

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 :

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

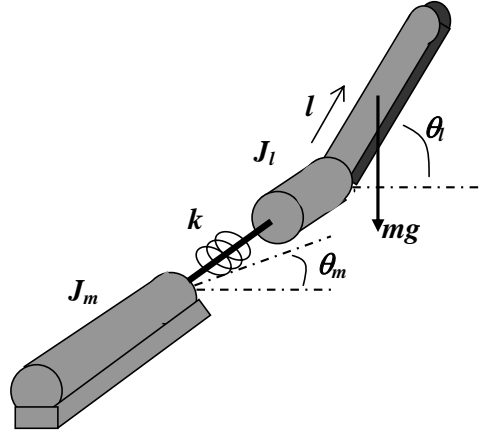


FIGURE 1 – Robot arm with flexible joint.

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

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

0. intro

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

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

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

alex -> r
matteo -> control-law 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.

kevin 6. propose a variable structure controller for the system linearized via linear feedback linearization to make $y(t) = \pi/4 - \theta_l$ tracks some (constant) reference signal y°

7. Analyze the performance achieved by the variable structure controller devised in point 6. focusing on one or more of the following aspects:

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- high frequency switching
- robustness with respect to parameters uncertainty
- robustness with respect to sinusoidal load disturbance
- impact on the saturation of the input