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Computer project on Nonlinear Systems

Robot control

Let us consider the dynamics of a robot arm as depicted in figure 1, made of a drive actuating a shaft through a flexible joint.
The corresponding dynamical equations can be written as follows :

$$\begin{aligned} J_l\ddot{\theta}_l + B_l\dot{\theta}_l + k(\theta_l - \theta_m) + mgl\cos(\theta_l) &= 0 \\ J_m\ddot{\theta}_m + B_m\dot{\theta}_m - k(\theta_l - \theta_m) &= u. \end{aligned}$$

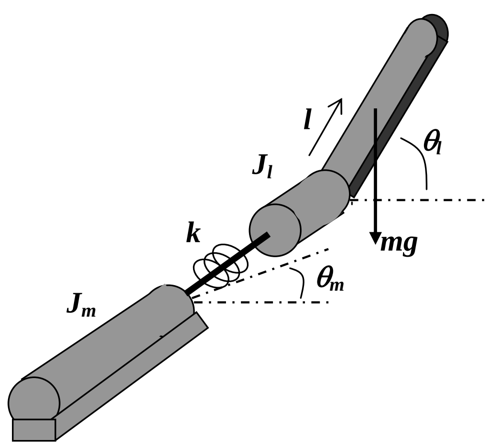

FIGURE 1 – Robot arm with flexible joint.

$$with : k = 0.8Nm/rad; J_m = J_l = 4e-4Nms^2/rad; B_m = 0.015Nms/rad; B_l = 0.0;$$
$$m = 0.3kg; l = 0.3m; g = 9.8ms^{-2}.$$

Let us consider the problem of stabilizing the arm at position corresponding to $\theta_l = \frac{\pi}{4}$.

1. Give a state space representation of this system and provide a related simulation scheme.

2. Give its linear tangent approximation at the point corresponding to $\theta_l = \frac{\pi}{4}$, and propose a stabilizing feedback on this basis.

3. Implement the obtained control law in the simulation scheme, and test its behavior.

4. Check that the original nonlinear system is fully exactly I/O linearizable by diffeomorphism and state feedback, with $\frac{\pi}{4} - \theta_l$ as the output, and propose a stabilizing state feedback law on this basis.

5. Verify the results in simulation, and comment.