EE302 Feedback Systems

Bonus Project Guidelines
Spring 2019

1. Scope

The purpose of the bonus project is to give the interested students a chance to experiment with easily affordable microcontroller hardware implementations of basic control systems. This document outlines the required hardware and software for such an implementation. Specific steps will be described in project leaflets through the term.

2. Introduction

As part of this project, you will implement possible control approaches for a one axis “helicopter” by using a simple Arduino microcontroller, a motor driver circuit as well as a simple output measurement circuitry. Figure 1 shows a simple diagram of the overall system to be implemented. The aim is to control the angle of the arm in a closed-loop configuration by using the lift generated by the propeller through controlling the motor speed. The control algorithms will be implemented and executed entirely on the microcontroller in real-time. You can check out this YouTube channel containing videos of previously made projects to get a better idea of what you will implement:

https://www.youtube.com/channel/UCoFs1D3a9GFCzUi3fbRHzuw

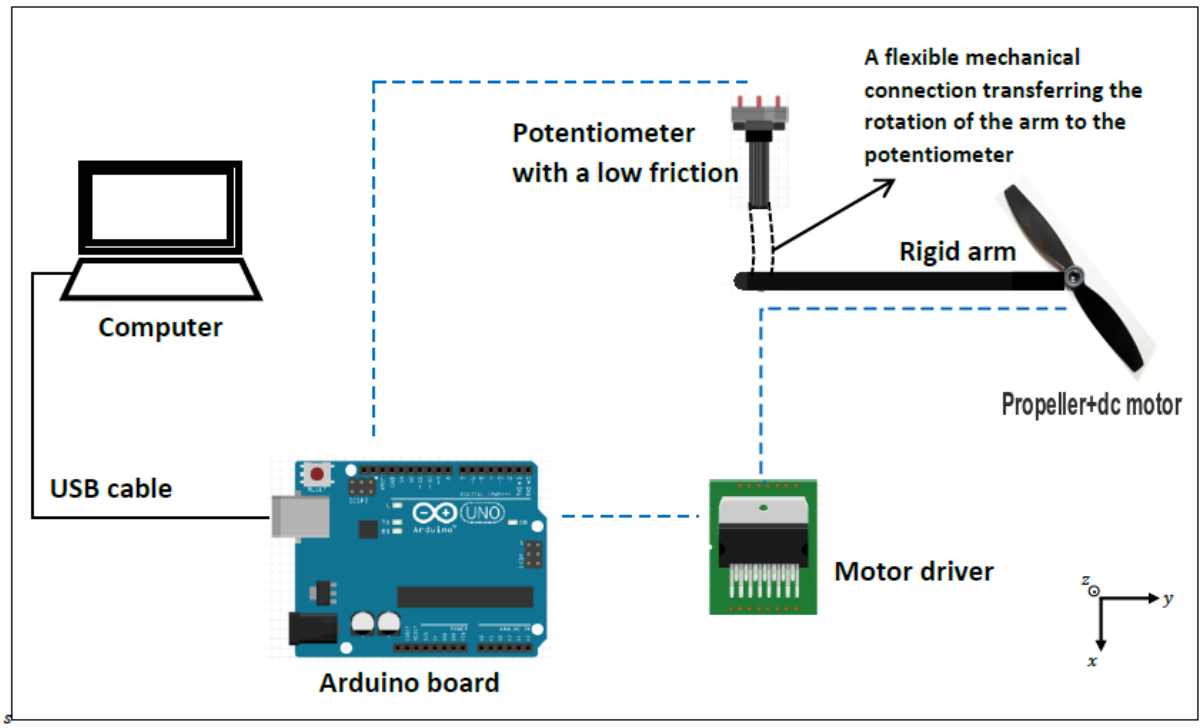

Fig. 1: Diagram of the overall system

We will provide you with some code templates for the controller software on the Arduino as well as interface software on the computer. We hope that the proposed hardware and the software will provide an excellent and affordable way to experiment at home with the theory you learn in class. You will have the chance to observe many of the interesting behaviours that a feedback system may exhibit. The single most important aim of this optional project is for the interested student to experience that with today's computational hardware, control theory is exciting, simple and affordable to implement.

3. Hardware

The project hardware consists of the popular and accessible Arduino microcontroller, a motor driver board, a 5V-3A switching power adapter, a small number of standard electronic components and a "plant" consisting of a swinging arm lifted by a motor-propeller pair. We will provide you with motor, gearbox and propeller.

Fig. 2: Illustration of some hardware components

4. Software

The software involves two components: The firmware component resides in the microcontroller and consists of an implementation of the chosen controller, such as P, PD or PID, in addition to some auxiliary functions to record the relevant variables for later observation. This code will be written by the easy-to-learn C-like language of Arduino.

The second part resides in your PC to communicate with the microcontroller in order to change/set configurable parameters, retrieve recorded signals and plot them. We will provide this code later.

5. Project Timeline and Conduct

Most of the theory required for this hardware implementation (rotational mechanical systems, DC motor models, and analysis of LTI systems and design of PID controllers) will

be covered early in our course. The only missing piece is an overview of the discrete-time concept and the simplest approach for its implementation.

There will be two stages throughout the term. The first one will be associated with an intermediate report, which is to be graded. The second stage will be concluded towards the end of the term with a final report and a video demo showing your team operating your setup and summarizing your results. Projects will be conducted by teams of three students who will share a hardware setup and work together on the two stages of the project. Moreover, you will make a project demo at the end of the semester.

6. Project Evaluation

Evaluation criteria will be based on specific steps that will be detailed as part of the stage leaflets.

7. Quick Start Guide

You should use this guide to start exploring the project topic, hardware and software. For this, you may use the following steps:

1. Use YouTube to explore similar project implementations and find out about similarities and differences (suggested starting keywords: DC motor, Arduino, position control, servo).
2. Examine basic Arduino programming projects, including toggling LEDs, reading potentiometer voltages, generating pulse-width-modulation (PWM) signals.
3. Examine hardware suppliers given in Section 8 below. Consider purchasing your Arduino board, and exploring its GUI and programming environment. You can have a quick start by compiling and running example programs that are directly available in the IDE.

8. Some Hardware Suppliers

- http://www.robotistan.com (Arduino kits, L293D, many other “maker” stuff)
- http://www.robit.com (similar to above)
- Ulus – Konya Sokak (Ankara’s electronics heaven – all electronic components)
- http://gittigidiyor.com (especially 5V, 3A adaptor and motor-housing-propeller set)
- http://n11.com (similar to above)
- http://www.aliexpress.com (almost anything)

9. Part list

1. Arduino Uno (clone) + USB cable

2. L293D Motor Driver

3. 5 KΩ low friction potentiometer

4. Jumpers (pre-stripped Male/Male + Female/Male)

5. Breadboard (small size)

6. Helicopter-arm set

7. 5V DC Switching Adapter (15 Watts – 3A minimum), and its connector to connect it to a circuit

9. 2.2 µF capacitors

10. 0.5 Ω resistor

11. A sufficiently long and **lightweight** stick (e.g. chopstick)

10. References

1. https://courses.edx.org/courses/course-v1:MITx+6.302.0x+2T2016/course/