Rheinische Friedrich-Wilhelms-Universität Bonn
Institut für Informatik
Abteilung VI
Autonome Intelligente Systeme

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Robot Learning

Assignment 7

Due Tuesday, July 4th, before class.

7.1) Consider a frictionless pendulum with point-mass m=6kg and length l=3m. The state shall be described by angle θ (deviation from upright) and angular speed ω. Gravity will act on the pendulum.
Control actions can accelerate the angular speed.
Model the system behavior as a discrete-time system with a step size of 0.1s!
Compute the evolution of the state over 5s for an initial state of $\theta_0 = -0.3$rad and $\omega_0 = 0.6$rad/s with zero control input.

4 points

7.2) Linearize the system around the upright position ($\theta=0$).
Compare the evolution of the state for this linearized system for the same initial state of $\theta_0 = -0.3$rad and $\omega_0 = 0.6$rad/s with zero control input.

4 points

7.3) Define a cost function which penalizes deviation from the desired upright zero-velocity state and costs of control actions in a quadratic way.

2 points

7.4) Use the method of Linear Quadratic Regulation (LQR) to design a state-feedback policy which optimizes your cost function from 7.3 over a time horizon of 50 steps (5s), starting from the initial condition $\theta_0 = -0.3$rad and $\omega_0 = 0.6$rad/s.
Show how the state evolves when the policy is applied.

8 points

7.5) Add zero-mean Gaussian noise with covariance matrix $\Sigma=\mathrm{diag}(0.04, 0.02)$ to the state after each transition and compare how the state evolves when above policy is applied from the same initial conditions.

2 points