ECE 595 Discrete-Time Control Systems

Description

ECE 595 Discrete-Time Control Systems (3 cr.) Class 3. P: ECE 382. An introduction to discrete-time control systems analysis and design in both frequency domain and state space, this course will review the z-transform and transfer function representation, then introduce the student to the discrete-time counterparts of the major observability, controllability, and feedback results. Additional topics will include sampling theory and its effect on digital control design, and implementation issues such as quantization and finite word-length effects. Controller designs will be tested in simulation using Matlab/Simulink.

Prerequisites: ECE 382 or equivalent. (Familiarity with basic modeling of systems and analysis of system behavior in continuous time, as well as understanding of basic objectives and methods for continuous time controller design.)

Course Information

- Website: \http://www.engr.iupui.edu/~skoskie/ECE483/ECE595s7_f05.html
- Lecture: TR 4–5:15 pm in SL 055
- Instructor Sarah Koskie, skoskie@iupui.edu
- Office Hours: TR 2:30-4pm and by appointment, in SL-164F
- Objectives: Students will learn to use the discrete-time counterparts of the mathematical control design and analysis tools for continuous-time systems taught in ECE 382. In addition, issues specific to discrete-time control such as effects of word-length, quantization, and processing speed will be addressed. A selection of methods for converting continuous-time models and controllers to discrete implementations and the implications of the various choices will also be discussed.

Course requirements / Exams / Grading

- Homework assignments, which may involve simple Matlab programming 34%
- One take-home midterm exam 33%
- One take-home final exam 33%
Recommended Alternate Reference(s):


Course Outcomes

Upon successful completion of the course, students should be able to:

- Derive discrete-time mathematical models in both time domain (difference equations, state equations) and z-domain (transfer function using z-transform).
- Apply sampling and reconstruction processes to signals and systems.
- Understand implications and trade-offs among specific choices of transform methods in discretization of continuous filters (controllers).
- Predict and analyze transient and steady-state responses and stability and sensitivity of both open-loop and closed-loop linear, time-invariant, discrete-time control systems.
- Design digital controllers to meet both time domain and frequency domain specifications and requirements.
- Use computer-aided tools such as Matlab/Simulink for digital control system analysis and design.
- Understand and address issues pertaining to real-time implementation of controllers using microprocessors/microcontrollers.
- Read a technical paper related to discrete-time control topics covered in the course and implement the described algorithm(s) in Matlab or Simulink code to verify results and use the proposed technique(s).
Homework Assignments

Homework assignments will be announced in class and posted on the web. Each homework is due in class on the assigned date, which will be announced in class and posted to the course website. Homework may be submitted as pdf files by email before class. Please do not send obscure formats, zipped files, or extremely long files.

- Late homework will NOT be accepted.
- Work submitted should be the student’s own.
- All necessary steps towards obtaining the solution, as well as any MATLAB code, must be included in the writeup for full credit.

There will be approximately ten homework assignments during the course of the semester. Each student’s lowest two scores will be dropped. Students should keep returned homework as results of some problems may be used in later homework assignments.

Students are allowed, even encouraged, to work on the homework in small groups, but each student must hand in an individual set of answers, which must be their own work. Students may discuss the problems but should not work jointly on them. Discussions should be noted, e.g. “John and I compared approaches to this problem because we found our results surprising; but after considering the alternatives decided that we both had the right approach.” or “I kept getting a negative number for an answer and Jane suggested I check whether I forgot to whiten the data, which I had. I fixed this and got the answer indicated.” or “John and Jane and I couldn’t see how to approach this and Jean suggested ... which yielded a successful approach.” Each student must write their own Matlab code where needed.

Students are referred to the code of student conduct at http://life.iupui.edu/dos/code.htm.
Tentative Lecture Outline

1. Introduction: real-time control, theory, design, and implementation (1 classes)
2. Review of the z-transform (2 classes)
3. Sampling and reconstruction of signals: S/H circuit, A/D conversions (1 class)
4. z-plane analysis of discrete-time control systems (2 classes)
5. Digital controllers/filters realization and implementation: simple digital controller implementation using DSPs (2 classes)
6. Analysis and design in frequency domain: time-domain characteristics, performance specs, stability, PID design and implementation issues (4 classes)
7. State-space analysis: state-space representation, Lyapunov stability (4 classes)
8. State space design: pole placement, state estimator design (4 classes)
9. Practical aspects of real-time control implementation: fixed- vs. floating-point, quantization effects, truncation and round-off effects, sampling rate selection, scaling for DSPs (2 classes)
10. Microprocessor implementation using DSPs and other processors (1 class)
11. General process of real time control design and implementation: modeling, algorithm development, software development, device simulators, hardware design (1 class)
12. Linear quadratic optimal control: LQR design (3 classes)
13. Advanced topics: system identification, fuzzy logic, neuro-control (1 class)
14. Midterm exam (1 class)
15. Review (1 class)
16. Final Exam