System Identification

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Course Outline

1. Introduction
2. Linear Time-Invariant Discrete-Time Systems
   • Controllability, Observability, and Stability
   • Balanced LTI Discrete-Time Systems
   • Computing Balanced Realizations
   • Hankel Matrices for LTI Discrete-Time Systems
   • Balancing on a Finite Interval and Realization for System Identification
3. ARX Models
   • State Space to ARX
   • ARX to State Space
4. Least-Squares Problems
   • Orthogonal Subspaces and Projections
   • The Basic Least-Squares Problem
   • QR Factorization
   • Regularization
   • A Result on Over-Parameterization
   • Recursive Least Squares (RLS)
5. Discrete-Time Convolutions
6. Subspace Methods: Problems with Broadband Noise
   • Least-Squares Prediction for Subspace Methods
   • Projection by QR Factorization
Introduction

This course covers methods for identification of dynamical systems from input/output data. The emphasis is on identification of discrete-time (i.e., digital) models of sampled-data systems; however, the relationship to underlying continuous-time physical models is covered. Models identified include transfer functions and state-space models.

Applications of system identification in mechanical and aerospace engineering are emphasized, but the methods are applicable to identification of dynamical systems in many fields. Also discussed are related applications of adaptive filtering and control to problems in active isolation, noise cancelation, and adaptive optics.

Least-squares parameter estimation is covered extensively and applied to estimating model parameters. Both batch least squares and recursive least squares are discussed, including efficient and stable numerical algorithms. The use of recursive least-squares parameter estimation for adaptive filtering is discussed.

The effect of noisy data on estimated system parameters is discussed, along with methods for removing parameter biases due to noise. Subspace methods for system identification are covered.

The primary emphasis is on identification of linear system models, although methods for identification of certain classes of nonlinearities are discussed.

Prerequisites

Consent of instructor. A sound background in the following subjects is essential: linear systems (MAE 270A/EE 240A), linear optimal control (MAE 270B), stochastic processes (MAE 271A).