ASEN 2803 Dynamics & Controls Lab

Spring 2025

Lab 3: Rotary Arm Control

Assigned Monday, March 17, 2025

Due Tuesday, April 29, 2025, at 11:59pm

OBJECTIVES

1. Design a controller for a second order system
2. Observe and characterize the step response of a closed loop control system for a rotary positioner
3. Observe the controller performance for a rigid and flexible arm structure
4. Apply knowledge of second order systems, vibrations, and control to a real system

BACKGROUND

Control is a key component on many large- and small-scale systems. For example, to successfully fly an inherently unstable fighter aircraft, complex control systems for coordination of thrust and control surface adjustments are required. In addition, the very motion of an actuator or control surface, such as an aileron, requires a smaller and simpler controller to ensure that the desired actuator position is achieved given varying aerodynamic loads. A similar situation occurs on a spacecraft where solar panels are positioned to maximize the incident radiation. Clearly, the performance requirements for the two examples are quite different, both in terms of the required accuracy and response time of the system.

In this lab, we will consider a simple control task that plays an important role in many dynamic systems relevant to aerospace, as well as other engineering disciplines. The objective is to control the position an arm mounted on a rotary shaft. We will consider two types of loads - a rigid arm mounted to the shaft and a more complex flexible arm mounted to the shaft. Figure 1 illustrates the two types of control arms used in this lab:

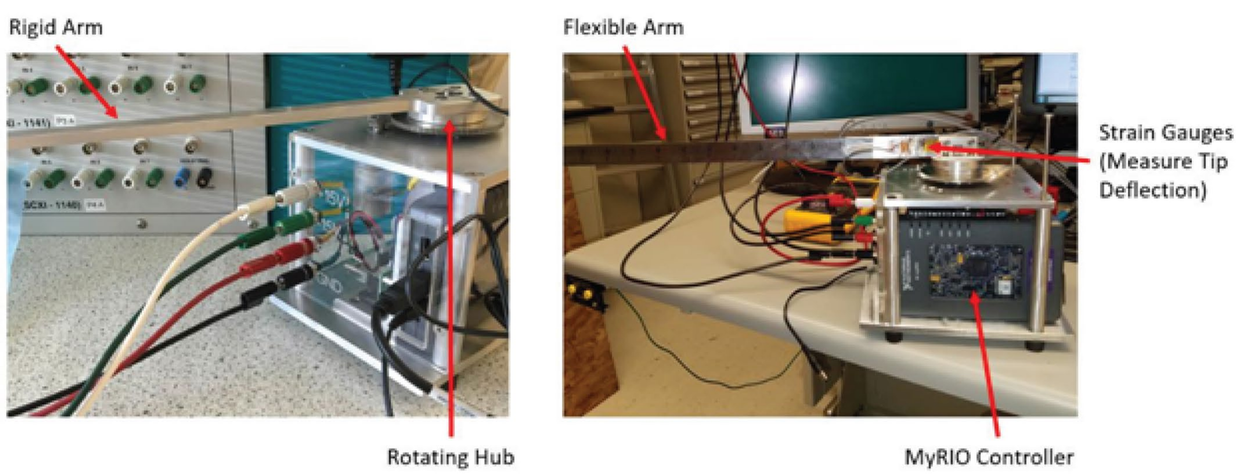

Figure 1. Rigid Arm (Left) and Flexible Arm (Right)

In order to effectively position the arm, we need to formulate a dynamic model of both the mechanical and electrical aspects of the system. A control strategy then needs to be developed to achieve a desired response - ie. we want the arm to move to the desired position quickly, accurately, and without a lot of overshoot or vibration. These control requirements will be defined mathematically in the following sections. The appendices provide a detailed description of the experimental apparatus shown in Figure 1 as well as the derivation for the dynamic model of the rigid and flexible arm system.

A major task is to observe the nominal controller response and see how changes in the control gains affect the performance. You will simulate the rigid arm to predict the response of the systems to specific control gains. The primary objective of this lab assignment is to compare simulated responses to the hardware responses and intelligently modify control gains to achieve specific performance requirements. Very often in control applications, the gains predicted using a theoretical approximation will need to be modified based on the response of the real system in order to meet design requirements imposed on the response of the system.

MODELING, SIMULATION, EXPERIMENT, AND RESULTS & ANALYSIS

The tasks that your team will need to complete for the modeling, simulation, experiment, and results & analysis steps are detailed in the Lab Worksheet. Refer to the Lab Worksheet for next steps.

SUBMISSION

- Download the Lab Worksheet from Canvas.
- Follow the instruction on the Lab Worksheet
- Complete the required steps and answer all required questions.
- Submit your completed Lab Worksheet via Gradescope.
- ***Remember to assign pages to your submission in Gradescope***.

GRADING

1. **Group Submission**

   20 Theory and Simulation
   50 Experiment
   30 Results and Analysis

   100 points total

2. **Individual Submission**

   10 Self-Assessment and Peer Evaluations

   10 points total