MASSACHVSETTS INSTITVTE OF TECHNOLOGY
Department of Electrical Engineering and Computer Science
6.01—Introduction to EECS I
Spring Semester, 2008

Exploration 10: Due: Thursday, May 1

Exploration 10: designing better heads

In design lab 9 (question 15) we studied the effects of gain on the stability of a head orientation controller. In that lab, we modified the gain by changing the gain of a circuit. In design lab 10 we studied the effect of delays on stability when head orientation was controlled by the computer. There is still one other aspect of the design that will have an important impact on the system stability: the physical design of the head itself. The way that you position the two photo-resistors on the head, how they are oriented, and the shape of the nose that you build may have very important implications for how the final system will behave. For example, for some designs, the output of the photoresistors varies smoothly with head rotation, while in others, it is not even monotonic. Nonlinearities can be problematic, especially when they effect the error signals that are generated when the head angle is close to the target. In the previous labs, design choices that affect these non-linearities were made arbitrarily. In this exploration we will study the effect of those choices.

This exploration is divided into three parts. In the first part, we will build the basic infrastructure for testing and calibrating the sensors. In the second part, we will explore several head designs and we will see how they affect the function relating the output of the photo-resistors with the angle of the head. In the third part, you can study the effect of your design choices on the stability of the angle controller. Can you propose an optimal head design?

Question 1: Write a Python program to sweep the head back and forth. The head should first rotate so that it is "looking" directly forward ($\theta = 0$). It should then sweep uniformly to the left. When it reaches $\theta = -\pi/3$ (not quite full left, which would be $\pi/2$), it should reverse direction and sweep uniformly to the right till it reaches $\theta = \pi/3$. It should then return uniformly to $\theta = 0$. This whole sequence should take approximately 5 seconds.

Question 2: To build an optimal feedback controller for light tracking, we must quantify the performance of the photosensors. Measure and plot how the computer's representation of the left and right photosensor depend on the angle of the head when the light (which is stationary) is coming from a point that is 1 foot directly in front of the head.

Question 3: Change the distance between the two photo-resistors and remeasure the relations between the photosensor outputs and head angle. Compare results for the two different distances and explain any differences.

Question 4: Change the length of the nose (or remove the nose entirely) and remeasure the relations between the photosensor outputs and head angle. Compare results before and after the change and explain any differences.

Question 5: Suggest some other change to the physical layout of the head that will affect the relation between photosensor outputs and head angle. Compare results before and after the change and explain any differences.

Question 6: Describe features of the relations that were measured in the last three questions that are desirable and undesirable. Design a physical layout of the head that is "optimized" in the sense that the desirable features are maximized and the undesirable features are minimized. Describe the resulting layout.

Question 7: Test your "optimized" design from the last part for two different locations of the lamp: one at one foot (as before) and one at four feet. Describe the effect of changing the lamp distance.

Question 8: Generally, we expect better performance if the "error" signal that we generate from the photoresistors varies linearly with head angle and does not depend on distance to the lamp. Optimize your head design and the way you compute the error signal from the photoresistor voltages. Measure and plot the resulting error signal as a function of head angle and lamp distance.

Question 9: Test the effects of your optimizations on the stability of the system for light tracking. Determine the highest stable gain for the optimized system and for your original system. In what ways (if any) has the system been improved. Explain.