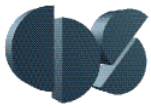
CDS 110: Lecture 1.2
Applications of Control



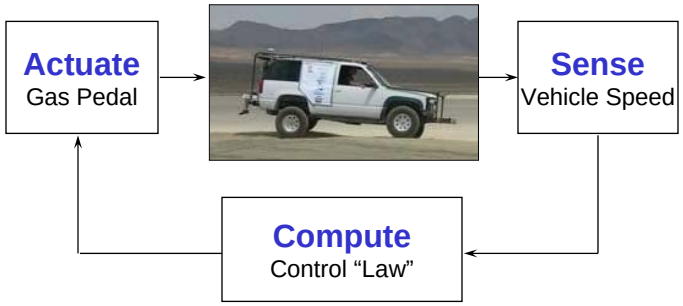
Richard M. Murray
29 September 2004

Goals:
- Describe modern engineering environment for control
- Survey engineering applications of control and key features
- Provide information on CDS 110 sections; explain schedule process
- Honor System discussion

Reading (available on course web page):
- Optional: R. Murray (ed), *Control in an Information Rich World,* 2003.

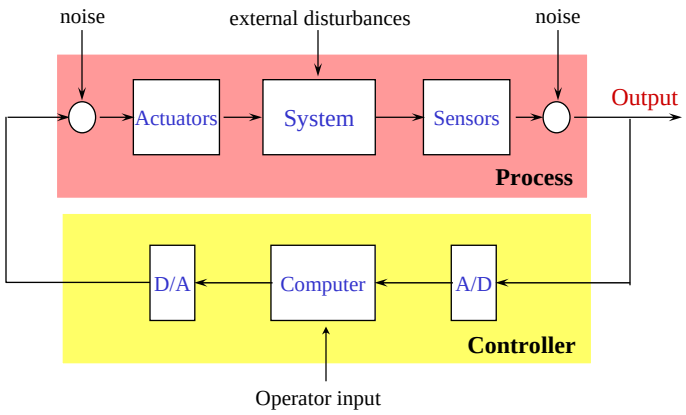
Control = Sensing + Computation + Actuation

In Feedback "Loop"



Goals
- Stability: system maintains desired operating point (hold steady speed)
- Performance: system responds rapidly to changes (accelerate to 6 m/sec)
- Robustness: system tolerates perturbations in dynamics (mass, drag, etc)

Modern Control System Components



Process	Physical system, actuation, sensing
Controller	Microprocessor plus conversion hardware (single chip)
Feedback	Interconnection between plant output, controller input

Active Control Methodologies

Black box methods

- Basic idea: learn by observation or training
- Examples: auto-tuning regulators, adaptive neural nets, fuzzy logic

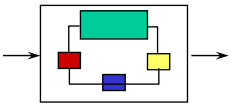
Advantages:

- No need for complex modeling or detailed understanding of physics
- Works well for controllers replacing human experts

Disadvantages:

- No formal tools for investigating robustness and performance
- Don't work well for high performance systems with complicated dynamics

Model-based methods



- Use a detailed model (PDEs, ODEs) for analysis/design
- Examples: optimal regulators, H_∞ control, feedback linearization

Advantages:

- Works well for highly coupled, multivariable systems
- Rigorous tools for investigating robustness and performance (using models)

Disadvantages:

- Tools available only for restricted class of systems (e.g., linear, time-invariant)
- Requires control-oriented physical models; not always easy to obtain

CDS 101/110 Course Sequence

CDS 101 – Introduction to the *principles* and *tools* of control and feedback
- Summarize key concepts, w/ examples of fundamental principles at work
- Introduce MATLAB-based tools for modeling, simulation, and analysis

CDS 110a – Analytical understanding of key concepts in control
- Detailed description of classical control and state space concepts
- Provide knowledge to work with control engineers in a team setting

Fall

CDS 110b – Detailed design tools for control systems
- Estimation and robust control tools for *synthesis* of control laws

Winter

CDS 111 – Implementation of control systems for engineering applications ⇨ CS/EE/ME 75 – Intro to Multi-Disciplinary Eng'g

Spring

CDS Minor: CDS 110, CDS 140, senior thesis/project or Ae/CDS 125

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CDS 110 Recitation Sections

Goals
- Respond to 2003 feedback: more worked out examples
- Provide more discipline-specific examples and discussion

Approach
- Weekly 1 hour meeting led by TA
- Held after Wed lecture ⇒ reinforce concepts from class, answer questions
- Each recitation will provide additional details on lectures + worked examples

Available sections
- Biomolecular and chemical processes
- Information systems
- Mechanical and aerospace systems
- Electrical and electronic systems
- Robotics and autonomous systems

How to sign up
- Fill out scheduling sheet
  - List top 3 section choices
  - List available times for section
- Sections assignments will be announced on Monday
- OK to attend a different section than you are assigned, if you prefer

Scheduling forms due by Friday (10/1) @ 5 pm

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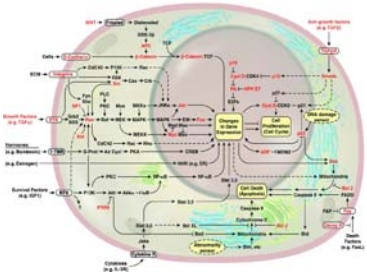
Biomolecular and Chemical Processes

