dutch institute of systems and control

Model Predictive Control 1

Dates and time

13-04-2026
20-04-2026
11-05-2026
18-05-2026
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

Dr. M. Lazar, Eindhoven University of Technology, EE
Dr. Chanfreut Palacio, Eindhoven University of Technology, ME

Objective

The course will teach Model Predictive Control (MPC) theory, design methods and implementation in Matlab at the level of PhD or PostDoc researchers. The objective of the course is to provide participants with fundamental and practical knowledge of the MPC field, enabling them to conduct research in the MPC field or to apply MPC controllers to specific application domains.

MPC relies on three main building blocks:

(i) multi-step prediction models,
(ii) cost function and constraints, and
(iii) dynamic (receding horizon) optimization.

At each time instant, an MPC controller predicts the future behavior of the system over a finite time horizon, and computes a sequence of control inputs by solving a constrained optimization problem based on measured data. However, it applies only the first input of this sequence to the system, and the process is repeated again at the next time instant. We will teach all the aspects necessary for mastering the building blocks of MPC mainly for discrete-time linear systems, along with systematic methods for guaranteeing asymptotic stability and recursive feasibility, and ensuring robustness. Additional material for extending the developed techniques to nonlinear discrete-time systems will also be indicated, but not covered in this course. Besides the stabilization problem, we will also provide solutions to tracking MPC problems and robust tube MPC problems with recursive feasibility and robust stability guarantees.

The course will be split into two parts: the first part will focus on centralized MPC of standalone / isolated systems; the second part will focus on distributed MPC of multi-agent/interconnected systems. The second part will be built on the knowledge acquired in the first part of the course and will teach specific methods for dealing with the challenges of distributed MPC. Examples of applications from various domains will be provided.

Contents

Lecture 1: INTRODUCTION & LINEAR MODEL PREDICTIVE CONTROL (MPC).
-Principles of MPC, introduction to MPC books and toolboxes used in the course.
-Building blocks of linear MPC, QP solvers for MPC, sparse and condensed implementation.
- Stability of closed-loop MPC systems
-Recursive feasibility guarantees using invariant terminal sets

Lecture 2: INTEGRAL & SUBSPACE MPC FORMULATIONS WITH APPLICATIONS.
- Integral MPC formulation.
- Subspace MPC formulation for linear systems and adding integral action.
- Implementation of MPC in application examples (mechatronics, power electronics, drones, automotive, etc.).

Lecture 3: MPC FOR TRACKING & INTRODUCTION TO DISTRIBUTED MPC (DMPC)

3.1a. Linear MPC formulations for tracking time-varying output references.
3.1b. Implementation example of MPC for tracking.

3.2a. Motivation for distributed control: from centralized MPC to DMPC.
3.2b. Introduction to Lagrange-based DMPC algorithms: dual ascent and dual decomposition.

Lecture 4: LAGRANGE-BASED DMPC ALGORITHMS & APPLICATIONS OF MPC IN LARGE-SCALE SYSTEMS

4.1a. Dual decomposition (cont.), alternating direction method of multipliers (ADMM), and ALADIN.
4.1b. Brief overview of other DMPC strategies.

4.2. Applications of MPC in complex large-scale systems (e.g., energy systems, transportation networks, multi-vehicle systems, agriculture, etc.).

For further studying data-driven predictive control methods, we recommend the DISC course Data Driven Control.

Course materials

A full set of lecture notes and some tutorial material will be made available on the DISC course platform. Several books specializing in different MPC topics will be recommended.

Prerequisites

Following the MPC course will require some background knowledge in convex optimization, discrete-time state-space systems, Lyapunov functions, linear algebra. Experience with basic Matlab programming and simulating dynamical systems in Matlab is recommended. However, the course will also contain tutorial material about the above-mentioned subjects and will allow less familiar participants to catch up during the course.

Homework assignments

Two homework sets will be distributed via the course website. Homework is graded on a scale from 1 to 10. Homework sets will include both theoretical, open exercises and Matlab programming assignments, i.e., students will have to submit a report and software files in a zip archive. Missing sets receive the grade 1. The final grade for the course is a weighted average of the grades for the homework sets.