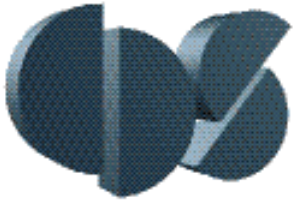
Teaching CDS 101: Principles of Feedback and Control



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Control and Dynamical Systems
California Institute of Technology

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Outline

I. Course overview
II. Teaching mechanisms
III. Future plans
IV. Discussion

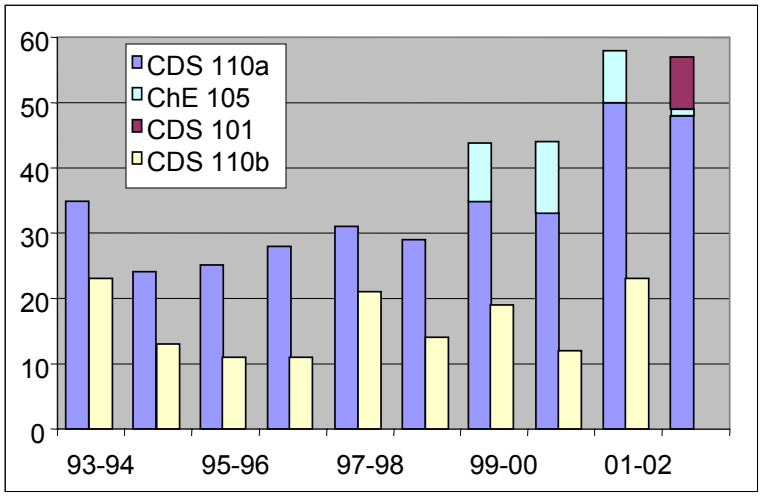
Course overview

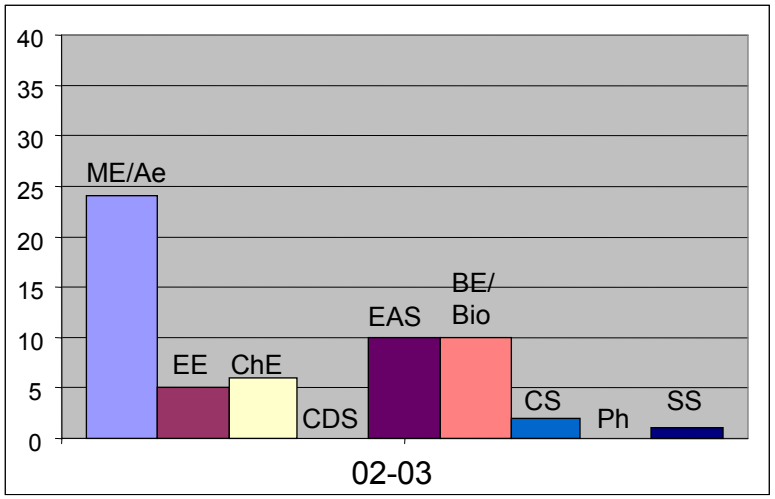
CDS 101 is a new course on "Principles of Feedback and Control"

- Aimed at a broad audience of scientists and engineers
- Focused on teaching principles and computer tools (MATLAB based)
- Format:
  - Monday: powerpoint lecture on concepts, with examples and experiments
  - Friday: optional lectures by Caltech faculty on current applications

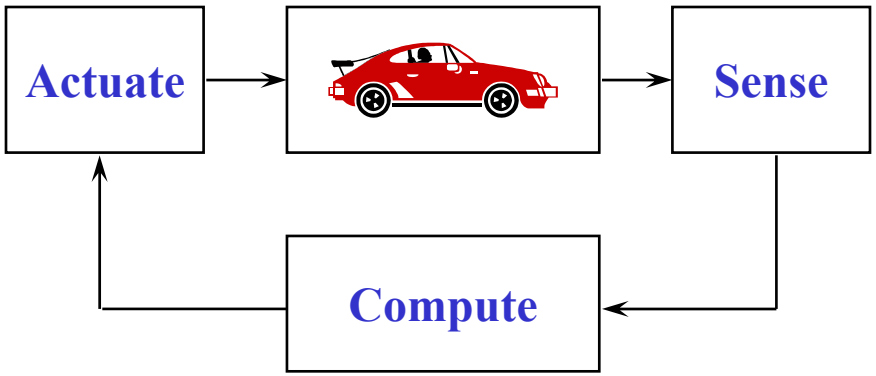
Co-taught with CDS 110, a traditional engineering course on control

