Model Reduction for Control Systems

Dates and time

22-04-2024
06-05-2024
13-05-2024
27-05-2024
from 13.45-16.00

Course location

Cursus- en vergadercentrum Domstad, Utrecht

ECTS

3 ECTS if the homework is completed successfully

1 ECTS for auditing the entire course

Lecturers

Dr. Xiaodong Cheng, Wageningen University and Research

Dr. Amritam Das, Eindhoven University of Technology

Course Description

In various real-world applications, such as simulations, control systems design, and optimization, models can become unwieldy due to their size and complexity. Model reduction techniques offer a systematic approach to transform these intricate models into simplified versions that are computationally more efficient and easier to analyse, yet still capture the crucial dynamics and relationships of the original system. This course provides a comprehensive introduction to the principles, methods, and applications of model reduction. Students will delve into the theoretical underpinnings of various reduction techniques, including Balanced Truncation, Moment Matching, Graph Clustering, and Proper Orthogonal Decomposition (POD).

Contents

Lecture 1-Introduction to Model Reduction & Balancing Methods:

1. Overview of model reduction methods (SVD-based and moment matching)
2. Controllability and observability Gramians, Energy functions, H2 and H∞ norms
3. Balancing, balanced truncation, Singular perturbation reduction
4. Other types of balancing methods: LQG balancing, Bounded real balancing, Positive real balancing, Stochastic balancing

Lecture 2- Model Reduction for Networked Systems:

1. Introduction to structure-preserving model reduction
2. Graph theory and network systems
3. Balanced truncation for interconnected systems
4. Graph clustering and clustering-based model reduction

Lecture 3- Moment Matching & Krylov Subspace Methods:

1. Krylov subspace methods for time-domain model reduction
2. Model reduction by rational interpolation
3. Model reduction by moment matching
4. Extension towards model reduction of Linear Parameter Varying (LPV) systems

Lecture 4- Model Reduction for Distributed Parameter Systems:

1. Time-delay systems and their model reduction
2. Orthogonal projection methods for model reduction of PDEs
3. Data-driven model reduction using Principle Component Analysis (PCA) and Proper Orthogonal Decom- position (POD)

Course materials

The lecture notes will be distributed during the course.

Prerequisites

A basic knowledge on systems and control, including state-space and transfer function models, controllability/observability, frequency responses.

References

1. Approximation of Large Scale Dynamical Systems, A.C. Antoulas, SIAM 2005.
2. Other reading materials provided by instructors.

Homework assignments

There are two homework sets, which will be distributed via the course platform. Each has 100 scores, and students receive 3 ECTS from this course with a minimal 60 scores on average.