Department of Mechanical Engineering

MCE 493/593 (Special Topics): Rapid Control Prototyping and Benchmarking
Spring 2008

Instructor: Hanz Richter, Assistant Professor.
Pre-requisites: MCE380 and MCE441 or equivalent courses, with instructor approval.
Text: Not Required. Pertinent materials will be placed on Electronic Course Reserve.

Objectives
Enable students to design, implement and evaluate the performance of feedback control systems in a laboratory setting. Specific goals are:

1. Obtain a dynamic model of the controlled system using first-principles modeling and system identification techniques.
2. Establish a set of performance specifications which are consistent with the hardware limitations of the controlled system.
3. Select candidate control strategies and perform realistic simulation studies.
4. Understand the limitations introduced by sampled-data implementations and select an appropriate sample rate and anti-aliasing filters.
5. Deploy the control law to commercial prototyping boards (dSPACE, NI) or DSP.
6. Perform tuning and evaluate system performance.

Outline
The course consists of preparatory lectures followed by practical control projects. A final project will be assigned involving a classical benchmarking experiment (inverted pendulum, magnetic levitation, active beam vibration control, etc.). There will be one exam and 6 practical projects, some of which will become final projects. The final grade will be computed from the average of all projects and the exam.

Project Grades
Each individual student is required to maintain a laboratory notebook containing the details of each practical experience. Notebooks will be turned in for grading by the specified deadline. In addition, each group will maintain an account in a server, where all data, programs and reports must be uploaded by the specified deadline. Individual student grades for the projects will be determined from the laboratory notebook and the electronic reports and data organization from each group.

Theory: (not necessarily in sequential order):

1. Review of dynamic system modeling and simulation techniques.
2. Basic Op-Amps and analog filters.
3. Parametric (least-squares) and spectral identification techniques. Use of spectrum analyzer.
7. Sampling and its effects. Sample rate selection. Design by emulation vs. digital control design.


Experiments (* indicates final projects):

1. System identification of simple linear positioner by spectral and parametric methods. Real-Time linear control by PID (Ziegler-Nichols) and observer-based state feedback.

2. Real-Time linear control of DC motor speed by PID and observer-based state feedback.

3. Physical modeling of magnetic levitation system. Linearized real-time control and various nonlinear control techniques.

4. Time-optimal attitude control of satellite prototype.

5. (*) Adaptive and sliding mode control of linear positioner with variable payload.

6. (*) Linearized and nonlinear control of inverted pendulum.