Data-driven control

Dates and time

11-11-2024
18-11-2024
25-11-2024
02-12-2024
From 13.45-16.00 hrs

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. Henk van Waarde, University of Groningen
Prof. Kanat Camlibel, University of Groningen
Dr. Valentina Breschi, TU Eindhoven

Course description

Controllers for dynamical systems are often designed on the basis of a mathematical model of the to-be-controlled system. However, obtaining a model can be a tedious process, for example because the complexity of the system prevents first-principles modelling. In the absence of a reliable model, data-driven approaches are a viable alternative to their model-based counterparts. It is challenging, however, to ensure that data-driven methods come with the same stability and performance guarantees that are traditionally associated with model-based control. This course provides a comprehensive introduction to the principles and methods of data-driven control. Students will delve into various methods, such as data-driven stabilisation, regulation and predictive control, as well as their theoretical underpinnings like persistency of excitation, the fundamental lemma, and matrix versions of Yakubovich' S-lemma. The homework exercises will provide a deepening of the theory developed in class, as well as simulations that aim at applying data-driven control techniques.

Contents

Lecture 1 - Introduction to data-driven control:

1. Overview of data-driven control methods
2. Introduction to discrete-time dynamical systems
3. Willems' et al.'s fundamental lemma
4. Data-driven simulation and control

Lecture 2 - The informativity framework:

1. Data-driven analysis of stability, stabilisability and controllability
2. Data-driven stabilisation
3. Data-driven linear quadratic regulation

4. Noise models and quadratic stabilisation using noisy data

Lecture 3 - Robustness to noise:

1. Recap of noise models
2. Matrix S-lemmas
3. Solution to quadratic stabilisation problem
4. Extensions to performance and input-output data

Lecture 4 - Data-driven predictive control:

1. Data-driven predictive control: the deterministic setting
2. Towards a stochastic setting: handling noise with regularization
3. Properties and guarantees
4. Data-driven predictive control in a stochastic setting

Course materials

Lecture notes will be distributed during the course.

Prerequisites

A basic knowledge on systems and control, including state-space models, controllability and observability, and stabilisation.

Homework assignments

There are three homework sets, which will be distributed via the course platform. The final grade is the average of the three homework sets. Students receive 3 ECTS from this course if they have scored at least a 6.