- Monday lectures are shared; additional lectures on Wed for CDS 110





Summary: Introduction to Feedback and Control



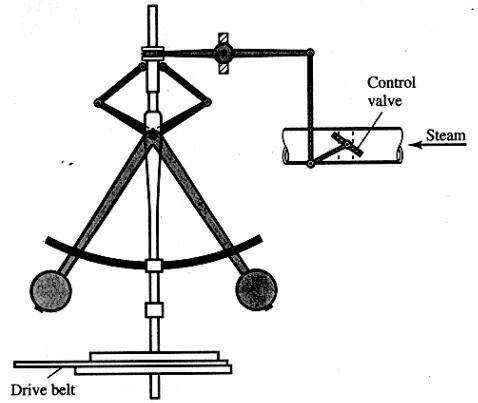
Control =

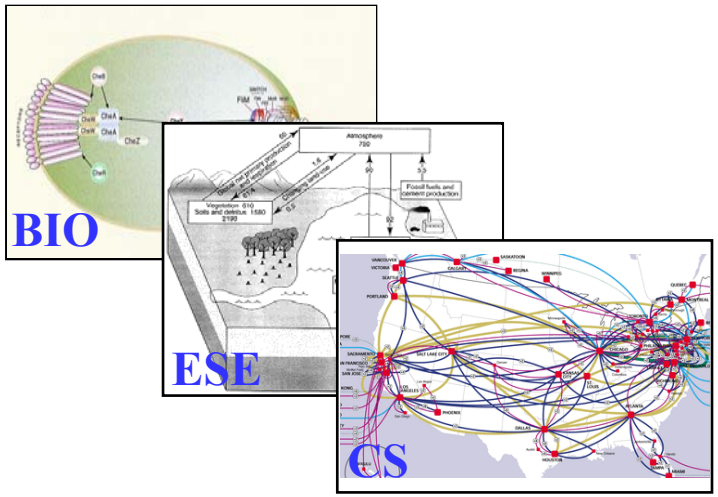
Sensing + Computation + Actuation

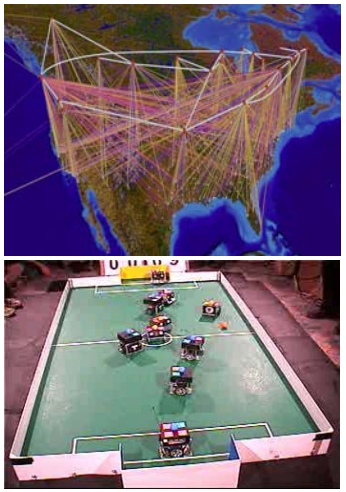
Feedback Principles

- Robustness to Uncertainty
- Design of Dynamics

Many examples of control and feedback in natural and engineered systems:







Fall 2002 Topic Overview

Wk	Date	Topic	Concepts		Friday lecture
1	9/30	Introduction + administration	Feedback, control, mud cards		MATLAB tutorial
2	10/7	System modeling	ODEs, diff eqs, FSM + examples		Insect flt t→n (MD)
3	10/14	Stability and performance	Stability, global vs local, step/freq resp		Aerospace (UTRC?)
4	10/21	Linear systems	Matrix exp, e-values, linearization		Congestion Ctrl (EK)
5	10/28	Controllability + midterm	Controllability, state space feedback		Midterm review (SH)
6	11/4	Freq response, xfer functions	DGM on Wed?		Bio S/A (MD)
7	11/11	Loop stability	Nyquist		Keck/CELT (DGM)
8	11/18	Control design I	Loop shaping		Q fbk control (HM)
9	11/25	Control design II	PID	Astrom	*Thanksgiving*
10	12/2	Robustness + final	DFT framework	Garen	Final review (SH)

Course Text

- CDS 101: CDS Panel report, Astrom
- CDS 110: Astrom, Packard (?)

