Lab 6: Implementation of Code on Blimp

Objectives

Hardware

1. Become familiar with the layout and design of the *Blimp* and the attached gondola.

Software

1. Test the P&D control algorithm for both the altitude and the heading.
2. Be able to successfully test your C code on a hovering *Blimp*.

Motivation

You will test your code on an autonomous aerial vehicle; the real *Blimp*! With the gondola on the lazy Susan, factors such as inertia and drag that affect the *Blimp's* movement are not taken into consideration. These directly affect the value of the gain constants in the P&D control for both altitude and heading. Furthermore, the altitude P&D control algorithm cannot be tested properly with the lazy Susan.

Lab Description and Activities

Hardware

For the lab sessions, you will be in the Armory. LITEC staff will be stationed there with the *Blimp* to assist you with the *Blimp*. A gondola is attached to the bottom of a *Blimp* that is identical to the gondola used in Lab 5. The major difference will be the direction of the ultrasonic range finder; it will point downwards. Familiarize yourself with the setup of the *Blimp*, how to download code to the *Blimp*, how to use the LCD display and number pad, and how to debug any problems you may encounter.

Software

Use the LCD display and number pad to set desired heading, heading proportional gain constant, heading derivative gain constant, altitude proportions gain constant, and altitude derivative gain constant. Desired altitude can be fix at 150 cm for this lab.

The pair that wrote the P&D altitude control algorithm must ensure that code works properly. Recall that in Lab 5, altitude control could not be fully tested. Using “log session” option in SecureCRT, capture the actual altitude values and the pulse width signal used to drive the thrust fans as the *Blimp* corrects itself using the P&D control algorithm. You must obtain altitude response curves much the same as the heading response curves obtained in Lab 5.

For the compass pair, the code must also be tested to ensure that proper P&D control has been implemented to correct the heading. Using “log session” option in SecureCRT, capture the values of the actual heading, the compass reading, as the *Blimp* corrects itself using the P&D control algorithm. You may need to adjust the gains. Make judicious use of the number pad to set the gains.

Note that the team should be using the same integrated code even though the pairs will be testing different parts of the code separately. In other words, the *Blimp* will be controlling both the heading and the altitude at the same time. You may however choose to only print one set of numbers at a time. Also note that the values for the gain constants may need to be changed because the gondola on the *Blimp* may not behave the same as the gondola placed on the turntable.

Lab Check-Off: Demonstration and Verification

1. Complete the entries in your lab notebook and present it to your TA. These entries must include at least three response plots for the altitude readings and one or more response plots for heading readings on the *Blimp*. One curve in each case should represent a good response. Be able to explain why the other curve isn't desirable. Show the TA a plot of the performance curves while you are still in the Armory. This can be a soft copy on your laptop. Print a hardcopy later for the lab notebook.
2. Set a value for the compass heading and explain to the TA how P&D control works. Use LCD display and number pad.
3. Set the desired altitude to 150 cm. Show that actual altitude higher or lower than the desired altitude causes the thrust fans to operate in the proper direction.
4. Your TA may ask you to explain how sections of the C code or circuitry you developed for this exercise works. To do this, you will need to understand the entire system.
5. Print the output in the in the SecureCRT screen in the following format

```
Heading - Altitude - Battery Voltage
  xxxx       xxx           xxx
  xxxx       xxx           xxx
  ....       ...           ...
  xxxx       xxx           xxx
```

   Capture and print the screen and attach it to your lab notebook. Plot graphs using these readings (with an appropriately scaled x-axis).

Enhancements

If time permits, enhancements are encouraged and will be rewarded as an extra credit assignment. Hand in a written statement if you decide to do an enhancement. The statement should describe the concept and the purpose. Enhancements must have a purpose, though your enhancement might just demonstrate the concept if full implementation is unreasonable. Flying time in the Armory is very limited and enhancement flights are given a low priority. Please consider enhancements that can be demonstrated on the turntable or on a car.

Writing Assignment - Lab Notebook

Enter the full schematics of the circuitry (which will be very similar to the schematic from Lab 5). You must show the pins (and hence which CCM) that are connected to the components on the *Blimp*. Print and attach the full code. Describe in your lab notebook any modifications you made to the code from Lab 5 to allow it to function on the *Blimp*. Make comments about the performance with both high gains and low gains.

Attach at least 3 graphs of the response curves for each altitude and at least one of heading with the P&D control algorithms. Write a brief description on why the graphs are shaped as they are.

Writing Assignment - Final Design Report Addendum

Submit the results of this lab as an addendum to your report that you have made after Lab 5. In your addendum, do not repeat what you have already written in your final report.

Words of advice for this lab.

1) **Read the Gondola Info PDF file on LMS.** The gains needed for the lab can range in values from 1 to 900. With large gains, the pulse width calculations can have intermediate steps with negative values or with values that exceed 32767. In these cases long int variables are required. Codes that worked in Lab 5 with relatively small gains might fail in Lab 6 if you don't pay attention to this issue.

2) **If you turn off the power to the gondola and then turn it back on - your code will restart.** This is a good way to reset the gains. You don't need to download your code again just to set new gains if you are using the number pad. The power up of the gondola is slow, about 2 seconds. So in some cases the LCD display won't display lines of text sent in the first few seconds after a power up. Your code is still running.

3) **When flying: a) One student always holds onto one of the tether strings. Make sure that this person stays awake. b) TAs and only TAs change the batteries. c) Tether the *Blimp* when you reconnect to download a code.**

4) When trying to pick gains, consider that the heading error can range from -1800 to +1800, while the altitude error will be more like -100 to +100. Logic indicates that since the altitude error is a comparatively small number, then the altitude gains should be larger than the heading gains. A similar logic would say that since the *Blimp* moves slowly, the derivative term (error - previous error) is often small, (small compared to the error.) So one might expect the derivative gain must be significantly larger than the proportional gain. All of this discussion is to help you get started. The true nature of the system is more complicated. Up/down dynamics aren't the same as the turning dynamics. There are 2 thrust fans but only one tail fan. Without a full dynamic model, you can't predict the gains needed but you can make reasonable guesses.