Robotics II

April 1, 2015

Exercise 1

Consider the planar RP in Fig. 1, moving in the vertical plane. The center of mass of the first link lies always on the axis of the revolute joint. In the following, use the generalized coordinates $\boldsymbol{q} = (q_1, q_2)$ defined in this figure.

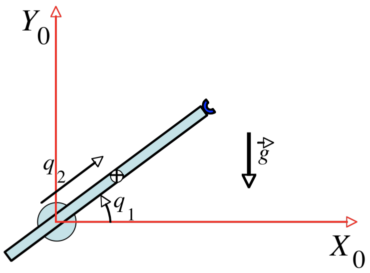

Figure 1: A planar RP robot moving in the vertical plane

a) Determine all equilibrium configurations $\boldsymbol{q}_0 = (q_{01}, q_{02})$ for the *open-loop* system.

b) Derive the *linearized* model equations, obtained by a first-order Taylor expansion around an equilibrium $\boldsymbol{x} = (\boldsymbol{q}, \dot{\boldsymbol{q}}) = (\boldsymbol{q}_0, \boldsymbol{0}) = \boldsymbol{x}_0$, expressed in the state-space format $\dot{\boldsymbol{x}} = \boldsymbol{A}\boldsymbol{x} + \boldsymbol{B}\boldsymbol{u}$, where $\boldsymbol{u}$ is the vector of generalized joint forces provided by the actuators.

c) Design a regulation controller that *globally* asymptotically stabilizes any desired state of the form $\boldsymbol{x}_0 = (\boldsymbol{q}_0, \boldsymbol{0})$ in the *closed-loop* system, specifying all model terms in the control law.

d) What kind of behavior can be inferred *locally* around the desired state for the obtained closed-loop system, using the linearized model as in step b)?

Exercise 2

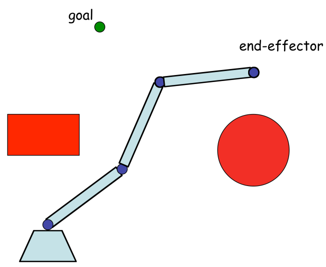

Figure 2: A planar 3R robot moving among obstacles

The 3R robot shown in Fig. 2 has equal links of unitary length and is redundant for all tasks defined only in terms of the position of its end effector in the plane. The robot should move its end-effector toward the goal, while avoiding to collide with the obstacles in its workspace. Discuss the use of redundancy for the specific configuration shown in the figure, illustrating also graphically the instantaneous velocities imposed to the robot structure by the goal attraction and the repulsion from the obstacle(s).

[120 minutes; open books]