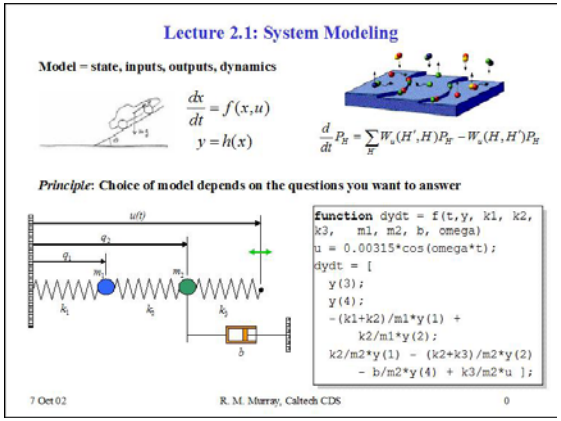
Course Software

- MATLAB/SIMULINK (heavy use)

CDS 101 Lecture Techniques

Powerpoint presentations

- Allows better presentation of main concepts, including pictures, graphics, simulations, videos, etc
- Copies of slides are available at the beginning of each lecture
- Presentations are available on the web, including movies



Videos

- Substantial use of videos in the lectures; mainly tied to Caltech research

Experiments

- Physical systems are used to illustrate the main concepts
- Shows that the theory we are talking about makes a difference in the real world
- Relatively limited use this term; plan to increase for next term (ala Ph 1)

CDS 101 Teaching Features

CDS Precourse

- 2 day tutorial on modeling, ODEs, linear algebra the week before classes start
- Designed to bring students up to speed on underlying math
- Attended by 25 students; mainly in biology/bioengineering

Course web page

- All course information (lectures, reading, homework) available via course homepage

Course Instructional Staff

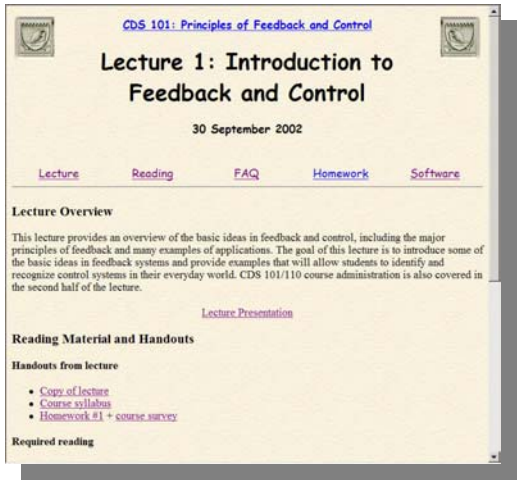
- 4 co-instructors: course planning, optional lectures
- 5 TAs: Homework, office hours, mud cards, grading

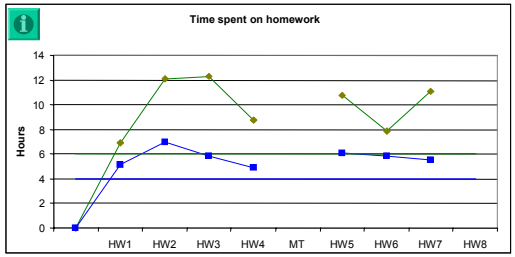
Lecture Videos and Remote Instruction

- All lectures available in VHS and online to students

Student Feedback Mechanisms

- Mud cards (lectures); time spent on HW; e-mail to TAs, prof; course surveys (3)





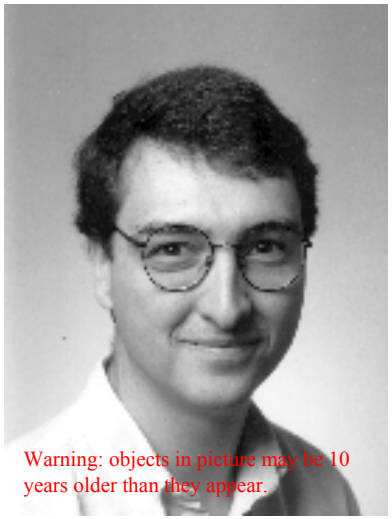
Instructional Staff

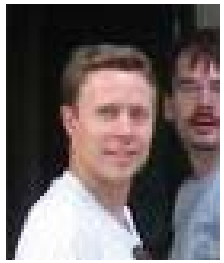
Lecturer: Richard Murray (CDS)

- Overall course management

Co-Instructors

- Michael Dickinson (BE)
- Eric Klavins (CS)
- Hideo Mabuchi (Ph)
- Doug MacMartin (CDS)





