Analysis and Control of differential-algebraic systems

Dates and time
28-03; 04-04; 11-04 (Utrecht+online) ; 25-04 (Utrecht+online)
from 10.15-12.30

Course location
Cursus- en vergadercentrum Domstad, Utrecht

ECTS
3 ECTS if the homework is completed successfully
1 ECTS for auditing the course

Lecturers
Prof. dr. S. Trenn, University of Groningen
Jun. Prof. T. Berger, University of Paderborn, Germany

Objective
The course is devoted to the analysis and control of systems of differential-algebraic equations (DAEs). When modeling dynamic processes which are subject to algebraic constraints one naturally arrives at DAEs. Typical examples are electrical circuits (where the algebraic constraints are the well-known Kirchhoff laws); but they also occur in multibody dynamics, chemistry and whenever for a network of systems the interconnection is modelled by imposing algebraic relations between the variables.

In the last four decades, the theory of differential-algebraic equations has matured into a discipline of its own in applied mathematics, with a vast amount of available literature. The course will give an overview of the most relevant topics of DAE control theory, including the behavioral approach due to Jan C. Willems.

The learning goal of this course is that the students will be able to analyse linear DAEs w.r.t. existence and uniqueness of solutions, response to inconsistent initial values, controllability, stabilizability and observability.

Contents
Lecture 1: Existence and uniqueness of solutions, quasi-forms

Lecture 2: Inconsistent initial values, distributional solutions

Lecture 3: Controllability, feedback forms and feedback stabilization

Lecture 4: Observability and observer design

Course materials

The course is based on the following surveys and journal articles:

- Stephan Trenn. Solution concepts for linear DAEs: a survey. In Achim Ilchmann and Timo Reis, editors, Surveys in Differential-Algebraic Equations I, Differential-Algebraic Equations Forum, pages 137–172. Springer-Verlag, Berlin- Heidelberg, 2013.

- Thomas Berger and Timo Reis. Controllability of linear differential-algebraic systems - a survey. In Achim Ilchmann and Timo Reis, editors, Surveys in Differential-Algebraic Equations I, Differential-Algebraic Equations Forum, pages 1–61. Springer-Verlag, Berlin-Heidelberg, 2013.

- Thomas Berger, Timo Reis, and Stephan Trenn. Observability of linear differential-algebraic systems: A survey. In Achim Ilchmann and Timo Reis, editors, Surveys in Differential-Algebraic Equations IV, Differential-Algebraic Equations Forum, pages 161–219. Springer-Verlag, Berlin-Heidelberg, 2017.

- Thomas Berger and Timo Reis. Observers and dynamic controllers for linear differential-algebraic systems. SIAM Journal on Control and Optimization 55 (6), 3564-3591, 2017

Prerequisites

The course is self contained, but relies on basic linear algebra and calculus knowledge. Furthermore, knowledge about the behaviour framework as taught in the DISC course "Mathematical Models of Systems" is beneficial, however, necessary knowledge will be recapitulated.

Homework assignments

homework assignments will be distributed during the lectures. Each assignment must be handed in within two weeks.