Robotics II

June 10, 2014

Exercise 1

Consider a planar 3R robot with unitary link lengths as in Fig. 1. Taking into account the robot redundancy, a velocity control scheme is active so as to track desired end-effector position trajectories while trying to locally maximize the minimum Cartesian distance of the robot body from the obstacles.

- In the shown configuration $\boldsymbol{q} = (30°, -30°, 30°)$, the end-effector is assigned a unitary velocity $\boldsymbol{v}$ in the positive $\boldsymbol{x}_0$ direction. Specify the velocity control scheme and provide the associated numerical value of the command vector $\dot{\boldsymbol{q}} \in \mathbb{R}^3$.
- Compare with a minimum velocity norm solution that neglects the presence of the obstacle.

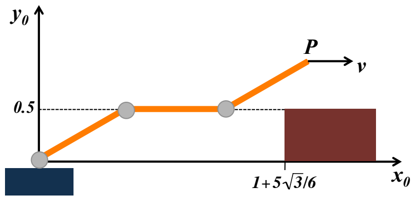

Figure 1: A planar 3R robot moving in the presence of an obstacle

Exercise 2

The two-mass flexible system in Fig. 2 moves under gravity and is subject to a control force F. The position coordinates q_1 and q_2 have their zero in a position where the elastic spring is undeformed.

- Derive the dynamic model assuming that all friction effects can be neglected.
- Determine all forced equilibrium configurations of the system.
- Design a feedforward plus linear feedback control scheme using only measurements of the position q_1 and velocity $\dot{q}_1$ of the first mass, which is able to regulate the position of the second mass to a constant desired position $q_{2,d}$.
- Prove the global asymptotic (actually, exponential) stability of the desired closed-loop equilibrium. *Hint: The closed-loop system dynamics is* affine*, and a simple analysis can be made by linearizing the system around the desired equilibrium, which removes constant terms.*

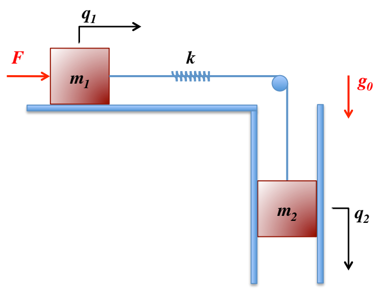

Figure 2: A system of two masses m_1 and m_2, coupled by an elastic transmission of stiffness k

[180 minutes; open books]