EE 141 – Project
Spring 2019

Due on June 7th by 5pm (homework dropbox)

In this project you will design a controller for a quad-rotor with the objective of regulating its altitude. We will assume that a controller is already in place to ensure the quad-rotor can only move up and down.

1. Write the equations of motion for the quad-rotor assumed to be a point mass that can only move along a vertical line and is subjected to the action of two forces: gravity and thrust.

2. Knowing that there are 4 propellers, and that each propeller produces a trust force given by:

   $$C_T \omega^2,$$

   where the thrust coefficient C_T is given by $C_T = 1.536 \times 10^{-7}\,\mathrm{Ns}^2$ and ω is the propeller's rotational speed, compute the value of ω required to make the quad-rotor hoover when its total mass is $0.027\,\mathrm{Kg}$.

3. With the objective of tracking step altitude commands, linearize the equations of motion by treating[1] ω as the control input.

4. Design a controller tracking steps inputs and show that it achieves a rise time no longer than 3 seconds and a settling time no greater than 5 seconds when acting on the nonlinear plant model.

5. Design a controller that tracks ramp commands.

[1] In a real drone the propellers' speed is controlled by a feedback loop that commands the current fed to the motors attached to the propellers.

6. Compare the performance of the following two control strategies with the objective of making the quad-rotor hover at 2 meters:

   (a) Give a step input of 2 meters;

   (b) Give a ramp input followed by a step input of 2 meters (you are free to design the value of the ramp and the time at which the reference changes from a ramp to a step).

7. Compare again the previous strategies when the altitude sensor is affected by noise according to the model:

$$y(t) = h(t) + n(t),$$

   where y is the sensor output, h is the drone's altitude, and $n(t) \in [-0.1, 0.1]$ is an arbitrary time-varying signal modeling sensor noise.