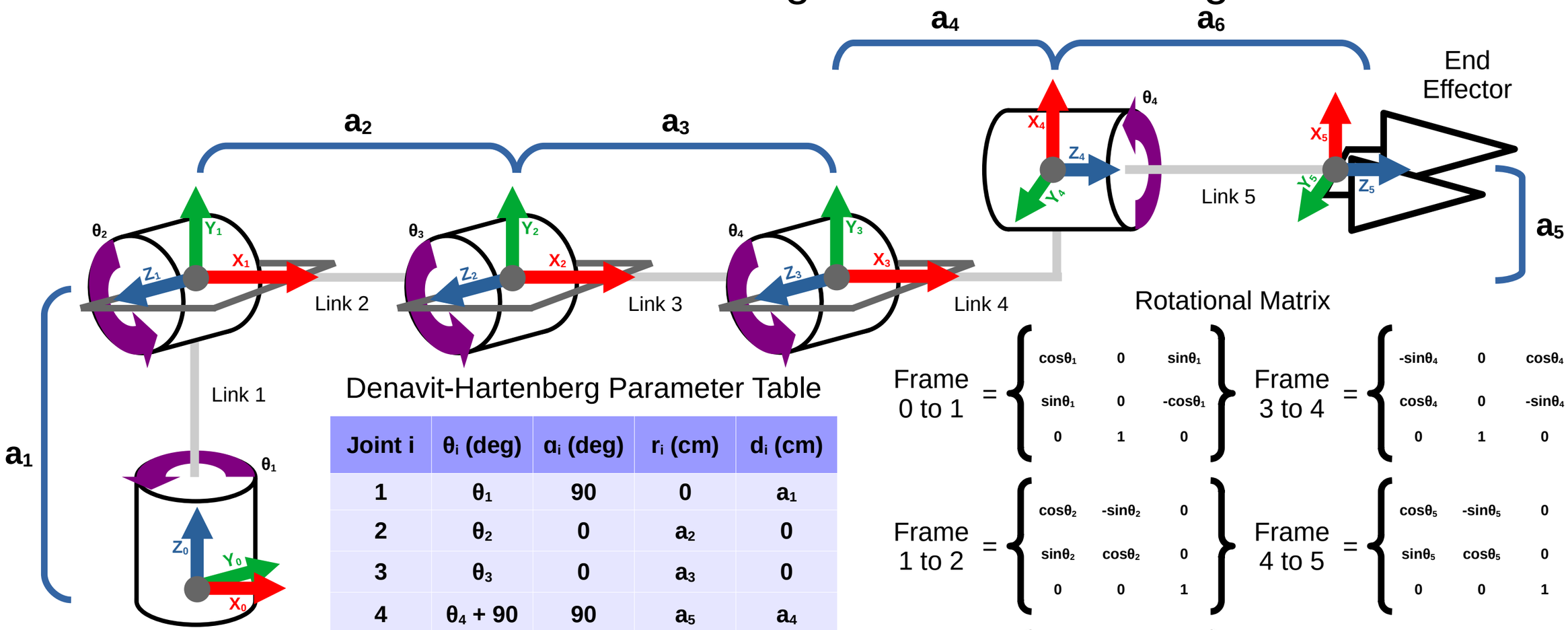
Grab-It Kinematics Model using Denavit-Hartenberg Method



Denavit-Hartenberg Parameter Table

Joint i	θ_i (deg)	α_i (deg)	r_i (cm)	d_i (cm)
1	θ_1	90	0	a_1
2	θ_2	0	a_2	0
3	θ_3	0	a_3	0
4	$\theta_4 + 90$	90	a_5	a_4
5	θ_5	0	0	$a_4 + a_6$

Parameter rules :

1. θ is the angle from X_{n-1} to X_n around Z_{n-1}
2. α is the angle from Z_{n-1} to Z_n around X_n
3. r is the distance between the origin of frame n-1 and the origin of frame n along X_n
4. d is the distance from X_{n-1} to X_n along Z_{n-1}

Displacement Matrix

	0 to 1	1 to 2	2 to 3	3 to 4	4 to 5
X	0	$a_2 \cos\theta_2$	$a_3 \cos\theta_3$	$a_4 \cos\theta_4$	0
Y	0	$a_2 \sin\theta_2$	$a_3 \sin\theta_3$	$a_4 \sin\theta_4 + a_5$	0
Z	a_1	0	0	0	a_6

Rotational Matrix

$$\text{Frame 0 to 1} = \begin{Bmatrix} \cos\theta_1 & 0 & \sin\theta_1 \\ \sin\theta_1 & 0 & -\cos\theta_1 \\ 0 & 1 & 0 \end{Bmatrix} \quad \text{Frame 3 to 4} = \begin{Bmatrix} -\sin\theta_4 & 0 & \cos\theta_4 \\ \cos\theta_4 & 0 & -\sin\theta_4 \\ 0 & 1 & 0 \end{Bmatrix}$$

$$\text{Frame 1 to 2} = \begin{Bmatrix} \cos\theta_2 & -\sin\theta_2 & 0 \\ \sin\theta_2 & \cos\theta_2 & 0 \\ 0 & 0 & 1 \end{Bmatrix} \quad \text{Frame 4 to 5} = \begin{Bmatrix} \cos\theta_5 & -\sin\theta_5 & 0 \\ \sin\theta_5 & \cos\theta_5 & 0 \\ 0 & 0 & 1 \end{Bmatrix}$$

$$\text{Frame 2 to 3} = \begin{Bmatrix} \cos\theta_3 & -\sin\theta_3 & 0 \\ \sin\theta_3 & \cos\theta_3 & 0 \\ 0 & 0 & 1 \end{Bmatrix}$$

$$\text{Frame 0 to 5} = \{\text{Frame 0 to 1}\} \times \{\text{Frame 1 to 2}\} \times \{\text{Frame 2 to 3}\} \times \{\text{Frame 3 to 4}\} \times \{\text{Frame 4 to 5}\}$$

Frame 0 to 5 With all $\theta_n = 0°$ =

	X_5	Y_5	Z_5
X_0	0	0	1
Y_0	0	-1	0
Z_0	1	0	0

0 : Axes are perpendicular
1 : Axes point in the same direction
-1 : Axes point in opposite directions