UNIVERSITÄT BONN
RHEINISCHE FRIEDRICH-WILHELMS-UNIVERSITÄT BONN
Prof. Dr. Sven Behnke
AIS
COMPUTER SCIENCE VI
AUTONOMOUS INTELLIGENT SYSTEMS
Endenicher Allee 19a

Robot Learning

Assignment 8

Due Tuesday, June 23rd, before class.

8.1) Consider a frictionless pendulum with point-mass $m = 4$ kg and length $l = 3$ m. The state shall be described by angle θ (deviation from upright) and angular speed ω. Gravity will act on the pendulum.
Control actions produce a torque around the pendulum hinge joint.
Model the system behavior as a discrete-time system with a step size of 0.01 s!
Compute the evolution of the state over 1 s for an initial state of $\theta_0 =$ 0.3 rad and $\omega_0 = -1$ rad/s with zero control input.

4 points

8.2) Linearize the system around the standing still upright state ($\theta = 0$, $\omega = 0$).
Compare the evolution of the state for this linearized system for the same initial state of $\theta_0 =$ 0.3 rad and $\omega_0 = -1$ rad/s with zero control input.

4 points

8.3) Define a cost function which penalizes deviation from the standing still upright state and costs of control actions in a quadratic way.

2 points

8.4) Use the method of Linear Quadratic Regulation (LQR) to design a state-feedback policy which optimizes your cost function from 8.3) over a time horizon of 0.5 s, starting from the initial condition $\theta_0 =$ 0.3 rad and $\omega_0 = -1$ rad/s.

Show how the state evolves when the policy is applied.

8 points

8.5) Add zero-mean Gaussian noise with covariance matrix $\Sigma=\mathrm{diag}(0.01, 0.04)$ to the state after each transition and compare how the state evolves when above policy is applied from the same initial conditions.

2 points