Optimization with the Derived Model

ODE

Second order ODE from Lagrange Formalism:

$$A(x,p)\begin{pmatrix}\ddot{s}\\ \ddot{\theta}\end{pmatrix} = b(x,u,p)$$

Transformed into first order ODE:

$$\frac{d}{dt}\begin{pmatrix}s\\ \theta\\ \dot{s}\\ \dot{\theta}\end{pmatrix} = \begin{pmatrix}\dot{s}\\ \dot{\theta}\\ A^{-1}(x,p)b(x,u,p)\end{pmatrix} = f(x,u,p)$$

state	$x = (s, \theta, \dot{s}, \dot{\theta})^T$
control	$u = (\tau_1, \tau_2)^T$
parameters	$p = (p_1, ..., p_k)^T$

Discretization of the ODE

Discretize time interval:

$$[0, T] \to \{0 = t_0, t_1, \ldots, t_{m-1}, t_m = T\}$$

Discretize state and control:

$$x_n = x(t_n)$$
$$u_n = u(t_n)$$

Discretization of the ODE

Explicit Euler for every time step $h_n = t_{n+1} - t_n$:

$$x_{n+1} \approx \tilde{x}_{n+1}(p) = x_n + h_n f(x_n, u_n, p)$$

Discrete constraint:

$$0 = x_n - \tilde{x}_n(p) \quad \forall n = 1, \ldots, m$$

Optimization problem

$$\min_{p} f(p) = 0$$

s.t.

$$\begin{aligned} x_n - \tilde{x}_n(p) &= 0 && \forall n \\ p_i &\geq 0 && \forall i \end{aligned}$$

Parameters

masses	M_1, M_2
inertia of pulleys	$I_{B_1}, I_{B_2}, I_{P_1}, I_{P_2}$
friction coefficients	$\mu_{B_1}, \mu_{B_2}, \mu_{P_1}, \mu_{P_2}$

Optimization with the Black Box Model

Parameters

hoist:

$\text{inertia}_{\text{engine}}$

inertia_{yy}

friction

crowd:

mass

inertia_{yy}

cog_x

Optimization problem

$$\min_p f(p) = \alpha_1 \| u^*_{\textsf{hst}} - u_{\textsf{hst}}(p) \| + \alpha_2 \| u^*_{\textsf{crd}} - u_{\textsf{crd}}(p) \|$$
$$+ \alpha_3 \| y^*_{\textsf{hst}} - y_{\textsf{hst}}(p) \| + \alpha_4 \| y^*_{\textsf{hst}} - y_{\textsf{hst}}(p) \|$$

s.t. $\quad p_i \geq 0 \quad \forall i$

with torque u and position y.