Individual Assignment 1

Instructions

Full solutions should be turned in as a pdf-file, you turn-in the solutions in Ping-Pong. The solutions can be handwritten or generated in LaTeX/Word. The solutions should be complete and well explained. For problems that involve programming or simulations the code and/or Matlab models should be included in a zip-file that should be attached. This is an individual assignment and cooperation is not allowed.

Problem 1

In the lecture we derived how to estimate the orientation from the accelerometer when using the Euler-Angles XYZ (roll-pitch-yaw) rotation order. From the rotation matrices derive how to estimate pitch and roll if we instead use the YXZ (pitch-roll-yaw) rotation order.

Problem 2

In the quadrotor we use a a complementary filter to estimate an angle from readings from the accelerometer and gyroscope. The complementary filter is given by

$$\theta(s) = G(s)\theta_a(s) + (1 - G(s))\theta_g(s)$$

where

$$\theta_g(s) = \frac{1}{s}Y_g(s).$$

θ_a is the estimated angle from the accelerometer, and y_g is the angular velocity from the gyroscope.

Use Euler-backward discretization to derive a difference equation that tells how to calculate the an estimated angled from readings from the accelerometer and gyroscope.

Problem 3

Consider the water tank control system shown below.

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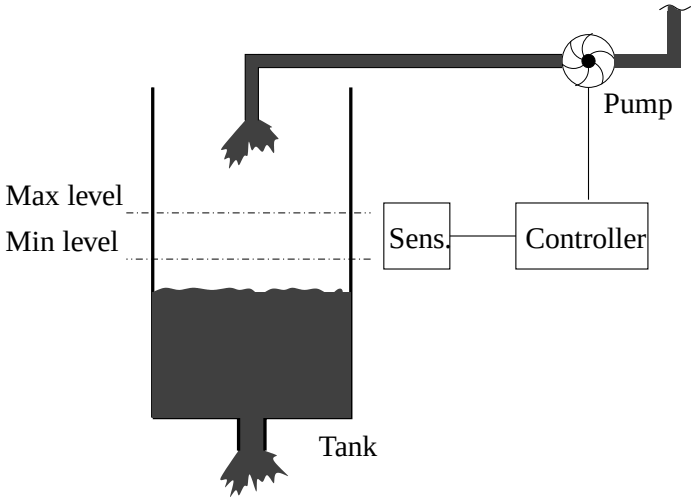

The control objective is to maintain the water level l within the maximum and minimum levels indicated in the figure. The controller can either turn on the pump or turn it off. When the pump is on, the dynamics of the tank is

$$On : \frac{dl(t)}{dt} = -l(t) + 25$$

and when it is off

$$Off : \frac{dl(t)}{dt} = -l(t)$$

The controller will turn the pump on if $l < 10$ and will turn it off if $l > 15$.

a) Draw a hybrid automata of the system.

b) Build a model a model of the hybrid automata in Simulink. Simulate the system, assuming the initial state is $l(0) = 12$. Simulate the system with and without zero-crossing detection enabled.

c) Is the hybrid automaton Zeno, i.e., does it have Zeno solutions?

d) The water tank overflow if $l > 20$, which corresponds to the unsafe (or bad) states. Analyze if the hybrid automaton is always safe if we start with the level $l_0 \in [0, 20]$.