Course Syllabus

ECE/MAE 7750 - Distributed Control Systems

http://mechatronics.ece.usu.edu/ece7750/

Spring 2010

First offered : Spring 2002
Last offered: Spring 2008, Spring 2005.

Instructor: YangQuan Chen, Center for Self-Organizing and Intelligent Systems
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Class Schedule: TuTh 13:00 PM to 14:15 PM
Class Venue: EL109 (Lectures) and **EL112 Control Lab/Your Office** (Projects).
Office Hours: TuTh 14:15 PM to 15:15 PM o or by appointment. Try to formulate your question in written form first (your question may no longer be a question during your write-up!)

Course website: http://mechatronics.ece.usu.edu/ece7750/

Text: No single official textbook. Handouts will be given during the class.
Major Recommended Reference Texts:
Books:

1. Real-Time PDE-Constrained Optimization. Edited by Lorenz T. Biegler, Omar Ghattas, Matthias Heinkenschloss, David Keyes, and Bart van Bloemen Waanders. *Computational Science and Engineering 3. SIAM Press, ISBN: 978-0898716-21-4*
2. Weijiu Liu, Introduction to Feedback Control of Distributed Parameter Systems, Textbook Manuscript. Nov. 2007. Dept. of Mathematics, University of Central Arkansas
3. R. F. Curtain and H. J. Zwart, *An Introduction to Infinite-Dimensional Linear Systems Theory*, Springer-Verlag, 1995.
4. William S. Levine (Editor), The Control Handbook (Electrical Engineering Handbook Series), CRC Press, March 1996 (1566 pages!)
5. Normey-Rico, J.E., Camacho, E.F., Control of Dead-time Processes, Springer-Verlag, 2007.
6. M. Malek-Zavarei, M. Jamshidi, Time-Delay Systems, Analysis, Optimization and Applications. North-Holland. 1987.
7. Andrei D. Polyanin, Handbook of Linear Partial Differential Equations for Engineers and Scientists, CRC Press. 2002.
8. Aslak Tveito, Ragnar Winther, Introduction To Partial Differential Equations: A Computational Approach, Springer 2005.
9. Matthew N.O. Sadiku.: Numerical Techniques in Electromagnetics, Second Edition. CRC Press, 2000.
10. Desineni Subbaram Naidu, Optimal Control Systems, CRC Press, 2003.

CSOIS Theses:

1. 2005. Pengyu Chen. "*Pattern Formation in Mobile Wireless Sensor Networks*", Master of Science Thesis.
2. 2005. Zhongmin Wang. "*Distributed Control of Distributed Parameter Systems Using Mobile Actuator and Sensor Networks*", Master of Science Thesis.
3. 2005. Jinsong Liang. "*Control of Linear Time-Invariant Disturbed Parameter Systems - From Integer Order To Fractional Order*", Master of Science Thesis.
4. 2007. Zhen Song. "*Optimal Observation Problems Involving Wireless Sensor Networks*" Ph.D. Dissertation.
5. 2007. William K. Bourgeous. "*Engineering Swarms for Mobile Sensor Networks*", Master of Science Thesis.
6. 2008. Shelley Rounds. "Distributed control for robotic swarms using centroidal Voronoi tessellations", Master of Science Thesis.

Control Journals:

- SIAM J. of Optimization and Control
- IEEE Transactions on Automatic Control
- IEEE Transactions on Control Systems Technology
- IEEE Control Systems
- Control Engineering Practice
- Automatica
- Mechatronics
- IEEE/ASME Trans. on Mechatronics
- Int. J. of Sensor Networks.

Conferences:

- IEEE CDC (Conference on Decision and Control) www.ieeecss.org
- AACC ACC (American Control Conference) www.a2c2.org
- IFAC World Congress www.ifac-control.org
- ASME/IEEE MESA http://iel.ucdavis.edu/mesa/ (networked mechatronics)

Online papers/books:

- http://www.ieeexplore.ieee.org (all IEEE/IEE paper)
- USU library – online journals
- For more online research resource, check links from the instructor's personal web: http://www.ece.usu.edu/csois/people/yqchen/students.html
- http://www.engnetbase.com/ (many free handbooks)
- www.arxiv.org
- citeseer

Prerequisites: Undergraduate control systems and graduate linear multivariable systems, or subject to the Instructor's approval. It is advantageous to have one or more subject knowledge backgrounds in Real Functional Analysis, Networking Techniques, Industrial Control, Fluid Mechanics etc.

Course Requirements:

Projects	30 points

Assignments	30 points
Focus Independent Studies and Presentations:	40 points

There is no Mid-term Exam and Final Exam.

Notes:

1. This is a **research-type** course at 7000 level with mixed lectures from the Instructor and presentations by the students of the class.
2. The course will follow the topics outline below.
3. There will be 3 projects and 6 assignments. The due time is plus or minus 0.5 week around the due date designated. Projects can be completed in team. However, for assignments, independent work is required.
4. FISP (focused independent study and presentation) will be assigned to each student with different topics. This FISP includes a survey report on the chosen specific topic or a specific analysis/design technique in distributed control systems. There will be two FISP topics for each student. The first FISP will be a literature review in a topic chosen within the Wireless Sensor Networks framework. The topics for the second one can be chosen from any topic within the Distributed Systems framework and proposed by the students upon instructor's approval.
5. Computer simulations will be necessary for some homework/FISP problems. Matlab/Simulink is the preferred computing environment for these simulations.

Course Description:

This course is meant to prepare the students to better fit in the "*information and nano age*" or "*nano-bio-info age*" where the distributed dynamic systems modeling and control are ubiquitous.

This research type course is a comprehensive exposition of the state-of-the-art in distributed control systems including four major parts:

- (1) Cyber-physical Systems (CPS)/networked control system (NCS),
- (2) wireless sensor networks (WSN),
- (3) distributed parameter systems (DPS), and
- (4) industrial DCS (iDCS) and large scaled system optimization (LSS).

Note that each part listed above could be an independent graduate level course. This course is with an emphasis on the broad coverage. The depth rests at the students' FISP topics, projects and assignments.

In Part (1), we will focus on control systems involving (or via) networks. In addition to introducing various networking components in NCS, we shall focus on the stability analysis, controllability and observability, delay compensation methods, controller design and performance evaluation of NCS with various types of network-induced delays. In Part (2), we will focus on the sensor networks in general and wireless sensor networks and actuator networks in particular, we will also study optimal sensor location and introduce the MAS-Net (Mobile Actuator-Sensor Network) platform from CSOIS. In Part (3), the basic concepts in analysis, numerical methods and control of systems described by partial differential equations (PDE) will be covered including the