Out: *November 1, 2015*

16.30 - 16.31: Feedback Control Systems

Laboratory Assignment 4 and Projects

Lab Assignment 4: All students taking 16.30 and 16.31 must do a final laboratory assignment. The topic for this laboratory assignment is open. You can implement an estimation or a control algorithm that we have learned in the class, or you can read, learn and implement completely new algorithms which we have not covered in the class. You are encouraged to use the Parrot drones we have given out in the class. However, other experimental platforms (e.g., those you may have in your lab) are also accepted. You are expected to submit a short report about this lab. The report should describe the problem, your approach, and some plots of your data from your experiment. We expect a 2- or 3- page laboratory report, including the figures. You do not need to be elaborate.

The report can be structured as follows. Present all of the following sections:

1. Description of the problem: Which problem are you trying to do? Why is this problem important? Please describe in at most two paragraphs.

2. Description of the approach: What approach did you use? Please feel free to cite other books/papers. You can also use a few equations to describe your approach. Please describe in at most two paragraphs.

3. Description of the experiment: Describe your experimental procedure? Which steps did you follow? Please describe in at most two sentences.

4. Description of the results: Present one or two figures from your experiments, and describe your conclusions in at most two paragraphs. If you are citing any data in this section, you should also upload the data you are citing in the matlab .dat format and the figures in the .fig format.

Please make sure to include at least one 'killer figure' that shows the value of your experiment. The report must be in .pdf format. To emphasize, in addition to the report, each team must also submit the data that is cited in the report in the matlab .dat file format, the matlab figures in the .fig format. Finally, each team must also submit a video that

1. shows the experiment working,

2. presents at least one (possibly more) 'killer' figure that summarizes the conclusions of the experiment.

The video submission should be self contained. That is, it should either have (clear) voiceover or subtitles, which describes the problem, the approach, the experiment, and the results very briefly, while showing the experiment working and showing the killer figures. Someone watching the video should understand all these aspects without having to read your report. The video should be at most 2 minutes.

When you upload your lab work, there will be three submission sites: (i) report in pdf format, (ii) data/figures in dat/fig format, (iii) video. Please make sure to upload all.

Projects: The graduate students taking 16.31 are required to do a project. If you are enrolled in 16.31, you can align your project with Lab Assignment 4. In fact, you are encouraged to. However, in addition to the laboratory report described above, we expect a more thorough analysis of the problem, a discussion of your contributions with references to the literature. We expect this report to be a 5- or 6-page document (with the figures).

Working in Teams: Both for the Lab Assignment 4 and for the projects, you are welcome to work in teams. We will allow teams of up to 5 students, if you would like to take a substantial project. However, we will expect much more from large teams. If you are working with a team, each team must submit only one laboratory report. However, each graduate student in your team must submit their own project reports with their own contributions. If you would rather be in a team, but you can not find a team member, then we will help you find partners.

Timeline: You should determine your team and your lab/project idea by November 13th, Friday 11:59pm. You should submit your idea through Stellar in a small document. The document should have the students proposing this lab/project, the project title, and an abstract (that does not exceed 400 words). The document should be submitted in the pdf format. We will give you feedback until November 16th. Most project ideas will be finalized by November 16th. We will make sure to finalize all project ideas by November 20th. The lab reports and the project reports will be submitted on December 4th. The video will be submitted on December 6th.

Potential project ideas: You are more than welcome to come up with your idea for the projects. Here are a few examples:

- **Design and implement robust controller for the drone (1 person)** We will learn more about robust control techniques, such as $\mathcal{H}_\infty$ control. This lab/project focusses on the application of $\mathcal{H}_\infty$ control techniques to drone control.
- **Design and implement a state estimator for the drone (1 person)** The drone uses an estimation technique we have learned in the class, other than the subjects of Lab Assignment 2 and Lab Assignment 3. The lab details its tuning and implementation.
- **Adding integral action to full state feedback control (1 person)** The control structure is augmented with integral action to eliminate steady state errors.
- **Control with battery feedback (2-3 people)** The drone uses battery feedback to eliminate steady state errors when battery voltage is low or changing. This might required some sort of a battery state estimator.
- **Adaptive control with weight changes (2-3 people)** The drone quickly adapts to changes in weight and inertia using adaptive control techniques, when a weight is put on the quadcopter.
- **Detect and fly to a marker (2-3 people, requires programming in C)** The drone detects a specially colored marker, and flies to hover on top of this marker.
- **Flip control (3-4 people)** The drone flips around its y-axis and catches back stability. This also requires tweaking the orientation estimator.
- **Better stabilization with external camera feedback (3-4 people, requires programming in C)** Use an external camera to detect the drone in the camera image. Feedback the information to the drone via bluetooth, and allow the drone to do precision position control.