Arm Constraints

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1 Arm Constraints

1.1 Features

The feature matrix of a motor is given by

$$F_m = \begin{bmatrix} \tau_{stall}^{(0)} & \tau_{stall}^{(1)} & \tau_{stall}^{(2)} \\ \omega_{free}^{(0)} & \omega_{free}^{(1)} & \omega_{free}^{(2)} \\ P^{(0)} & P^{(1)} & P^{(2)} \\ M^{(0)} & M^{(1)} & M^{(2)} \end{bmatrix} \tag{1}$$

where $\tau_{stall}^{(i)}$ is the stall torque in Newton-meters for motor i, $\omega_{free}^{(i)}$ is the free speed in radians per second for motor i, $P^{(i)}$ is the price of motor i, and $M^{(i)}$ is the mass in kilograms of motor i.

1.2 Required Tip Torque

F is the applied force on the tip (given). R_i is the length of link i.

$$\boldsymbol{\tau_{stall}} \geq \begin{bmatrix} F \cdot (R_1 + R_2) \\ (F \cdot (R_1 + R_2) + (M_1 \cdot G \cdot R_1)) \\ F \cdot R_2 \end{bmatrix} \tag{2}$$

1.3 Required Tip Velocity

V is the tip velocity (given).

$$\boldsymbol{\omega} = \begin{bmatrix} \frac{V_y}{R_1+R_2} \\ \frac{V_z}{R_1+R_2} \\ \frac{V_z}{R_2} \end{bmatrix} \tag{3}$$

The torque-speed curve of a motor is given by:

$$t(\omega_i) = \tau_{stall} - \frac{\omega_i \cdot \tau_{stall}}{\omega_{free}} \tag{4}$$

We can then describe the minimum required torque ($\boldsymbol{\tau_r}$, given) at the applied speed $\boldsymbol{\omega}$.

$$t(\boldsymbol{\omega}) \geq \boldsymbol{\tau_r} \tag{5}$$

1.4 Maximum Price

P_r is the maximum allowable price (given).

$$P_r \geq \sum_{i=0}^{2} P_i \tag{6}$$