Class Hours

MWF 11:30am--12:20 pm, WANG 2579

Course Video Portal

On-campus students will have access to the course MPEG-4 files. To access the sessions log in at

https://engineering.purdue.edu/ProEd/OnCampus

The course credentials are:

Course Login ID Number: 9999936049
Course: ECE68000

Prerequisites

Linear algebra, ordinary differential equations, calculus of several variables. In particular: matrix manipulation, linear spaces, quadratic forms, differentiation of real-valued functions of *n* variables, gradients, the chain rule. Working knowledge of linear systems.

Required Textbook

Stanislaw H. Żak, **Systems and Control**, Oxford University Press, New York, 2003, ISBN 0-19-515011-2

Computer Facilities

The Student Edition of MATLAB (a math-tools program), or its professional version, Version 7 or higher;

Course Objective

To familiarize students with current trends in dynamical system control while at the same time equipping them with the tools necessary for advanced feedback design. The emphasis will be on design in order to show how control theory fits into practical applications.
Another course objective is to promote a deeper understanding of the area of automatic control and enable the student to read papers from the area technical publications such as the *IEEE Control Systems Magazine*, *IEEE Transactions on Control Systems Technology*, and the *IEEE Transactions on Automatic Control*.

Brief Course Description

An introduction to modeling, analysis, and design of dynamical control systems. Stability; Lyapunov's second method and its applications to the control system design. Optimal control methods; linear quadratic regulator, dynamic programming, Pontryagin's minimum principle. Robust feedback control of dynamic systems. Proportional-integral-derivative (PID) control design. Adaptive control. Model predictive control (MPC).

Course Syllabus

Introduction and motivation:

- Dynamical system concept
- Formulation of the control problem
- Modeling---the design model and the simulation model
- Analysis of modeling equations:
  - (a) State-plane analysis
  - (b) Linearization

Modeling---design and simulation models

Modeling using the Lagrange equations of motion

Controllability and observability of linear systems:

- Controllability and reachability
- Controllability tests
- Observability
- Duality
- Observability tests

Controller synthesis:

- Linear state feedback
- Pole assignment and stabilization via linear state-feedback

State observers:

- Combined controller-observer compensators
- Application example
- Application in control of Cyber-Physical Systems (CPSs)

Stability:

- Definitions
- Solving the Lyapunov matrix equation
- Kronecker product
- Robust feedback control design using Lyapunov's method

Optimal control:

- Linear quadratic regulator (LQR) problem
- Algebraic Riccati equation (ARE)
- Design of optimal control systems with prescribed poles
- Dynamic programming

- The Hamilton-Jacobi-Bellman (HJB) equation
- Pontryagin's minimum principle---handout
- The two-point boundary-value (TPBV) problem

Model-based predictive control (MPC)---handout

- Intro to gradient and Newton’s methods
- Nonlinear MPC---paper by Chen and Allgower

Controller design using linear matrix inequalities (LMIs):

- Linear matrix inequalities (LMIs) and their properties
- An Intro to LMIs
- Formulating controller design in the LMI framework
- Relations between LMI and ARE
- Constructing a fuzzy observer-based secure communication system

Fuzzy Logic Control

Proportional-integral-derivative (PID) control design

- Intro to PID control
- Ziegler and Nichols 1942 paper

Advanced Control Design Example

Last updated on December 06, 2017