Jacob Sayono

505368811

MAE C163B Midterm

Foward Kinematics

$$ {}^{i-1}_{i}T = \begin{bmatrix} c\theta_i & -s\theta_i & 0 & a_{i-1} \\ s\theta_i c\alpha_{i-1} & c\theta_i c\alpha_{i-1} & -s\alpha_{i-1} & -s\alpha_{i-1} d_i \\ s\theta_i s\alpha_{i-1} & c\theta_i s\alpha_{i-1} & c\alpha_{i-1} & c\alpha_{i-1} d \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

i	α_{i-1}	a_{i-1}	d_i	θ_i
1	0	0	0	θ_1
2	$-90°$	0	0	θ_2
3	0	a_2	d_3	θ_3
4	$-90°$	a_3	d_4	θ_4
5	$90°$	0	0	θ_5
6	$-90°$	0	0	θ_6

$$ {}^{0}_{1}T = \begin{bmatrix} c\theta_1 & -s\theta_1 & 0 & 0 \\ s\theta_1 & c\theta_1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

$$ {}^{1}_{2}T = \begin{bmatrix} c\theta_2 & -s\theta_2 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ -s\theta_2 & -c\theta_2 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

$$ {}^{2}_{3}T = \begin{bmatrix} c\theta_3 & -s\theta_3 & 0 & a_2 \\ s\theta_3 & c\theta_3 & 0 & 0 \\ 0 & 0 & 1 & d_3 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

$$ {}^{3}_{4}T = \begin{bmatrix} c\theta_4 & -s\theta_4 & 0 & a_3 \\ 0 & 0 & 1 & d_4 \\ -s\theta_4 & -c\theta_4 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

$$ {}^{4}_{5}T = \begin{bmatrix} c\theta_5 & -s\theta_5 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ s\theta_5 & c\theta_5 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

$$ {}^{5}_{6}T = \begin{bmatrix} c\theta_6 & -s\theta_6 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ -s\theta_6 & -c\theta_6 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

$a_2 = 0.4318$

$a_3 = 0.0190$

$d_3 = 0.1254$

$d_4 = 0.4318$

$$ {}^{b}_{t}T = \begin{bmatrix} c\theta_t & -s\theta_t & 0 & -0.1 \\ s\theta_t & c\theta_t & 0 & 0 \\ 0 & 0 & 1 & 0.08 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

$\alpha = 0$

$a = -0.1$

$d = 0.08$

$\theta = \theta_t$

Inverse Kinematics

$$P_x = a_2 c_2 + a_3 c_{23} - d_4 c_{23}$$

$$P_y = d_3$$

$$P_z = -a_3 s_{23} - a_2 s_2 - d_4 c_{23}$$

$$p_x = \rho \cos\phi$$

$$p_y = \rho \sin\phi$$

$$\rho = \sqrt{p_x^2 + p_y^2}$$

$$\phi = A\tan2(p_y, p_x)$$

$$\theta_1 = A\tan2(p_y, p_x) - A\tan2\left(\frac{d_3}{\rho}, \pm\sqrt{1 - \frac{d_3^2}{\rho^2}}\right)$$

$$k = \frac{1}{2a_2}\left(p_x^2 + p_y^2 + p_z^2 - a_2^2 - a_3^2 - d_3^2 - a_4^2\right)$$

$$\theta_3 = A\tan2\left[(-a_3 - a_2 c_3)p_z + (c_1 p_x + s_1 p_y)(a_2 s_3 - d_4),\ (a_2 s_3 - d_4)p_z - (-a_3 - c_{12} c_3)(c_1 p_x + s_1 p_y)\right]$$

$$\theta_2 = \theta_{23} - \theta_3$$

$$\theta_4 = A\tan2(-r_{13} s_1 + r_{23} c_1,\ -r_{13} c_1 c_{23} - r_{23} s_1 c_{23} + s_{23} r_{33})$$

$$-s_5 = r_{13}(c_1 c_{23} c_4 + s_1 s_4) + r_{23}(s_1 s_{23} c_4 - c_1 s_4) - r_{33}(s_{23} c_4)$$

$$c_5 = r_{13}(-c_1 s_{23}) + r_{23}(-s_1 s_{23}) + r_{33}(-c_{23})$$

$$\theta_5 = A\tan2(s_5, c_5)$$

$$s_6 = r_{11}(c_1 c_{23} c_4 c_5 + s_1 s_4 c_5 - c_1 s_5 s_{23}) + r_{21}(c_4 c_5 s_1 c_{23} - s_1 s_5 s_{23} - c_1 c_5 s_4) + r_{31}(-c_{23} s_5 - c_4 c_5 s_{23})$$

$$\theta_6 = A\tan2(s_6, c_6)$$