Syllabus CSCE 990-001: Cyber-Physical Systems

Updated: September 1, 2016

Instructor: Justin Bradley 261 Avery Hall
Class: TR 14:00 - 15:15 AVH-118 CITY
Office hours: TR 13:00 - 14:00 or by appointment (preferred)
Email: justin.bradley@unl.edu
Phone: (402) 472-5072

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 - 10%
  - actively discussing topics, asking questions
  - preparation for and participation in student-led discussion
  - ***please*** be on time!! If you're consistently late and haven't made arrangements with me to be late I will dock you participation points relative to how often I observe you coming in late.
- homework - 40%
  - HW1 - 5%
  - HW2 - 20%
  - HW3 - 15%
- project - 50%
  - project proposal - 10%
  - presentation - 10%
  - draft of final report focusing on intro, background, etc. - 15%
  - final report - 15%

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

Class 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).
3. All homework assignments must be typed unless otherwise specified. If you are not proficient with either LaTeX, Microsoft Word, or some other word processor or typesetting language now is your chance to learn as this will be a necessary component of your professional career.[1] If writing is difficult for you, or you are not proficient with English the UNL Writing Center (`http://www.unl.edu/writing/home`) may be able to help you. If I can't understand what you write I will dock you points. This is the subjective nature of writing and communicating.

[1] Personally, I use LaTeX, so if that's your platform and you need technical help I can offer it. If you use Microsoft Word I will be of no use to you.

4. Late work policy: no late work will be accepted. All deadlines are hard-deadlines. All assignments must be turned in prior to class on the day indicated, unless otherwise noted.

5. Students have one week from time of grade posting to challenge a grade.

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

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

CSE Policies

1. 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`)

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

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

4. 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.

UNL Policies

1. UNL's Academic Senate makes available a Syllabus Policy (`http://www.unl.edu/facultysenate/syllabuspolicy.pdf`), which lists elements that must be included in the syllabi of all UNL courses. This is also summarized by ASUN (`http://asun.unl.edu/content/syllabus-policy`).

2. Text on accommodations of students with disabilities:

   > Students with disabilities are encouraged to contact [the instructor or teaching assistant] 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		models, Models, MODELS!, HW 2 assigned	

2		models, Models, MODELS!		Intro to Control (vernacular), HW 1 due, Project assigned	
3		Control (models, loops, GNC)		Control (same as previous week), Project Proposal due	
4		Control (State-space, feedback, estimation)		Control (State-space, feedback, estimation)	
5		Control (Digital control)		special control topics: Networked Control Systems, Optimal Control, Model Predictive Control, etc., HW2 due, HW 3 assigned	
6		Student-led discussion		Intro to Real-Time Systems	
7		RTS tasks (WCET)		RTS Scheduling (Feedback Scheduling), HW3 due	
8		Fault Tolerance and Robustness (RTS and Control)		Student-led discussions	
9		Fall break		no class (Dr. Bradley out of town)	
10		Intro to Automata (graphs, trees)		Finite State Automata, Draft of project paper due	
11		Timed Automata		Hybrid Systems	
12		Mathematical Optimization (planning and guidance)		AI Search (planning)	
13		CPS Control (Event-triggered Control, Receding Horizon Control, Anytime Control)		CPS Metrics	
14		Special Topics/Project Presentations	Thanksgiving break	Thanksgiving break	
15		Project Presentations		Project Presentations	
16		Project Presentations		Project Presentations, Last day	