Lecture 33, Nov 28, 2025

Linear Parametrization of the Robot Model

- How can we learn the parameters of the system?
- The robot model can be "factorized" as $M(q)\ddot{q} + C(q,\dot{q})\dot{q} + B(q)\dot{q} + G(q) = Y(q,\dot{q},\ddot{q})\Phi$, where $Y(q,\dot{q},\ddot{q})$ is a *regressor* matrix that models the structure of the robot, and Φ is a vector containing all the physical parameters of the robot
  - $Y(q,\dot{q},\ddot{q})$ is considered known, since it's based on the structure of the robot, which we have exactly even if we don't know the exact system parameters
  - Φ is unknown, and an adaptive controller would need to learn this parameter vector
- Example: for the pendulum cart $D(q)\ddot{q}+C(q,\dot{q})\dot{q}+G(q) = \begin{bmatrix} M\ddot{q}_1 - m_2 l\cos(q_2)\ddot{q}_2 + m_2 l\sin(q_2)\dot{q}_2^2 \\ -m_2 l\cos(q_2)\ddot{q}_1 + (I + m_2 l^2)\ddot{q}_2 - m_2 lg\sin(q_2) \end{bmatrix}$
  - Identify the independent parameters: $M, m_2 l, I + m_2 l^2 = \bar{I}$
    - The fewer independent parameters we have, the better, so in this case because we never see m_2 and l on their own, we group them into a single parameter
  - We can factor into $\begin{bmatrix} \ddot{q}_1 & -\cos(q_2)\ddot{q}_2 + \sin(q_2)\dot{q}_2^2 & 0 \\ 0 & -\cos(q_2)\ddot{q}_1 - g\sin(q_2) & \ddot{q}_2 \end{bmatrix} \begin{bmatrix} M \\ m_2 l \\ \tilde{I} \end{bmatrix}$