Out: Oct 21 **Due:** October 30th, 11:59pm.

16.30/31: Feedback Control Systems

Fall 2015

Laboratory Exercise #2

In this laboratory exercise you will implement the fullstate feedback controllers that you computed in PSET2 with a pole-placement approach - initially in simulation using the Simulink model that is part of the toolbox and then on the actual drone in order to use this controller to actually fly it.

Please make sure to follow all safety procedures before you fly the drone. In particular, please make sure to wear safety glasses and make sure your drone is fitted with the wheels.

For this laboratory exercise, please execute all of the following steps, and turn in a report and data as described in bold font below:

1. First, make sure that your toolbox is up-to-date and that you downloaded the solutions to PSET 2 Part 2 (files LinearDroneAndPolePlaceControl.m, LinearizedComplexDrone_PolePlace.mat, SimulatingLinearizedDroneModelsWithControllers.slx).
2. Open MATLAB navigate to MIT_ROSMAT/trunk/matlab and run startup.m.
3. Open the file controllers/controller_fullstate/controller_fullstate.slx. It contains a template simulink block "ControllerPolePlace" for the fullstate feedback controller that you will implement. Copy this block and replace the existing controller block "ControllerPID" in sim_quadrotor.slx.
4. Now run the m-file LinearDroneAndPolePlaceControl.m from PSET 2 that generates the fullstate feedback controller matrix $K_{poleplace}$. You can use the solution file for this.
5. Complete the "ControllerPolePlace" simulink block such that it implements a fullstate feedback controller that uses the matrix $K_{poleplace}$. In the "ControllerPolePlace" block, please navigate to "FullstateController" to implement the missing steps.
   (Side note: The other blocks are essentially just for infrastructure pupose. They have quick descriptions inside and we will have a look at them in a recitation for those who are interested.)
6. Simulate the drone's behavior with this new controller.

In your report, show your implementation of the "FullstateController" block. Generate the following plots and add them with comments to your report:

- **One plot that describes the position of the drone. This plot should show three variables, namely the x, y, z coordinates of the drone, with respect to time, in one figure.**
- **One plot that describes the orientation of the drone. This plot should show three variables, namely roll, pitch, and yaw angles of the drone, with respect to time, in one figure.**
- **One plot that shows the four motor commands send to the drone with respect to time, in one figure.**

In your report, for each of the three plots, briefly discuss (in one short paragraph of at most five sentences) whether the data is what you expected and why.

7. Generate embedded C code from this fullstate feedback control system, and compile/upload the embedded C code to your drone. For this step, carefully read the "Embedded code generation" section of the GettingStarted document on pages 18-29, and carefully watch the DesigningControllers video.

8. Fly your drone with the fullstate feedback control system. For this step, carefully read the "Flying" section of the GettingStarted document on pages 20-24, and carefully watch the FlyingAndAnlyzingData video. Once the drone is in stable hover, hit the 'y' key to provide an altitude reference that is 0.6m higher (you can use the 'e' key, if you would like to exit the experiment).

9. Download the data of the this experiment from your drone into the Matlab environment. For this step, carefully read the "Data Analysis" section of the GettingStarted document on page 25, and carefully watch the FlyingAndAnalyzingData video.

   Use the FlightDataAnalyzer.m file to generate the following plots and add them with comments to your report:

   - **One plot that shows the time evolution of IMU, altitude, and motor commands. This plot is the first figure generated by FlightAnalyzer.m.**
   - **One plot that shows the time evolution of altitude. This plot is the second figure generated by FlightAnalyzer.m.**
   - **One plot that shows the time evolution of battery voltage. This plot is the fifth figure generated by FlightAnalyzer.m.**

   In your report, for each of the three plots, briefly discuss (in one short paragraph of at most five sentences) whether the data is what you expected and why.

   Also, rename the RSdata.mat data you downloaded into a new file "LastName_experiment1.mat" to save it for later use.

10. Repeat steps 4-9 with a new controller that has faster altitude dynamics. You can simply comment out the line with slow z-poles and uncomment the line with fast zpoles (in the file LinearDroneandPolePlaceControl.m).

11. Please tell us how long it took you to complete this lab exercise.

You should upload one .pdf report through the stellar website.

If you run into trouble, please utilize the Piazza website. Please do not send individual emails to the instructors. If you use Piazza, your fellow students can answer your questions as well; hence, you get a quicker response. Furthermore, your fellow students will also benefit from the answers.