Final Report

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ME 407

Preliminary Design of Robotic Systems

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1 Forward Kinematics

Table 1: DH Table for 6 DOF Manipulator

DH	d_i	θ_i	a_i	α_i
1	ℓ_1	θ_1	0	$\pi/2$
2	$-d$	θ_2	ℓ_2	0
3	0	$\theta_3 + \pi/2$	0	$\pi/2$
4	$\ell_3 + \ell_4$	θ_4	0	$-\pi/2$
5	0	θ_5	0	$\pi/2$
6	ℓ_6	θ_6	0	0

Where $\ell_1 = 22.08$cm, $\ell_2 = 25$cm, $\ell_3 = 20$cm, $\ell_4 = 8$cm, $\ell_6 = 5.25$cm, and $d = 1$cm.

$$A = Rot_{z,\theta}\ Trans_{z,d}\ Trans_{x,a}\ Rot_{x,\alpha} \tag{1}$$

Given an arbitrary homogeneous matrix T_i^{i-1} (computed by matrix multiplication of A matrices $\rightarrow \left[A_1 A_2 \cdots A_{i-1} A_i\right]$), the orientation vector $\bar{z}_i$ (with respect to φ, θ and ψ) and the relative joint position (displacement) vector $\bar{o}_i$ (with respect to x, y, and z) can be obtained via the 3^{rd} and 4^{th} columns of the matrix respectively, as shown in Equation 2 (given β as an arbitrary rotation angle about the z-axis).

$$T_i^{i-1} = \begin{bmatrix} c_\beta & -s_\beta & z_i^\varphi & o_i^x \\ s_\beta & c_\beta & z_i^\theta & o_i^y \\ 0 & 0 & z_i^\psi & o_i^z \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{2}$$

$$A_1 = rotz(\theta_1)\ transz(\ell_1)\ rotx(\pi/2)$$

$$A_1 = \begin{bmatrix} \cos(\theta_1) & 0 & \sin(\theta_1) & 0 \\ \sin(\theta_1) & 0 & -\cos(\theta_1) & 0 \\ 0 & 1 & 0 & 22.08 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A_2 = rotz(\theta_2)\ transz(-d)\ transx(\ell_2)$$

$$A_2 = \begin{bmatrix} \cos(\theta_2) & -\sin(\theta_2) & 0 & 25\cos(\theta_2) \\ \sin(\theta_2) & \cos(\theta_2) & 0 & 25\sin(\theta_2) \\ 0 & 0 & 1 & -1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A_3 = rotz(\theta_3 + \pi/2)\ rotx(\pi/2)$$

$$A_3 = \begin{bmatrix} \cos(\theta_3 + \pi/2) & 0 & \sin(\theta_3 + \pi/2) & 0 \\ \sin(\theta_3 + \pi/2) & 0 & -\cos(\theta_3 + \pi/2) & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A_4 = rotz(\theta_4)\ transz(\ell_3 + \ell_4)\ rotx(-\pi/2)$$

$$A_4 = \begin{bmatrix} \cos(\theta_4) & 0 & -\sin(\theta_4) & 0 \\ \sin(\theta_4) & 0 & \cos(\theta_4) & 0 \\ 0 & -1 & 0 & 28 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A_5 = rotz(\theta_5)\ rotx(\pi/2)$$

$$A_5 = \begin{bmatrix} \cos(\theta_5) & 0 & \sin(\theta_5) & 0 \\ \sin(\theta_5) & 0 & -\cos(\theta_5) & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A_6 = rotz(\theta_6)\ transz(\ell_6)$$

$$A_6 = \begin{bmatrix} \cos(\theta_6) & 0 & -\sin(\theta_6) & 0 \\ \sin(\theta_6) & 0 & \cos(\theta_6) & 0 \\ 0 & 0 & 1 & 5.25 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$