Syllabus CSE 990-001: Cyber-Physical Systems

Updated: August 24, 2015

Instructor: Justin Bradley 261 Avery Hall
Class: TR 14:00 - 15:30 OLDH-209 CITY
Office hours: TR 13:00 - 14:00 or by appointment (preferred)
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Course Overview

This course introduces students to the research, design, and analysis of cyber-physical systems - the tight integration of computing, control, and communication. Applications for CPS research are far reaching and span medical devices, smart buildings, vehicle systems, and mobile computing. The application domain for this course will be cyber-physical (aerospace) vehicle systems though techniques are more broadly applicable. Current literature, techniques, theories, and methodologies will be reviewed and discussed. A semester project will help students creatively apply cutting-edge CPS research to their research problems. Because CPS research is so broad prerequisites are minimal and basics in the specific areas of study will be reviewed. Helpful background includes digital control, real-time systems theory, scheduling, optimization, optimal control, and algorithm development. Students from Computer Science, Computer Engineering, Electrical Engineering, and Mechanical Engineering should be appropriately prepared for this course.

Course Requirements

Prerequisites: an undergraduate degree in Computer Science, Computer/Electrical/Mechanical Engineering or related field.
Text: Officially there is no required textbook. We will use several sources which I will make available to you (mostly papers). Here is a list of decent textbooks for you to consider in your research:

- Lee, Edward Ashford, and Sanjit Arunkumar Seshia. *Introduction to embedded systems: A cyber-physical systems approach.* Lee & Seshia, 2011.
- Alur, Rajeev. *Principles of Cyber-Physical Systems.* MIT Press, 2015.
- Wolf, Marilyn. *High-Performance Embedded Computing: Applications in Cyber-Physical Systems and Mobile Computing.* Elsevier, 2014.
- Control theory books (I have several that include)
  - Hespanha, Joao P. *Linear systems theory.* Princeton university press, 2009.
  - Åström, Karl J., and Björn Wittenmark. *Computer-controlled systems: theory and design.* Courier Corporation, 2013.
  - Franklin, Gene F., J. David Powell, and Michael L. Workman. *Digital control of dynamic systems.* Vol. 3. Menlo Park: Addison-wesley, 1998.
- Krishna, C. Mani. *Real-Time Systems.* John Wiley & Sons, Inc., 1999.

Grading

This course will require active, in-class participation as part of group discussions as well as leading paper presentations (one per student). There will also be a end-of-semester project in lieu of a final exam wherein you will need to apply CPS concepts to a project you and I deem appropriate (hopefully your current research). The goal will be to write a final report that can easily be turned into a high-quality paper for you to submit. The grade breakdown will be:

- in-class participation (e.g. actively discussing topics, asking questions, etc.) - 10%
- homework - 30%
- final project - 60%
  - project proposal - 10%
  - presentation - 10%
  - final report - 40%
    - appropriate citations
    - IEEE, AIAA, or other major society formatting

Grades will then be assigned using the following table:

A+: [98-10]	A: [93-98)	A-: [90-93)
B+: [88-90)	B: [83-88)	B-: [80-83)
C+: [78-80)	C: [73-78)	C-: [70-73)
D+: [68-70)	D: [63-68)	D-: [60-63)
F: [0-60)		

Policies

1. Attendance is not mandatory but you are responsible for anything that transpires during class...plus you want your in-class participation points!
2. Exchange of ideas and techniques is **highly** encouraged but **your work must be your own**. Also, because we are preparing you to be serious researchers you need to cite and acknowledge sources and contributions where appropriate (not necessary for homework).

   (a) All homework assignments, quizzes, exams, etc. must be your own work. No direct collaboration with fellow students, past or current, is allowed unless otherwise stated. The Computer Science & Engineering department has an Academic Integrity Policy (`http://cse.unl.edu/academic-integrity-policy`. All students enrolled in any computer science course are bound by this policy. You are expected to read, understand, and follow this policy. Violations will be dealt with on a case by case basis and may result in a failing assignment or a failing grade for the course itself.

3. All homework assignments must be typed unless otherwise specified. If you are not proficient with either LaTeX, Word, or some other word processor now is your chance to learn as this will be a necessary component of your professional career.
4. Students have one week from time of grade posting to challenge a grade.
5. The CSE Department has an anonymous contact form that you may use to voice your concerns about any problems in the course or department if you do not wish to be identified. (`http://cse.unl.edu/contact-form`)

6. Feel free to swing by my office, contact me by email, or even call or text if you're inclined. I'd be happy to talk to you most anytime, but would appreciate setting up an appt. if you need a specific question addressed.

   (a) Consider the Student Resource Center in Avery 12 if I am not available, or you otherwise need help: (`http://cse.unl.edu/src`)

7. Course announcements will be posted on blackboard and some may be distributed by email. Check your email regularly!

   (a) CSE Department policy dictates that students in CSE courses are expected to regularly check their email so they do not miss important announcements.

8. Students with disabilities are encouraged to contact the instructor for a confidential discussion of their individual needs for academic accommodation. It is the policy of the University of Nebraska-Lincoln to provide flexible and individualized accommodations to students with documented disabilities that may affect their ability to fully participate in course activities or to meet course requirements. To receive accommodation services, students must be registered with the Services for Students with Disabilities (SSD) office, 132 Canfield Administration, 472-3787 voice or TTY.

Schedule

This schedule is tentative and may change:

Week	Monday	Tuesday	Wednesday	Thursday	Friday
1		Introduction, syllabus, review, HW1 assigned		Intro to Control (vernacular), HW 2 assigned	
2		Control (models, loops, GNC), HW1 due		no class	
3		Control (same as previous week), HW3 assigned		Control (State-space, feedback, estimation), HW2 due	
4		Control (State-space, feedback, estimation)		Control (Digital control)	
5		special Control topics: Networked Control Systems, Optimal Control, Model Predictive Control, etc.		special Control topics: Networked Control Systems, Optimal Control, Model Predictive Control, etc.	
6		Student presentations		Intro to Real-Time Systems	
7		RTS tasks (WCET)		RTS Scheduling (Feedback Scheduling)	
8		Fault Tolerance and Robustness (RTS and Control)		(flexible time)	
9		Fall break		Intro to Automata (graphs, trees)	
10		Finite State Automata		Timed Automata	
11		Hybrid Systems		Student Presentations	
12		Mathematical Optimization (planning and guidance)		AI Search	

13		CPS Control (Event-triggered Control, Receding Horizon Control, Anytime Control)		CPS Metrics	
14		Student Presentations	Thanksgiving break	Thanksgiving break	
15		Special Topics		Project Presentations	
16		Project Presentations		Project Presentations, Last day	