Head TA: Sean Humbert (ME)

- Coordinate course infrastructure + TAs

TAs

- Lars Cremean (ME)
- Tim Chung (ME)
- Zhipu Jin (EE)
- Shreesh Mysore (CDS)

Mud Cards

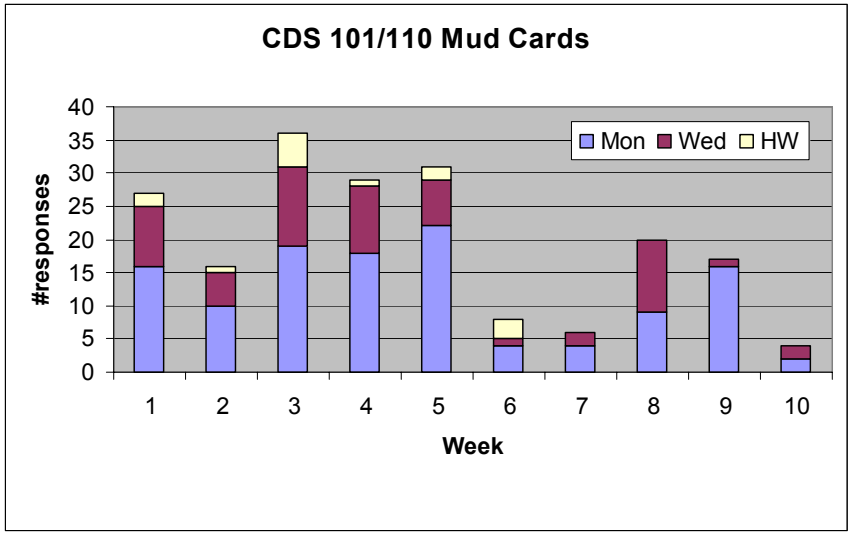
Mud cards

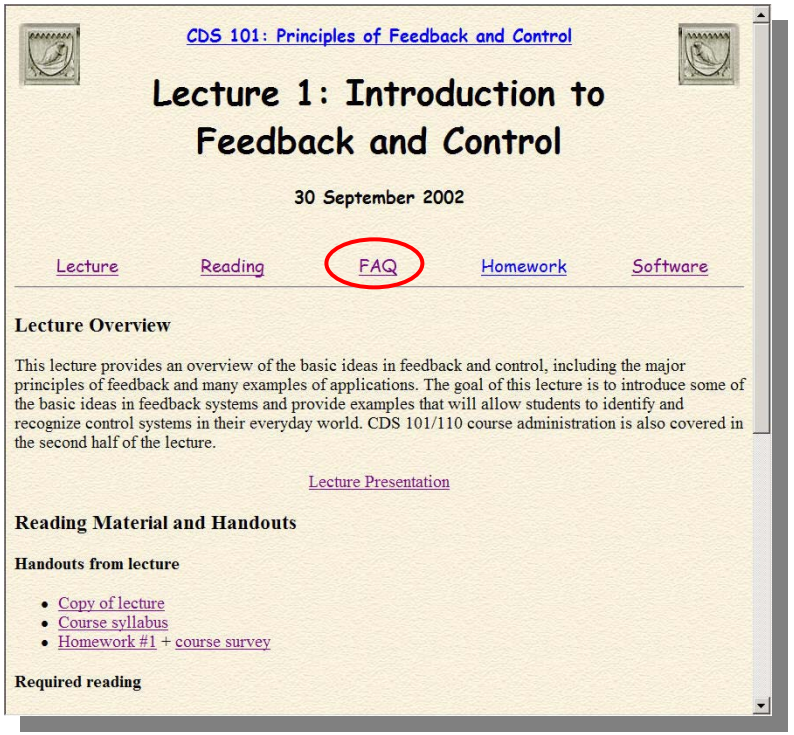
- 3 x 5 cards distributed at each lecture
- Describe "muddiest" part of the lecture
- Turn in cards at end of class
- Responses posted by 8 pm on day of lecture

What does closed loop mean? You used this term without defining it.

