Robotics [IIT-Jodhpur]
Practical 6: Inverse Dynamics and Introduction to ReDySim

Part A : 75 minutes

For the 2-link robot shown in Figure 1, equations of motion of are given by

$$\begin{bmatrix} m_2 d_2^2 & 0 \\ 0 & m_2 \end{bmatrix}\begin{bmatrix} \ddot{\theta}_1 \\ \ddot{d}_2 \end{bmatrix} + \begin{bmatrix} m_2 d_2 \dot{d}_2 & m_2 d_2 \dot{\theta}_1 \\ -m_2 d_2 \dot{\theta}_1 & 0 \end{bmatrix}\begin{bmatrix} \dot{\theta}_1 \\ \dot{d}_2 \end{bmatrix} + \begin{bmatrix} m_2 d_2 s\theta_1 g \\ -m_2 c\theta_1 g \end{bmatrix} = \begin{bmatrix} \tau_1 \\ f_2 \end{bmatrix}$$

The robot is commanded to follow the cycloidal trajectory:

$$q_{i\_des} = q_i(0) + \frac{q_i(T) - q_i(0)}{T}\left[t - \frac{T}{2\pi} sin\left(\frac{2\pi}{T}t\right)\right]$$

$$\dot{q}_{i\_des} = \frac{q_i(T) - q_i(0)}{T}\left[1 - cos\left(\frac{2\pi}{T}t\right)\right]$$

$$\ddot{q}_{i\_des} = \frac{q_i(T) - q_i(0)}{T}\left[\frac{2\pi}{T} sin\left(\frac{2\pi}{T}t\right)\right]$$

where $q_1\,(0) = 0°,\ q_1\,(T) = 120°,\ q_2\,(0) = 0.5\ m,\ q_2\,(T) = 1\ m$ and T = 3 sec. Note that $q_1 = \theta_1$ and $q_2 = d_2$.

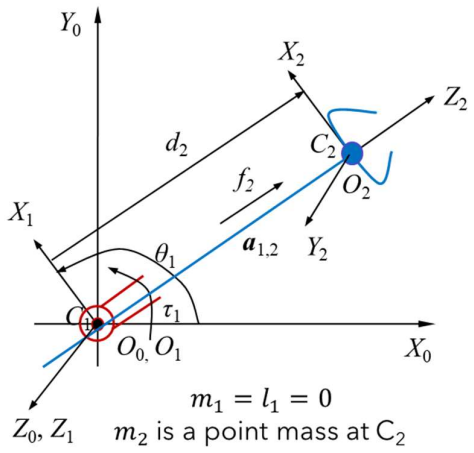

Figure 1: RP robot

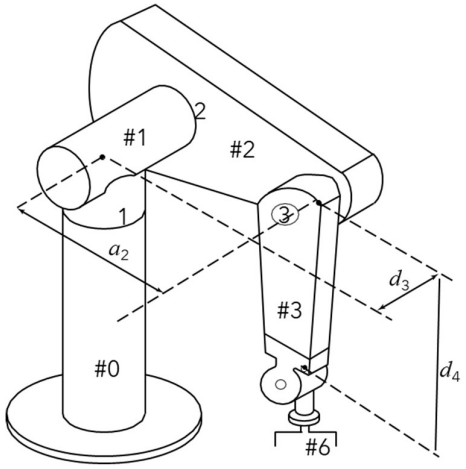

Figure 2: Puma Robot

Perform Inverse dynamics to find driving torque and force, i.e., solve for $\boldsymbol{\tau} = \boldsymbol{I}(\boldsymbol{q})\ddot{\boldsymbol{q}} + \boldsymbol{C}(\boldsymbol{q}, \dot{\boldsymbol{q}})\dot{\boldsymbol{q}} + \boldsymbol{h}(\boldsymbol{q})$ given the inputs: $\boldsymbol{q}, \dot{\boldsymbol{q}}, \ddot{\boldsymbol{q}}$.

a. Plot the commanded joint position, velocity and acceleration vs. time for time period T = 3 s
b. Find joint torque/force required to follow the above trajectory and plot joint torque vs time
c. Animate the system for the commanded trajectories and trace motion of the end-effector.

Assume m_2 = 1.5 kg, l_2 = 1.5 m, and g = 9.81 m/s^2.

Hint: You can build on Practical 1.

Part B: 45 minutes

1. Download: Basic Module: Fixed-Base Systems: Version 2
   Link: http://home.iitj.ac.in/~surilshah/redysim.php
2. Demonstration of Inverse Dynamics of 3 Link revolute jointed robot using ReDySim.
3. Verify the results obtained in Part A above using ReDySim
4. Perform inverse dynamics of 6-DOF PUMA Robot shown in Figure 2 using ReDySim for the DH parameter given. Refer the following document for DH parameters, mass, inertia properties and location of center of mass : https://khatib.stanford.edu/publications/pdfs/Armstrong_1986.pdf