Course title: Optimal Control of ODEs

Lecturer: Prof. Davide M. Raimondo

Aim of the course

The aim of the course is to provide students with a general overview about optimization-based control. The objectives of this course are:

- gaining understanding of how to optimally control systems described by ODEs
- gaining understanding of how to optimally observe such systems
- extend the acquired knowledge to the case of discrete-time systems
- implement programs to solve simple optimization-based control problems

Subject of course

a) General Hamilton-Jacobi-Bellmann theory for the solution of optimal control problems. Nonlinear systems and generic cost functions will be considered. Then, this theory will be specialized to linear continuous-time systems and quadratic cost functions. The Linear Quadratic (LQ) control is derived and its stability and robustness properties are presented.

b) Kalman filter, a well known observer which is optimal under suitable assumptions on the stochastic noises affecting the system. The main results of this topic are proven by exploiting the duality between the Kalman Filter and the LQ control.

c) The results obtained in a) and b) will be combined to state and solve the Linear Quadratic Gaussian (LQG) control problem for systems with stochastic disturbances.

d) The previous results will be extended to discrete-time systems.

e) Model Predictive Control (MPC), a family of control methods which has gained a wide popularity in view of its widespread diffusion in process control. We will first show how MPC can be viewed as a variant of finite horizon LQ control of discrete-time systems. The main characteristics and features of the most popular industrial MPC algorithms are discussed, and the stability properties of MPC are synthetically described.

Exercise sessions throughout the course will help the students to gain confidence with the implementation of optimization and control problems in Matlab.

Creditability: Freier Wahlbereich

Language: English

Prerequisites

Analysis, Ordinary Differential Equations (ODEs), Linear Algebra, Numerics

Tentative schedule: Monday 10:00a.m.-12:00 p.m. lecture, Tuesday 10:00 a.m.-11:00 a.m exercises

Reference book: Magni, Lalo, and Riccardo Scattolini. *Advanced and multivariable control*. Pitagora, 2014