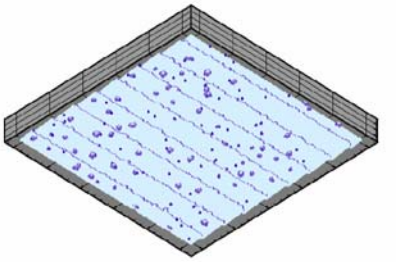
TAs: Domitilla Del Vecchio, Steve Chapman

Instructor: Anand Asthagiri

Application areas
- Chemical process control
- Biological feedback systems

Primary options: BE, Bio, ChE, MS





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Information Systems

TAs: Morr Mehyar, Kevin Tang

Instructor: Steven Low

Application areas
- Communications networks
- Software systems
- Economic systems

Primary options: CS, Ec, EE, SS

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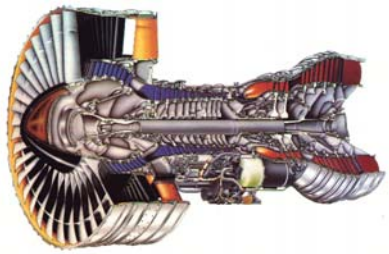
Mechanical and Aerospace Systems

TAs: Hao Jiang

Instructor: Tim Colonius

Application areas
- Servo systems
- Fluid systems
- Flight control

Primary options: Ae, ME



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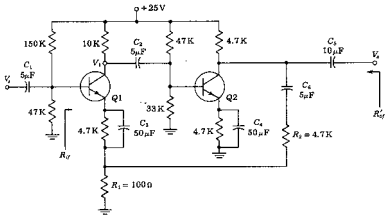
Electrical and Electronic Systems

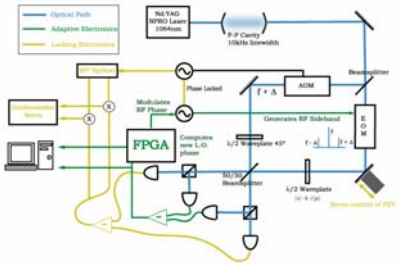
TAs: Asa Hopkins

Instructor: Ali Hajimiri, Hideo Mabuchi

Application areas
- Electronic systems
- Optical systems
- Photonics/quantum systems

Primary options: APh, EE, Ph





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Robotics and Autonomy

TAs: Haomiao Huang, Demetri Spanos

Instructor: Richard Murray

Application areas

- Autonomous robot systems
- Sensor-based navigation
- DARPA grand challenge

Primary options: CS, EE, ME

- Opportunities for hardware implementation on “Bob” or “Homer”

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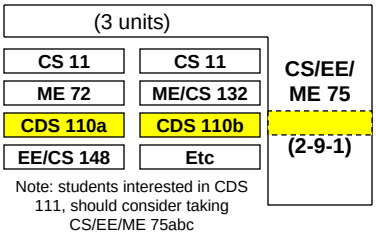
CS/EE/ME 75 – Multi-Disciplinary Systems Engineering

Course Goals

- Provide an introduction to team-based *multi-disciplinary* engineering
- Introduce tools for coordinating work across a large group
- Design, build and document a complex engineering system



Note: students interested in CDS 111, should consider taking CS/EE/ME 75abc

Approach

- Select a major project each year (ideally with some prize money)
- Link work in individual classes to CS/EE/ME 75 project
- First two terms focused on design (through individual classes)
- Bring entire team together third term (and summer) to complete the project

See http://www.cds.caltech.edu/~murray/dgc75 for more info and signup

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Honor System

What is it?

No member of the Caltech community shall take unfair advantage of any other member of the Caltech community

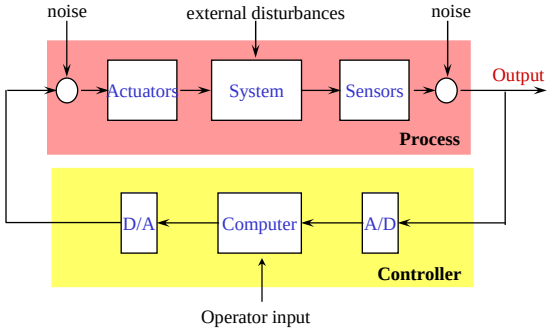
Why is it important?

- Provides a framework for ethical conduct in an academic setting
- Supports a *community* of scholars, working together to learn and educate
- Allows greater academic freedom through mutual trust and respect

How does it apply to this class?

- Homework: full collaboration allowed, but write up your own results
- Tests: take home, open book, limited time, non-proctored
- Violations: student centered – investigated by the BoC or GRB

Summary: Applications of Control



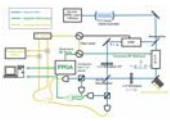
Modern applications of control

- Control = sensing, actuation and computation
- Digital control systems are increasingly common
- Applications across engineering and science


Molecular and chemical processes


Information Systems


Mechanical and Aero Systems


Electrical and Electronic Systems


Robotics and Autonomy