Course Title and Number
System Analysis and Design, EECE660 / MECH653

Instructor
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Catalog Description
A course that outlines state-space models of discrete and continuous, linear and nonlinear systems; controllability; observability; minimality; eigenvector and transforms analysis of linear time invariant multi-input multi-output systems; pole shifting; computer control; design of controllers and observers. 3 credits.

Prerequisite
Control Systems: EECE 460 or MECH 435, or equivalent

Prerequisite by Topic
1. Physics: Dynamics
2. Mathematics: Differential Equations, Linear Algebra
3. Engineering: Control systems specifications, analysis, and design
4. Computer Simulation skills using MATLAB, or similar packages

Textbook
None required, see suggested list of *References* below.

References
1. Linear System Theory and Design, Third Edition, Chi-Tsong Chen. Oxford Press.
2. Linear Systems: A state variable approach with Numerical Implementation, Ray DeCarlo, Prentice Hall.
3. Linear Systems, Panos J. Antsaklis and Anthony N. Michel, Birkhauser Boston

Objectives

1. This course seeks to develop in students the analysis and design techniques for large-scale systems, specifically:
    a. Linear time invariant (LTI) and time variant,
    b. Continuous and discrete ,
    c. Multi-Input Multi-Output (MIMO),
    d. Partially observable,
    e. Partially controllable systems.
2. Train students in analysis of stability, controllability, and observability.
3. Train students in the design of modern controllers using state-space models of fully or partially controllable systems.

4. Train students in the design of observers or state estimators of fully or partially observable systems.

Course Structure
Lecture – 2 days per week at 75 minutes each.

Assessment:
- Midterm 30%
- Final 40%;
- Project 30%
- Homework problems are assigned, but not collected nor graded

Software
MATLAB or similar packages

Resources
Lecture notes, Moodle course webpage, references, library, and internet.

Outcomes
Students will be able to
1. Understand the classification of dynamical systems: linearity, time invariance, causality, continuous and discrete, etc.
2. Model linear systems as non-unique multi-input multi-output state models including canonical forms
3. Analyze control systems that are continuous/discrete, SISO/MIMO, LTI/LTV relative to stability and system response
4. Find analytically system trajectories for both LTI and LTV systems with nonzero initial conditions and nonzero forcing input.
5. Compute linear systems' state transition and fundamental matrices
6. Deploy singular value decomposition (SVD) on linear systems
7. Obtain controllability and observability matrices
8. Divide and characterize the state space of MIMO linear systems through controllable (&un), observable (&un) subspaces
9. Determine controllable modes in MIMO linear systems
10. Determine observable modes in MIMO linear systems
11. Analyze various stability characterizations on MIMO linear systems
12. Design, when possible, pole placement controllers to meet desired specifications for MIMO partially controllable systems using State Feedback
13. Design, when possible, effective observers to estimate observable internal states of MIMO partially observable linear systems

Term
Fall 2015