Class FAQ list

- Searchable database of responses to mud cards and other questions from class





Student Surveys

Background Survey

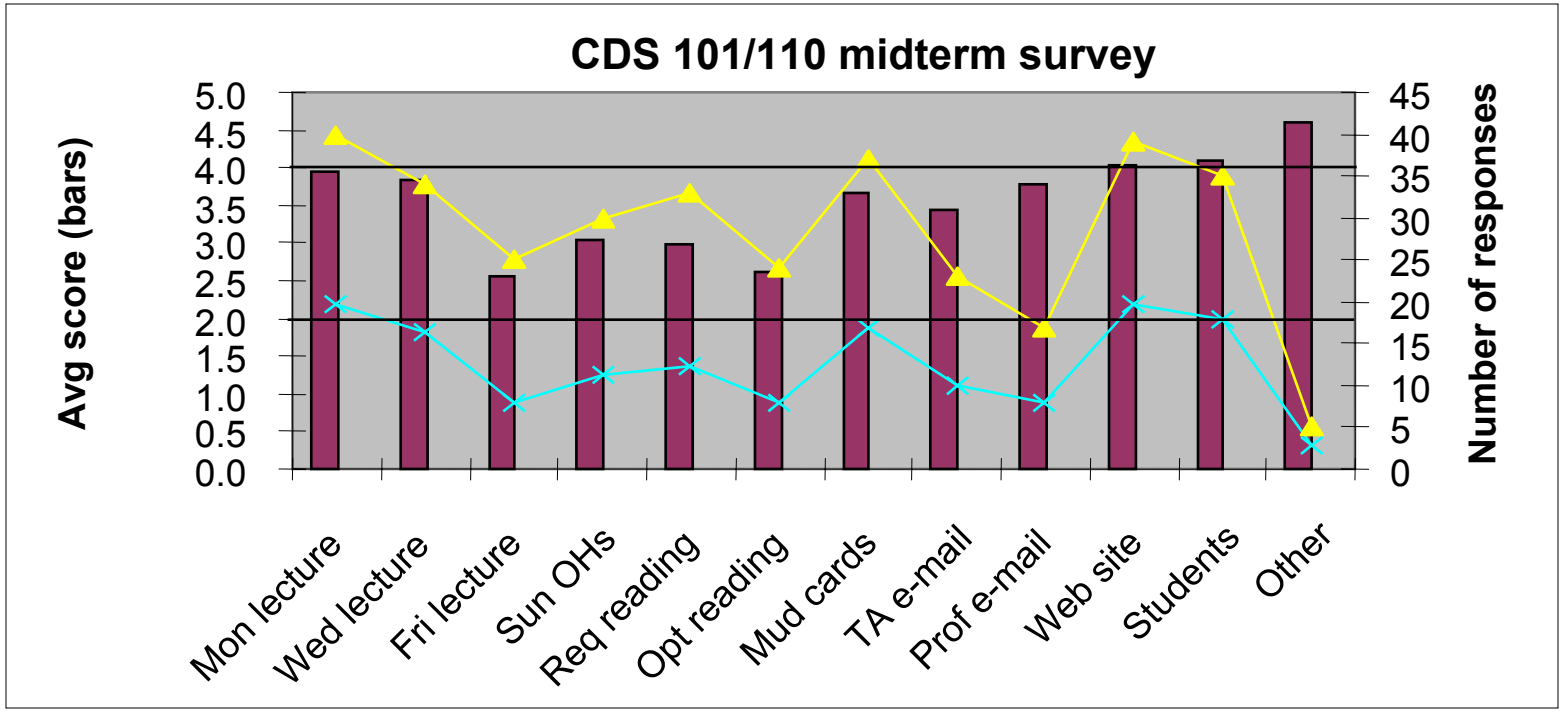
- Identify year, options, courses taken, topics that students are familiar

Midterm Survey

- Evaluate teaching mechanisms + ask for comments on improvements

Final Survey

- Check on familiarity with topics, updated teaching mechamisms, comments



Summary and Next Steps

CDS 101 version 1.0 is shipped

- Very positive experience with first iteration of the class
- Format seemed to work well and was well received
- Major areas for improvement: slow down lectures, increased help with MATLAB

CDS 101 version 1.1 plans

- Add remote instruction component (with UTRC)
- Increased use of classroom experiments
- Continuous improvement on classroom processes

Discussion

- What other ideas should we consider?
- Are there tools for supporting the teaching methods we are using?
- How do we transfer these ideas to other classes?