Module 01
Course Syllabus, Prerequisites, Policies, Course Overview

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EE 3413: Analysis and Desgin of Control Systems

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ELECTRICAL & COMPUTER ENGINEERING UTSA ROADRUNNERS

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Course Instructor: Background & Interests

Background

- Born and raised in Beirut, Lebanon
- Finished my Ph.D. in ECE from Purdue University in August 2015
- Undergraduate education: American University of Beirut — Class of 2011, B.E., ECE
- Assistant Professor, ECE Department @ UTSA
- At UTSA since . . . August 10, 2015

My Ultimate Objective

Understand how complex systems operate and utilize this knowledge to create tools & control algorithms that would be leveraged to solve system-level challenges

Essentially, this should improve the quality of our lives...Hopefully!

Module 01 Outline

1. You will introduce yourselves
2. Course syllabus and expectations *(very high ones, believe me!)*
3. Course outline
4. Homework #1 and Assessment Exam
5. The fun stuff starts — we'll introduce control systems and chat about them

Part I — Your Turn to Introduce Yourselves! ☺

Part II — Course Syllabus, Outline Assessment Exam & HW # 1

Course webpage & Communication

Course Pages:

- UTSA Blackboard: http://utsa.blackboard.com
- My Webpage: http://engineering.utsa.edu/~taha
- *Email is the best form of communication!*

Office Hours:

- Tuesdays & Thursdays, 12:30 – 14:00
- Or by appointment

Recitation and TA Info:

- Thursdays, 12:00 – 12:50, AET 0.102
- Teaching assistant — Name: Sebastian Nugroho, Office hours: Thursdays, 10:00 – 12:00, EB 2.04.30

Course Description

- Modeling, analysis, and design of linear automatic control systems
- Time and frequency domain techniques
- Stability analysis, state variable techniques, and other topics
- Control systems analysis and design software will be used
- One hour of problem recitation per week

Main References

- Lecture notes will be provided as handouts or presentation slides
- However, you may need to refer to the following textbook:
  - Richard C. Dorf, and Robert H. Bishop, *Modern Control Systems*, 11th Edition, Addison-Wesley 2008
  - K. Ogata, *Modern Control Engineering*, Prentice Hall, Upper Saddle River, New Jersey, Fifth Edition, 2011 [Not Mandatory]

Prerequisites

- Mild linear algebra
- Multivariable calculus
- Integration and differentiation
- Laplace transforms
- *And most importantly, the will to learn—that I cannot change*

Learning

- Education and teaching are all about learning
- There's a reason why infants learn faster than us—they wanna learn
- There are people who want to learn and change...
- And people who do not want to do so
- I'll try my best, but you'll have to do the hard work
- Forget about the grades, focus on learning
- Let's all be *control freaks* this semester

Grading Policy

- Homework assignments (15%) and drop quizzes (15%)
- Two midterm exams (40%)
- Final exam (25%)
- Instructor's evaluation (5%)

Course Grade Cutoffs [God, I hate this part]

- A−, A, A+: 85–100
- B−, B, B+: 70–84
- C−, C, C+: 55–69
- D: 50–54
- F: $\leq$ 49

Programming Tools

- MATLAB will be required for homework assignments and course projects
- Students can obtain the discounted student version of MATLAB
- Most answers to homework questions can be verified via MATLAB or Simulink

Class Policies

- Regular attendance
- Smartphone break
- Active feedback loop
- Showing up early
- Homeworks, quizzes, exams
- Course projects
- Aim of the project (and reward)
- Late submission policy
- Changes to the syllabus

Tentative Class Schedule

Part I — EE 3413 Introduction . . . .

- Course introduction & syllabus, prerequisites, major policies, course overview

Part II — Mathematical Modeling & Background . . . .

- Mathematical modeling of systems, Laplace transforms, differential equations

Part III —Block Diagrams . . . .

- High-level representations of control systems, feedback loops, transfer functions

Part IV — Closed-Loop System Characteristics . . . .

- 1st and 2nd order systems, time and frequency domain analysis, RH criterion

Part V — Root-Locus . . . .

- Design of systems with root-locus construction and stability analysis

Part VI — Frequency Response Plots . . . .

- Bode plots, gain and phase margins

Part VII — Compensator Design . . . .

- Design and analysis of PID controllers

Part VIII — Modern Control 1: State-Space and Beyond . . . .

- State-space construction, time-domain response, matrix exponential

Part IX — Modern Control 2: MIMO System Properties . . . .

- Controllability, observability, detectability, stabilizability, stability

Homework #1

- It's not really a homework, so chill
- Deadline: THIS SUNDAY!
- Be serious about it
- I'll get to see your handwriting later, so please type your output

Assessment Exam

Part III — Control Systems: Applications, Introduction, And Why You Should Care

What Is Control? What Is Feedback?

