EE 407 Process Control - Fall 2017
Project A-La-Carte Menu

Deadline for project choices: 23:55, 01.12.2017.

1 Starters

We have a strong belief that getting one's hands dirty by designing and implementing control systems using real equipment is the only way to acquire a deep understanding of the operation and performance of control systems. With this in mind, we have coined a number of menu items that you can choose from as your term project topics.

The idea is that each project alternative is loosely defined but self contained; can be implemented and tested with a very modest cost (shared by team members) and can possibly serve as valuable know-how in your EE493-EE494 projects that needs feedback control. Each menu item can be chosen by multiple groups.

As part of the term project, you will form teams of 3 students, select one project topic and build the required hardware. Part of the process is trying and selecting sensors and actuators suitable to solve the given problem.

2 Mid-Course

The project output will be in the form of a demonstration and project report. The report will be in the form of an "Experimental Sheet" where you will describe the system (setup), if needed: the mathematics (model of plant, sensors and actuators) and then write down the "experimental procedure" in the form of steps, questions, requests for comments etc. This experimental sheet will also include answers to all these questions, results of experimental steps and comments on the results. Evaluation will be based on the operation of the setup, the quality of the "questions" as well as the results and discussions.

3 Main Course

Here are the alternatives for project topics:

1. **Temperature Control in a Miniaturized Heating Process**
   In this project, the aim is to control the temperature of a specific point on a circuit board. The temperature will be measured via a thermistor, and the FET transistor will be the heating element. Heat generated by the transistor is transferred to the thermistor by radiation, convection, and conduction. The control algorithm is supposed to manipulate voltage fed to the transistor to control the temperature sensed by the thermistor.

2. **Miniaturized Water Level Control with an Electric Water Pump**
   In this project, you are to control the water level in a small tank (such as an typical bucket). This setup can be regarded as a scaled-down version of the system we make use of in the Experiment 3. You are not constrained in terms of the measurement device to measure the water level. However, you need to experiment with at least two different sensors. You can choose any two sensors that fits to your design from a wide range of sensors such as ultrasonic, infrared, pressure sensors and even cameras. You need to use a low-cost mini electrical water pump as the actuator of the system.

3. **Design of a Ball and Beam Setup**
   Ball and beam system has been widely used as an exciting setup to design and validate a variety of control algorithms. Although quite different variations of the system have been constructed, an example system, [1], is illustrated in Fig. 1, the main objective is to control position of a ball that is free to roll on a beam. You are allowed to control tilt angle of the beam with a DC motor (and auxiliary mechanical components if desired). Also, you need a way to sense the ball position by a resistive/ ultrasonic or capacitive sensor.

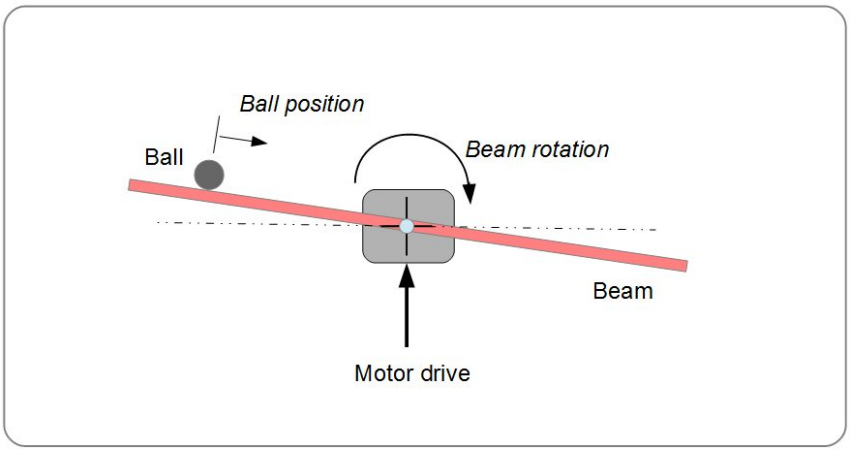

Figure 1: Diagram of a Ball and Beam Setup

4. **Position Control of an Arm Carrying Fixed Weight**
   The objective of this project is to accurately control the position of a primitive robotic arm which is carrying a fixed weight up or down. The arm is to be actuated with a single DC motor (possibly combined with a suitable gearbox). A measurement device is required to sense the angle of the arm or the position of the mass.

5. **Differential Drive Line Follower**
   The aim of this project is to design a controller for a miniature differential drive line following robot. There will be two DC motors & wheels as actuators, two H bridges (or suitable motor driver IC) as your final control elements and an array of IR sensor(s) to

detect the line. The line to be followed should not be a straight one; a piecewise linear and continuous path is acceptable. Controller performance under different conditions (e.g. added mass, changing slope, changing speed) should also be investigated.

6. **Design of a Blood Pressure Monitor Controller (Closed Loop Pressure Control)**
   The idea behind a blood pressure monitoring device is to quickly reach a desired pressure (follow unit step reference input) with preferably little overshoots (pumping up phase) and then decrease this pressure linearly with time (pumping off phase). You are to design a closed loop pressure controller where your system is required to perform well to both of these two types of inputs: unit step and unit ramp. A miniature air pump and a voltage controlled valve are your actuators (for pumping up and off phases, respectively), pressure in a constant volume container is your controlled variable and a pressure sensor of your choice is the measurement device.

7. **Physiological Heart-rate Control Sub-System Modeling/Identification**
   Our body can regulate our heart-rate to respond to changing needs of oxygen as our activity level changes. The scope of this project is limited to modeling/identification of this physiological closed-loop process. You are required to record and obtain an approximate model of how your heart rate (and, equivalently, oxygen demand) changes with changing physical activity. Consider, as an example, running at 10 kph, or 5 kph, under different slopes. You are required to obtain approximate models (e.g. an FOPDT model) through experimentation. A manual record of the activity level performed and a heart-rate sensor is required to collect the data. It might be interesting to build your own heart-rate sensor, e.g., using a web camera and calibrated illumination.

8. **Other reasonable proposals from EE493-EE494 projects**
   We are also open for your proposals that may contribute to a high-quality EE493-EE494 project. If you choose to do your own project, look for systems that have the following characteristics:

   (a) Presence of a dynamic system,

   (b) Affordable sensors that measure the controlled variable,

   (c) Continuous input to the actuator,

   (d) A microcontroller,

   (e) Facilities to record and analyze control system response (system performance)

   The scope of your proposal should be narrow: it should aim at a single subsystem where controller performance can clearly be demonstrated. Note that support provided by the course assistants will be limited in order not to create unfair circumstances among EE493-EE494 groups. Contact us with your proposal to check if it is acceptable.

4 Dessert

Microcontrollers, electronic parts, sensors and actuators are increasingly available at low cost for the engineer as well as the hobbyist like never before. The exciting and fun part will be to see a working system that you have built: A high performance controller built in a digital microcontroller. Another possible achievement will be that the document you have generated may become the basis for a EE407 experiment for the future generations of students! Have fun.

References

[1] "Ball and Beam Example," http://www.control-systems-principles.co.uk/teaching-equipment.html, accessed: 23.11.2017.