ECE/ME 238 : Advanced Control Design Lab

Lecture 3 Notes: Acrobot Project Overview

Acrobot: General Roadmap

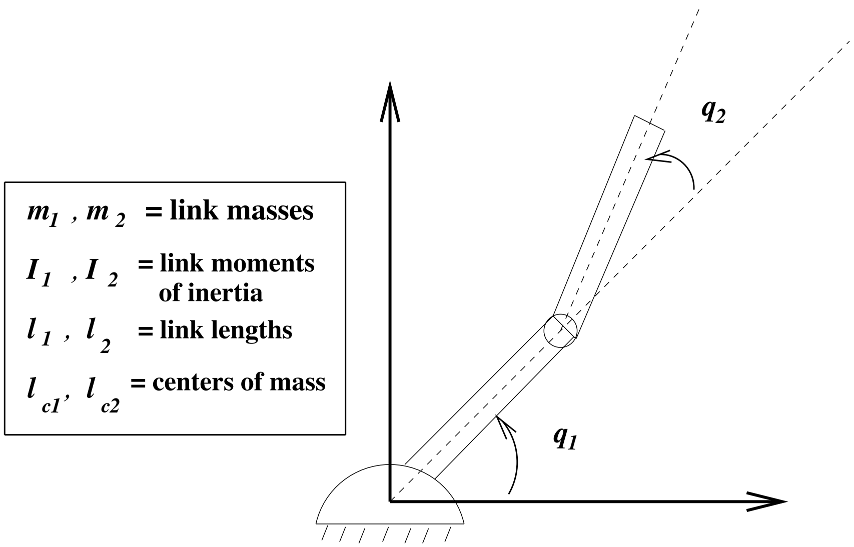

Figure 1: Two Link Robot

From Spong, 1995.

1. Define Goals
2. Model: Equations of Motion
3. Estimation and Control Design
4. Simulate and Animate
5. Results

Acrobot: (Partial) General Roadmap

1. Define Goals
   (a) pick equilibrium pose: must be able to BALANCE (in equilibrium)
   (b) swing-up: collocated versus non-collocated PFL
   PFL = “partial feedback linearization”
   (c) stabilize at equilibrium
2. Model: Equations of Motion
   - Lagrangian method
3. Estimation and Control Design
   - LQR, or pole placement
     Either requires “state space equations”, linearized near equilibrium

Acrobot: (Partial) General Roadmap

4. Simulate: Matlab’s ode45
    - Animate via creating drawings using ode45 output to depict the translations and/or rotations of rigid bodies over time
5. Results: Matlab plots, to later be explained

Equations of Motion (from Spong)

Example 1: Two Link Robot. Consider the two-link robot shown in Figure (1):

$$
\begin{aligned}
d_{11}\ddot{q}_1 + d_{12}\ddot{q}_2 + h_1 + \phi_1 &= \tau_1 \quad (4) \\
d_{12}\ddot{q}_1 + d_{22}\ddot{q}_2 + h_2 + \phi_2 &= \tau_2 \quad (5)
\end{aligned}
$$

Acrobot: tau1 = 0 (passive “shoulder”)

Pendubot: tau2 = 0 (passive ”elbow”)

where

$$
\begin{aligned}
d_{11} &= m_1\ell_{c1}^2 + m_2(\ell_1^2 + \ell_{c2}^2 + 2\ell_1\ell_{c2}\cos(q_2)) + I_1 + I_2 \\
d_{22} &= m_2\ell_{c2}^2 + I_2 \\
d_{12} &= m_2(\ell_{c2}^2 + \ell_1\ell_{c2}\cos(q_2)) + I_2 \\
h_1 &= -m_2\ell_1\ell_{c2}\sin(q_2)\dot{q}_2^2 - 2m_2\ell_1\ell_{c2}\sin(q_2)\dot{q}_2\dot{q}_1 \\
h_2 &= m_2\ell_1\ell_{c2}\sin(q_2)\dot{q}_1^2 \\
\phi_1 &= (m_1\ell_{c1} + m_2\ell_1)g\cos(q_1) + m_2\ell_{c2}g\cos(q_1 + q_2) \\
\phi_2 &= m_2\ell_{c2}g\cos(q_1 + q_2)
\end{aligned}
$$