Arm Constraints

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July 9, 2019

1 Arm Constraints

1.1 Features

The feature matrix of a motor module is given by

$$F_m = \begin{bmatrix} \tau_{stall}^{(1)} & \tau_{stall}^{(2)} & & \tau_{stall}^{(N)} \\ \omega_{free}^{(1)} & \omega_{free}^{(2)} & & \omega_{free}^{(N)} \\ P^{(1)} & P^{(2)} & \dots & P^{(N)} \\ M^{(1)} & M^{(2)} & & M^{(N)} \\ \omega'^{(1)} & \omega'^{(2)} & & \omega'^{(N)} \\ G^{(1)} & G^{(2)} & & G^{(N)} \end{bmatrix} \tag{1}$$

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 in USD, $M^{(i)}$ is the mass in kilograms of motor i, $\omega'^{(i)}$ is the precomputed term $\frac{\omega_{free}^{(i)}}{\tau_{stall}^{(i)}}$, and $G^{(i)}$ is the gear ratio on motor i.

1.2 Required Tip Force and Velocity

V is the tip velocity (`Limb.tipVelocity`). F is the tip force (`Limb.tipForce`). R_j is the r parameter of link j (`Link.dhParam.r`). The arm is mounted $90\,\mathrm{deg}$ off vertical.

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

$$\omega_i(\tau; \tau_{stall}^{(i)}, \omega'^{(i)}) = (\tau_{stall}^{(i)} - \tau) \cdot \omega'^{(i)} \tag{2}$$

$$\tau_{stall1} \geq F(R_1 + R_2 + R_3) + G(M_2 R_1 + M_3(R_1 + R_2)) \tag{3}$$

$$\tau_{stall2} \geq F(R_2 + R_3) + M_3 G R_2 \tag{4}$$

$$\tau_{stall3} \geq F R_3 \tag{5}$$

$$\omega_{free1} \geq \frac{V}{R_1 + R_2 + R_3} \tag{6}$$

$$\omega_{free2} \geq \frac{V}{R_2 + R_3} \tag{7}$$

$$\omega_{free3} \geq \frac{V}{R_3} \tag{8}$$

1.3 Optimization Goal

We want to optimize for price (lowest price).