- **Control:** use of information to affect the operation of a device, machine, system, a human being...pretty much everything
- *Why do we do control?*
- Because if we can affect the operation of something, we'll have better outcomes
- If we can control emissions, then we have a healthier environment
- The feedback idea

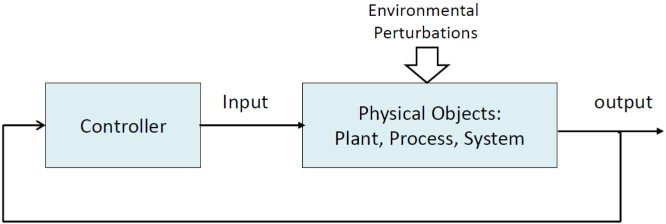
Control Systems (CS) Are EVERYWHERE!

- CSs vary in complexity, size, type, but...
- ...They're everywhere, more like *Adele's Hello*[1]
- In this room, in your tablets and phones
- In traffic lights, robots, the Internet, sports, music
- In your kitchen: fridge, toaster, coffee maker
- Hoverboards and Segways
- Most complex control system: *the human body*

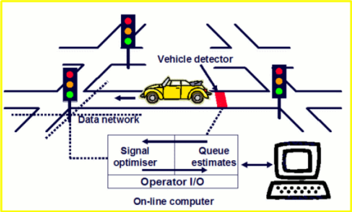
[1] When will they stop playing this song, anyway?

CSs Basic Definitions & Lingo

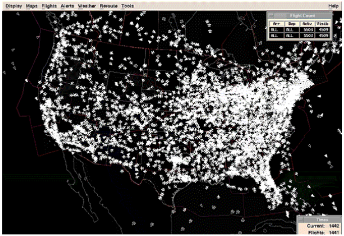
- ***Plants***: the physical object you're tryna control, impact, influence
- In this class we study how to **control plants'** behavior
- ***Control Objective:*** what is it that we want to achieve?
- ***Input***: the signals you're using to control a plant
- ***Output***: your measurements, data, what you're sensing or seeing
- ***Process***: what's happening inside the plant due to your inputs
- ***Model:*** mathematical depiction of the physics of the system
- ***Disturbances***: things that are harming the plant or the processes



Example 1 — Traffic Control



Ground Traffic



Air Traffic

- ***Plant:*** the transportation network—movement of cars, roads connectivity, highways, physics of the network
- ***Processes:*** the movement of cars, switching of traffic lights
- ***Control Objective:*** minimizing traffic
- ***Input:*** change traffic light signals
- ***Output:*** cars' movement
- ***Disturbances:*** accidents, snow, bad drivers, Snapchatters

Other CSs Examples

- Human body: temperature control—thermoregulation (a fascinating control system)
- Thermostat control: Turning heater/cooler on or off to maintain a desired room temperature
- Cruise control: maintaining constant speed given disturbances
- Robot control: changing voltage applied on the motors so that the robot hand moves in a certain way
- Nature control

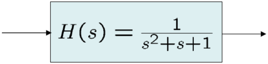
Two Control Strategies

(1) Black Box Strategy:

- **Learn by training**
- No idea what processes are happening inside your system
- Disadvantage: cannot analyze
- Advantage: no need for a physical understanding

(2) Model-Based Strategy:

- **Build a mathematical model through equations**
- Equations relate system inputs to outputs
- Advantages? Disadvantages?

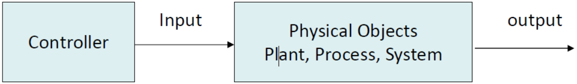


$$H(s) = \frac{1}{s^2+s+1}$$

Two Classes of Model-Based Strategies

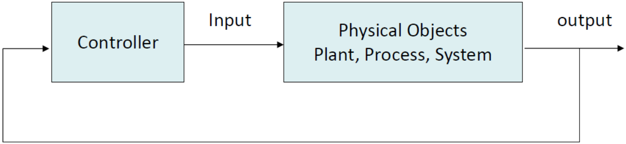
(1) Open-Loop Control Strategy:

- Controller determines the plant input without looking at output
- Advantage: only used if one has accurate **modeling** of the system
- Examples: washing machines, light switches, gas ovens



(2) Closed-Loop, Feedback Control Strategy:

- Controller uses plant output to help determine the plant input
- Advantages: robust to external and internal disturbances
- Examples: air conditioners, refrigerators, automatic rice cookers



Course Content

(1) System Modeling:

- How to construct the math behind the physics?
- From basic laws of physics to differential equations

(2) Control System Analysis

- Given the math depicting the physics, can I analyze the system?
- Can I change my input to have better system performance?

(3) Control System Design:

- Can I design a subsystem, a controller, so that my output follows a certain trend?
- How good is this design? What if the math was inaccurate?

Course Roadmap

Modeling (5-6 Weeks)	*Analysis* (7-8 Weeks)	*Design* (5-6 Weeks)

• Laplace Transforms
• Transfer Functions
• Solution of ODEs
• Modeling of Systems
• Block Diagrams
• Linearization
	• 1^{st} & 2^{nd} Order Systems
	  • Time Response
	  • Transient & Steady State
	• Frequency Response
	• Bode Plots
	• RH Criterion
	• Stability Analysis
		• Root-Locus
		• Modern Control
		• State-Space
		• MIMO System Properties

Questions And Suggestions?

Thank You!

Please visit

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IFF you want to know more ☺