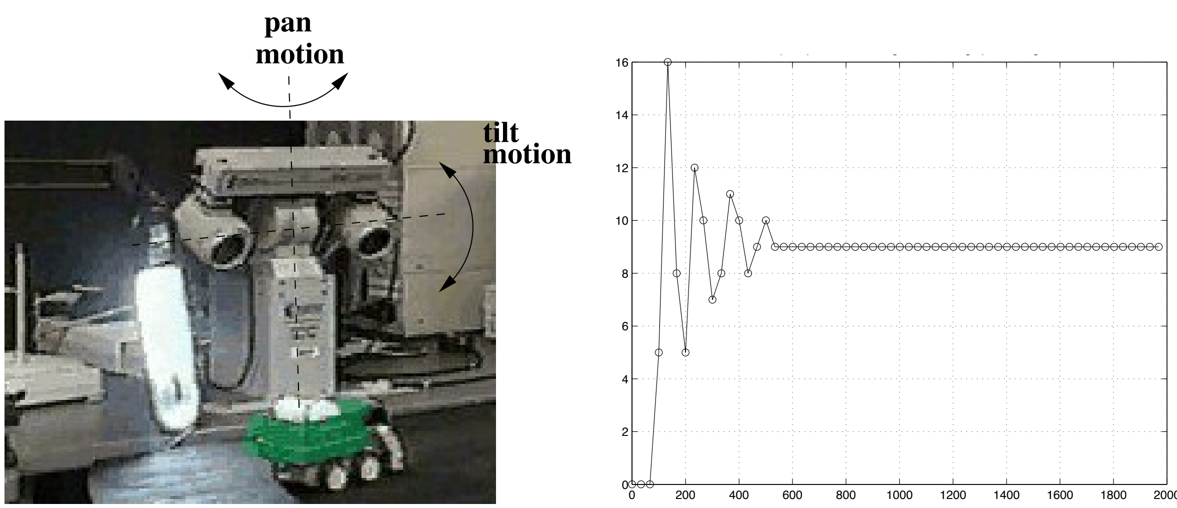
EECE 5610, Fall 2025, Final Project

“Teaching Robots to See”

1 Introduction

Recent hardware developments have rendered controlled active vision a viable option for a broad range of problems, spanning applications as diverse as Intelligent Vehicle Highway Systems, robotic–assisted surgery, 3D reconstruction, inspection, vision assisted grasping, MEMS microassembly and automated spacecraft docking. However, realizing this potential requires having a framework for synthesizing robust active vision systems, capable of moving beyond carefully controlled environments. In addition, in order to fully exploit the capabilities of newly available hardware, the control and computer vision aspects of the problem must be addressed jointly. The goal of the EECE5610 project is to briefly explore some of the issues involved in this problem (a more complete description and a key to the relevant literature can be found in the attached paper).

2 Problem Description



(a) (b)

Figure 1: (a)The Bisight Head, (b) Step Response Experiment

Figure 1 (a) shows a stereo head capable of pan, tilt and vergence motion (it has 4 degrees of freedom), but for the purpose of this project we will concentrate on pan (i.e. horizontal) motion. Figure 1 (b) shows the result of a step response experiment for the combined head/image processing system. The input here is a step of magnitude 110 counts (encoder units for the head motor) applied at $T = 0$, and the output is in pixels. The actual data, corresponding to a sampling time $T_s = 33.4ms$ is given in Table 1. Note that the system has a time delay due to the image acquisition and processing time.

Time (msecs)	Position (pixels)
0	0
33.4	0
66.7	0
100.1	5
133.5	16
166.9	8
200.2	5
233.6	12
267.0	10
300.4	7
333.7	8
367.1	11
400.5	10
433.8	8
467.2	9
500.6	10
534.0	9
567.3	9
600.7	9
634.1	9
667.5	9
700.8	9
734.2	9
767.6	9
801.0	9

Table 1: Step Response Data

The EECE5610 project consists in designing a pan controller to track (with zero steady state error) an uncooperative target.

3 Tasks:

The process of designing a controller for the head involves the following tasks:

1. Neglecting the time delay, find a model for the combined head/image processing. You can start by approximating the combination as a second order system (i.e 2 poles and 2 zeros). If necessary, you can add more dynamics latter to get a better match to the actual data.

2. Using the model that you found above, design a controller that achieves the following performance specifications:

   (a) Zero steady state error to a step displacement in the position of the object to be tracked.

(b) The closed loop response to a step displacement of 9 pixels of the object should satisfy the following specifications:
   i. The input to the head should not exceed 200 counts (due to physical limitations)
   ii. No more than 10% overshoot
   iii. The closed–loop should be insensitive to high–frequency noise.
   iv. Minimum possible settling time subject to the limitations above

(c) Set up a simulink simulation diagram a verify that your controller indeed satisfies the performance specifications (for the **non delayed** system)

(d) Model now your system as a pure time delay cascaded with the model found above, and investigate the performance of your controller. If necessary, modify your controller so that the performance specs are met. Comment on the effect of the time delay

(e) (optional) Assume that the step response data is corrupted by $\pm 1 pixel$ noise. How would you change the design to take this into account?

4 Report (due December 12, 2025, 11:59 PM)

The project report (no more than 10 pages) should be written like a technical paper, summarizing your results. It should contain the following information:

- A title page, with an abstract describing the project and the results obtained.
- A short introduction motivating the problem and describing the control objectives.
- A section describing the plant, indicating any assumptions made. This section should also contain an analysis of the open loop dynamics.
- A section where the controller is synthesized. This section should clearly justify your choice of controller and any judgement calls you made (i.e. values of gains, locations of poles, etc..).
- An analysis section where the performance of the controller is analyzed, in terms of the performance objectives stated above. You should also explicitly analyze the effects of the time delay.
- A Conclusions section summarizing your results and suggesting ways of improving your design.

5 Grading:

Grading of the project will take into consideration the following points:

- How well your solution meets the performance specifications.
- Complexity of the proposed controller.
- Clarity, completeness and conciseness of the reports.