3P Robot

Other name - Three Prismatic joint Robot

DOF - 3

Denavit Hartenberg (DH) Parameter

T_i = Minimum number of Parameters to describe forward kinematics

$$= Rot_{z,\theta_i} , Trans_{z,d_i} , Trans_{x,a_i} Rot_{x,\alpha_i}$$

$$= \begin{bmatrix} C\theta_i & -S\theta_i & 0 & 0 \\ S\theta_i & C\theta_i & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & d_i \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 & 0 & a_i \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & C\alpha_i & -S\alpha_i & 0 \\ 0 & S\alpha_i & C\alpha_i & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

where,

a_i - link length
α_i - link twist
d_i - link offset
θ_i - Joint angle

Final DH matrix

$$= \begin{bmatrix} C\theta_i & -S\theta_i C\alpha_i & S\theta_i S\alpha_i & a_i C\theta_i \\ S\theta_i & C\theta_i C\alpha_i & -C\theta_i S\alpha_i & a_i S\theta_i \\ 0 & S\alpha_i & C\alpha_i & d_i \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Forward kinematics

Joint 1

$\theta = 90^\circ$ $a_i = 0\,m$ $\alpha_i = 90^\circ$ $d_i = 0.3\,m$

$$T_1 = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0.3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Here,

$\cos 90^\circ = 0$
$\sin 90^\circ = 1$

Joint 2

$\theta = -90^\circ \quad a_i = 0.15\,m \quad \alpha = 90^\circ \quad d_i = 0.2\,m$

$$T_2 = \begin{bmatrix} 0 & 0 & -1 & 0 \\ -1 & 0 & 0 & -0.15 \\ 0 & 1 & 0 & 0.2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Here,

$\cos(-90^\circ) = 0 \qquad \cos(90^\circ) = 0$

$\sin(-90^\circ) = -1 \qquad \sin(90^\circ) = 1$

Joint 3

$\theta = 0^\circ \quad a_i = 0.15\,m \quad \alpha = 90^\circ \quad d_i = 0.2\,m$

$$T_3 = \begin{bmatrix} 1 & 0 & 0 & 0.15 \\ 0 & 0 & -1 & 0 \\ 0 & 1 & 0 & 0.2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Here,

$\cos 0 = 1 \qquad \cos 90 = 0$

$\sin 0 = 0 \qquad \sin 90 = 1$

$$T = T_1\ T_2\ T_3$$

$$= \begin{bmatrix} 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0.3 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 & 0 & -1 & 0 \\ -1 & 0 & 0 & -0.15 \\ 0 & 1 & 0 & 0.2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 & 0 & 0.15 \\ 0 & 0 & -1 & 0 \\ 0 & 1 & 0 & 0.2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

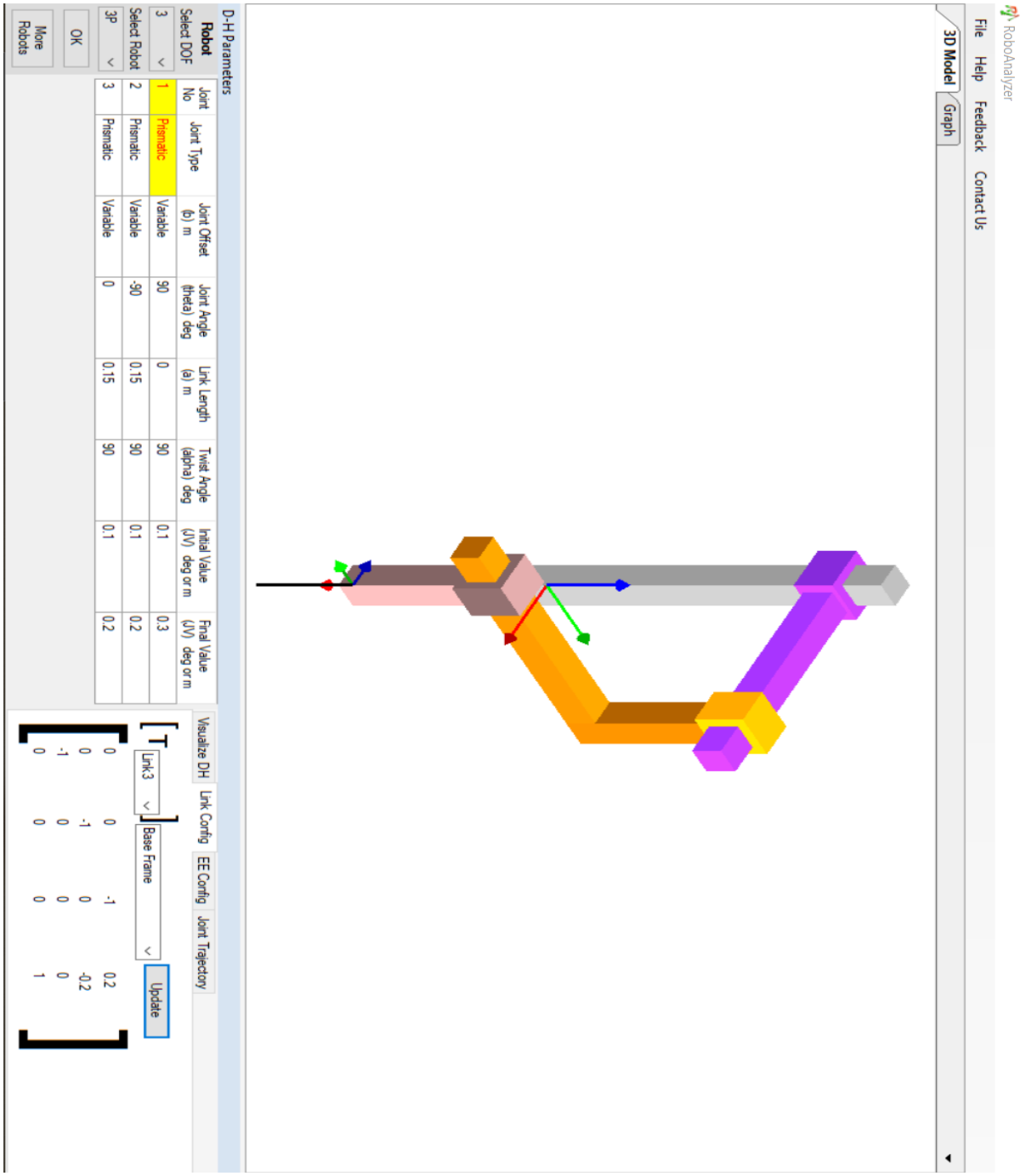
$$= \begin{bmatrix} 0 & 1 & 0 & 0.2 \\ 0 & 0 & -1 & 0 \\ -1 & 0 & 0 & 0.15 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0.15 \\ 0 & 0 & -1 & 0 \\ 0 & 1 & 0 & 0.2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Forward kinematics of 3P robot after set on desired position from origin point

