EE-717 **Learning to control**

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Cursus	Sem.	Type
Electrical Engineering		Opt.

Language of teaching	English
Credits	2
Session	
Exam	Oral presentation
Workload	60h
Hours	**21**
Courses	21
Number of positions	

Frequency

Only this year

Remark

May 3rd - 7th 2021

Summary

This course offers an overview of direct data-driven approaches to control design. In such methods, learning tools are used to compute optimal control laws from data without relying on a model of the system. Pros and cons of direct approaches as compared to model-based design are also discussed.

Content

For many industrial applications, finding a model from physical laws that is both simple and reliable for control design is a tough undertaking. However, when a set of measurements is available, the control law can be computed from data without relying on the knowledge of the underlying physics. Specifically, in model-based data-driven approaches, a model of the system is first derived from data, then a controller is computed based on such a model. In the so-called "direct" data-driven approaches, the controller is instead directly derived from experimental data.

The goal of this course is to give an overview of direct data-driven control design methods. More specifically, well-established linear parametric methods as well as the most recent results on nonlinear, nonparametric and predictive control will be presented and discussed in detail. It will be also shown that, in some situations, direct data-driven solutions theoretically outperform standard model-based design, thus showing the potential of future research. The course will end with a close examination of the open problems in the field.

Outline of the lectures:
Module 1 (4h). **IDENTIFICATION FOR CONTROL (I4C)**
Brief historical overview of system identification and feedback control. Limitations of model-based control when the model is uncertain. Joint design of identification and control. Taxonomy.
Module 2 (5h). **LINEAR PARAMETRIC DATA-DRIVEN METHODS**
Iterative Feedback Tuning, Virtual Reference Feedback Tuning, noniterative Correlation-based Tuning. Pros and cons of direct data-driven control over traditional model-based design. Lab session.
Module 3 (5h). **RECENT ADVANCES IN LINEAR CONTROL**
Nonparametric control design and regularization. Optimal experiment design. The receding horizon approach. Data-driven selection of control specifications.
Module 4 (5h). **NONLINEAR DATA-DRIVEN CONTROL**
Direct data-driven control of linear parameter-varying and piece-wise affine systems. Model-free predictive control for hierarchical schemes. Lab session.
Module 5 (2h). **CONCLUDING REMARKS**
List of successful applications. Challenges and major open problems.

Note

The course will be offered in partnership with the **International Graduate School on Control (IGSC) of the European Embedded Control Institute (EECI)** and, therefore, will be open to external students (see http://www.eeci-igsc.eu/).

Keywords

Learning-based control, data-driven control, system identification.

Learning Prerequisites

Required courses

Fundamentals of control theory, basics of system identification.

Recommended courses

Optimal and model-predictive control.

Learning Outcomes

By the end of the course, the student must be able to:

- Design simple and advanced control systems based on data.

Assessment methods

Oral presentation.