ECE 675 Spring 2022

- Introduction to Analysis of Non-linear Systems

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- Course Web Site:

https://engineering.purdue.edu/~zak/ECE675_2022/Index.htm

Text

S. H. Żak, Systems and Control, Oxford University Press, New York 2003

Course Objectives

- To familiarize with current trends in nonlinear dynamical systems and control
- Equip with the tools necessary for advanced design problems
- Show how theory fits into practical applications

Prerequisites

- Linear algebra; In particular, matrix manipulation, linear spaces, quadratic forms (MA 511 or equivalent)
- Calculus of several variables, differentiation of real-valued functions of *n* variables, tangent planes, gradients, the chain rule
- Working knowledge of linear systems; In particular, some familiarity with the state space

Computer Facilities

- Access to MATLAB (a math-tools program)

Course Policies

- Two midterm exams each weighted 100 points
- The final exam worth 200 points
- Funwork worth 200 points
- Course grade is based on 600 points

Brief Course Description

- Discussion of the control problem
- Modeling of nonlinear dynamical systems
- Stability analysis using the methods of Lyapunov
- LaSalle's invariance principle
- Variable structure sliding mode control
- Observers for nonlinear systems
- Adaptive control
- Introduction to chaos

The term *dynamical*

The term *dynamical* or *dynamic* refers to (following D.G. Luenberger---1979, page1):

- Phenomena that produce time-changing patterns
- The characteristics of the pattern at one time being interrelated with those at other times
- The term is nearly synonymous with *time-evolution* or *pattern of change*
- It refers to the unfolding of events in a continuing evolutionary process

Formulation of the Control Problem

Four Elements of the Control Problem

- A model of the system to be controlled
- A specified objective for the system
- A set of admissible controllers
- A means of measuring the controller performance to test the effectiveness of any given control strategy

System Definition (Text---page 1)

- A system is a combination of components that act together
- A system is a collection of objects that are related by interactions and produce various outputs in response to different inputs
- A system is any part of the real world surrounded by a well defined boundary

System Properties

- Interrelations between the components contained within the system
- The system boundaries that separate the components within the system from the components outside the system

Subsystem

- The system boundaries are elastic
- May choose to consider only a part of the original system as a system on its own---subsystem

Inputs and Outputs

- Inputs---the external quantities acting on the system
- That is, the system is influenced by its environment via input signals
- Outputs---the system quantities whose behavior can be measured or observed
- That is, the system acts on its environment via its output signals

Control

Specify the system inputs that force the system outputs to behave in a prespecified manner

Regulator and Servo Control Systems

- The goal of the regulator is to maintain the constant output
- The servomechanism control system forces the output to follow a desired trajectory

Mathematical Modeling

A mathematical description of the interrelations between the system quantities themselves as well as the system inputs