$$= \begin{bmatrix} 0 & 0 & -1 & 0.2 \\ 0 & -1 & 0 & -0.2 \\ -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} - (1)$$

∴ Thus the above matrix is verified based on "Robo Analyzer" software

VERIFICATION



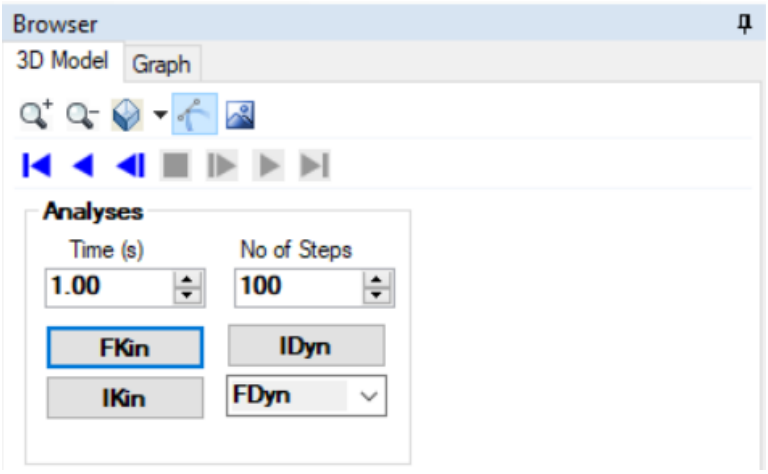
PROCEDURE VIDEO FOR ROBOANALYZER DEMO GIF AND DEMO VIDEO

PROCEDURE

1. Open the RoboAnalyzer software.

2. Select **3** on the **select DOF** dropdown list and also select **3P (3 PRISMATIC JOINT ROBOT)** on the **select robot** dropdown list.

3. Press **FKin** button on the 3D model tab to simulate forward kinematics matrices for the final (or) desired position from origin position (or) point.



4. Then click Link Config tab to select **link 3** and change previous frame to **base frame**. Eventually press the **Update** button to get the **DH matrix** for 3P Robot.

5. Finally, I compared the software DH matrix with an observed DH matrix that I solved.

Inverse kinematics

Joint 1

$\theta = 90^\circ \quad a_i = 0\,m \quad \alpha_i = 90^\circ \quad d_i = d_1$ (variable)

$$A_1 = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & d_1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Joint 2

$\theta = -90^\circ \quad a_i = 0.15\,m \quad \alpha_i = 90^\circ \quad d_i = d_2$ (variable)

$$A_2 = \begin{bmatrix} 0 & 0 & -1 & 0 \\ -1 & 0 & 0 & 0.15 \\ 0 & 1 & 0 & d_2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Joint 3

$\theta = 0^\circ \quad a_i = 0.15\,m \quad \alpha_i = 90^\circ \quad d_i = d_3$ (variable)

$$A_3 = \begin{bmatrix} 1 & 0 & 0 & 0.15 \\ 0 & 0 & -1 & 0 \\ 0 & 1 & 0 & d_3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T = A_1 A_2 A_3$$

$$= \begin{bmatrix} 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & d_1 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 & 0 & -1 & 0 \\ -1 & 0 & 0 & -0.15 \\ 0 & 1 & 0 & d_2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 & 0 & 0.15 \\ 0 & 0 & -1 & 0 \\ 0 & 1 & 0 & d_3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 0 & 1 & 0 & d_2 \\ 0 & 0 & -1 & 0 \\ -1 & 0 & 0 & -0.15 + d_1 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0.15 \\ 0 & 0 & -1 & 0 \\ 0 & 1 & 0 & d_3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 0 & 0 & -1 & d_2 \\ 0 & 0 & 0 & -d_3 \\ -1 & 0 & 0 & (-0.15 - 0.15 + d_1) \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 0 & 0 & -1 & d_2 \\ 0 & 0 & 0 & -d_3 \\ -1 & 0 & 0 & -0.3 d_1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

- (2)

Compare ① & ② matrix to find $d_1\ d_2\ d_3$

i) $d_2 = 0.2$

ii) $-d_3 = -0.2$

$d_3 = 0.2$

iii) $-0.3 + d_1 = 0$

$d_1 = 0.3$

∴ Thus above Parameters like d_1, d_2, d_3 are verified based on "RoboAnalyser" software.