

1 Inverse Kinematics

1.1 Rotation Matrices

$${}^0R_3 = \begin{pmatrix} \cos \theta_1 \cos \theta_2 \cos \theta_3 - \cos \theta_1 \sin \theta_2 \sin \theta_3 & -\sin \theta_1 & \cos \theta_1 \cos \theta_2 \sin \theta_3 + \cos \theta_1 \sin \theta_2 \cos \theta_3 \\ \sin \theta_1 \cos \theta_2 \cos \theta_3 - \sin \theta_1 \sin \theta_2 \sin \theta_3 & \cos \theta_1 & \sin \theta_1 \cos \theta_2 \sin \theta_3 + \sin \theta_1 \sin \theta_2 \cos \theta_3 \\ -\sin \theta_2 \cos \theta_3 - \cos \theta_2 \sin \theta_3 & 0 & -\sin \theta_2 \sin \theta_3 - \cos \theta_2 \cos \theta_3 \end{pmatrix}$$

$${}^3R_6 = \begin{pmatrix} \cos \theta_4 \cos \theta_5 \cos \theta_6 - \sin \theta_4 \sin \theta_6 & -\cos \theta_4 \cos \theta_5 \sin \theta_6 - \sin \theta_4 \cos \theta_6 & \cos \theta_4 \sin \theta_5 \\ \sin \theta_4 \cos \theta_5 \cos \theta_6 + \cos \theta_4 \sin \theta_6 & -\sin \theta_4 \cos \theta_5 \sin \theta_6 + \cos \theta_4 \cos \theta_6 & \sin \theta_4 \sin \theta_5 \\ -\sin \theta_5 \cos \theta_5 & \sin \theta_5 \sin \theta_5 & \cos \theta_5 \end{pmatrix}$$

$${}^0R_6 = \begin{pmatrix} \cos \theta_p \cos(\frac{\pi}{2} - \theta_e) \cos \theta_r - \sin \theta_p \sin \theta_r & -\cos \theta_p \cos(\frac{\pi}{2} - \theta_e) \sin \theta_r - \sin \theta_p \cos \theta_r & \cos \theta_p \sin(\frac{\pi}{2} - \theta_e) \\ \sin \theta_p \cos(\frac{\pi}{2} - \theta_e) \cos \theta_r + \cos \theta_p \sin \theta_r & -\sin \theta_p \cos(\frac{\pi}{2} - \theta_e) \sin \theta_r + \cos \theta_p \cos \theta_r & \sin \theta_p \sin(\frac{\pi}{2} - \theta_e) \\ -\sin(\frac{\pi}{2} - \theta_e) \cos(\frac{\pi}{2} - \theta_e) & \sin(\frac{\pi}{2} - \theta_e) \sin(\frac{\pi}{2} - \theta_e) & \cos(\frac{\pi}{2} - \theta_e) \end{pmatrix}$$

2 Hardware

2.1 Stepper Motor

A4988 Steper Driver

$$V_{ref} = I_{max} * 0.8 * R_{sens}$$

3 LGCODE

3.1 G0

G0 A1{} A2{} A3{} A4{} A5{} A6{} F{} }

3.2 G1

G0 X{} Y{} Z{} P{} E{} R{} F{} }