EE302 Feedback Systems

Bonus Project Guidelines
Spring 2017

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. In this project we will mostly stick with the hardware and software proposed in an on-line course by MIT:

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

To get a taste of what you will experience, you can watch the course introduction video:

https://youtu.be/6UKOWhIRKEw

The EdX web site has an introductory course on control systems with a much simpler content than EE302. However, a modified version of the proposed hardware and associated software provides 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 behaviors 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, the L293D motor driver IC, 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. 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 executing entirely on the microcontroller in real-time.

Figure 1: Illustration of some hardware components

4. Software

The software involves two components: The “firmware” component resides on the microcontroller and consists of an implementation of the chosen “controller” (such as P, PD or PID) as well as some auxiliary functions to record the relevant variables for later observation. The code will be written by the easy-to-learn C-like language of Arduino. The second part resides on your PC to communicate with the microcontroller to change/set configurable parameters, retrieve recorded signals and plotting them for observation.

5. Project Timeline and Conduct

The entire theory required for this hardware implementation 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. We will distribute the steps throughout the term by means of two stages. The first stage will be associated with an intermediate report (to be graded). The second stage will be concluded towards the end of the term with a “Final Report” where you will be summarizing your results and a “Working Demo” where your team will be demonstrating your setup. 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.

6. Project Evaluation

Evaluation criteria will be based on specific steps that will be detailed as part of the stage “leaflets” to be made available during the term.

7. Quick Start Guide

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

1. Using the link provided above, access the on-line course material for MITx – 6.302.0x. For accessing the content, you will need to create an EdX account. (Link provided above)
2. Examine first the “Hardware Guide” to review the required hardware. This consists of three main parts:

   (a) An Arduino startup kit (see the list of hardware suppliers).

   (b) Project specific components (see the list of hardware suppliers). Note the low-friction potentiometer which is the only non-standard part.

   (c) “Helicopter arm” - A motor-housing-propeller-arm combination. (SYMA X5C X5C-1 Quadcopter spare part – available online)
3. Note: We replace the transistor motor driver circuit by the L293D Driver IC which is a simpler option for our purposes. The back-EMF measurement filter is preserved.
4. Examine first the “Software Guide”. The web site describes a web interface that is provided to log and examine data as well as set controller configurable parameters. You can either strictly follow this guideline or you can develop your own data logging strategy. For example data can be transferred through the serial port to a file and/or Matlab and analyzed there.
5. Build the electronics and electro-mechanical hardware configuration. Start having fun!

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)