

$$= (0.593,\ 0.245)$$

Case ④: θ_4 is equal to 90 & rest are zero

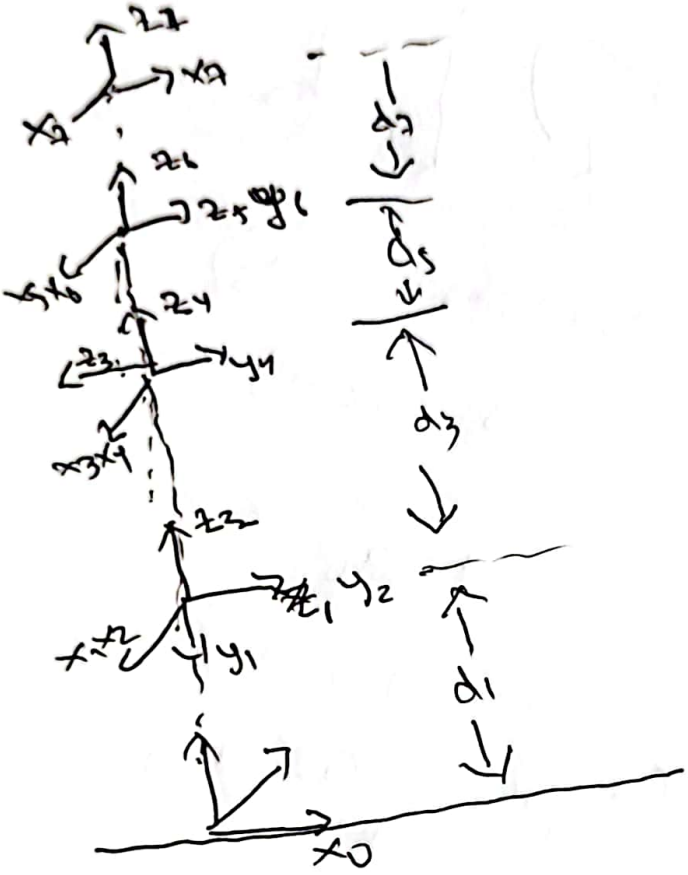
$$(x, z) = (a_3 + d_5 - d_7,\ d_1 + d_3)$$

$$(x, z) = (0.365,\ 0.649)$$



Positive kinematics - KUKA

2.1) Draw all DH - Co-ordinate frames



2.2) D-H table

Link	θ_i	a_i	d_i	α_i
1	$\theta_1 - 90$	0	d_1	$\pi/2$
2	θ_2	0	0	$\pi/2$
3	θ_3	0	d_3	$\pi/2$
4	θ_4	0	0	$-\pi/2$
5	θ_5	0	0	$\pi/2$
6	θ_6	0	0	$\pi/2$
7	θ_7	0	d_7	0