CT CPNL (Commande Prédictive Non Linéaire)

French Research Group on Nonlinear Model Predictive Control

GDR Groupement de recherche
MACS Modélisation, analyse et conduite des systèmes dynamiques

Scientific Day

SAGIP
Société d'Automatique, de Génie Industriel & de Productique

Tuesday, February 3, 2026

Location: ECE Paris, 10 Rue Sextius Michel, Paris,
Room EM324 (3rd floor)

Organizers: Ionela Prodan (LCIS, Grenoble INP, Valence)
Sylvain Bertrand (ONERA, Palaiseau)
ct-cpnl.fr

This scientific day continues the annual tradition of bringing together researchers from France and beyond to highlight efficient optimization-based control implementations, Nonlinear Model Predictive Control design and its various applications, as well as estimation methods. Each edition we have various international distinguished researchers in the field.
We warmly encourage Master, PhD students and researchers to participate. For more details you can contact the organizers (ionela.prodan@lcis.grenoble-inp.fr) and (sylvain.bertrand@onera.fr).
The registration is mandatory at the following link. The final program will be available at ct-cpnl.fr, one week before the event.

[10:30-10:40] Organizers speech

[10:45-11:30] **(Not so) invariant sets for MPC**
Ernesto Kofman
CIFASIS, CONICET. Departamento de Control, FCEIA, UNR. Rosario, Argentina.

[11:35-12:20] **High-performance real-time MPC via distributed optimization**
Yuning Jiang
ETH Zurich, Switzerland.

[12:30-13:45] Lunch break

[14:00-14:30] **On using parsimonious continuous-time polynomial identification in NMPC design**
Mazen Alamir
CNRS, Gipsa lab, Grenoble INP, UGA, France.

[14:40-15:10] **Constraint-tightening stochastic MPC with hard input constraints**
Carlo Karam
Gipsa lab, Grenoble INP, UGA, France.

[15:20-15:50] **MPC frameworks for anesthesia dynamics**
Kaouther Moussa
INSA Hauts-de-France, LAMIH, France.

[15:50-16:10] Quick break

[16:10-16:40] **Linear AC Power Flow for Optimal Transmission Switching**
Sergio Dorado-Rojas
GeorgiaTech, USA

[16:50-17:20] **Computationally efficient MIP-MPC for a three-phase electric arc furnace**
Minh Tuan Dinh
LCIS, Grenoble INP, UGA, Valence, France.

[17:30] Closing

Abstracts

[10:45-11:30] **(Not so) invariant sets for MPC**
Abstract: Control Invariant Sets (CIS) play a central role in MPC, ensuring recursive feasibility and stability. Unfortunately, exact CIS are often difficult to compute, and even when characterized, their shape is usually too complex for practical implementation. This talk explores a relaxation of the traditional invariance definition: using a pair of inner and outer sets. This approach allows trajectories to leave the inner set for short intervals, provided they remain within a larger outer set. These pairs are significantly easier to characterize and guarantee the existence of an implicit invariant set "sandwiched" between them (that does not need to be explicitly computed). We will discuss how inner-outer sets can be directly integrated into MPC to ensure recursive feasibility and finite-time convergence. Additionally, we will explore extensions to robust and stochastic MPC, and examine how this framework relates to other approximations, such as k-invariance.

[11:35-12:20] **High-performance real-time MPC via distributed optimization**
Abstract: This talk focuses on applying the Augmented Lagrangian–based Alternating Direction Inexact Newton (ALADIN) method to model predictive control (MPC) problems with long horizons and large-scale interconnected systems. We first introduce the main principles of ALADIN and discuss its convergence properties for both convex and non-convex optimization problems. We then present a real-time variant tailored to MPC, which executes a fixed number of ALADIN iterations per sampling instant. Finally, we show that closed-loop stability can be guaranteed for the proposed real-time MPC controller.

[14:00-14:30] **On using parsimonious continuous-time polynomial identification in NMPC design**
Abstract: This work leverages recent advances in high derivatives reconstruction from noisy-time series and sparse multivariate polynomial identification in order to improve the process of parsimoniously identifying, from a small amount of data, unknown SISO nonlinear dynamics of relative degree up to 4. The methodology is illustrated and then used in the NMPC-based control design for the Electronic Throttle Controlled automotive system.

[14:40-15:10] **Constraint-tightening stochastic MPC with hard input constraints**
Abstract: Performance considerations are central in practical control applications, where uncertainty is perva sive and actuator limitations are unavoidable. In this context, stochastic model predictive control (SMPC) has become a state of the art framework for constrained uncertain systems by exploiting probabilistic descriptions of disturbances and enforcing constraints in a chance constrained sense. Among SMPC formulations, stochastic tube–based methods are particularly attractive, as they decouple nominal trajectory optimization from uncertainty propagation and yield a deterministic, low dimensional MPC problem through offline designed tubes and ancillary feedback laws. However, existing stochastic tube approaches cannot guarantee hard input constraints when disturbances have unbounded support, since the prestabilizing feedback policy is fixed offline, and instead enforce input chance constraints which do not comply with actuator limits present in practice. This work addresses this limitation by explicitly accounting for saturation within the local feedback policy and incorporating its effects into the offline tube construction. The resulting SMPC scheme retains the computational efficiency and structure of stochastic tube MPC while ensuring satisfaction of state chance constraints alongside hard input limits, thereby overcoming a fundamental limitation of existing methods.

[15:20-15:50] **MPC frameworks for anesthesia dynamics**
Abstract: This presentation highlights practical challenges in the control of anesthesia dynamics, namely range tracking and time-varying steady-state problems. Predictive control strategies are well suited to such systems, as they naturally handle constraints and allow the formulation of cost functions that are better aligned with clinical practice. Accordingly, this presentation introduces MPC formulations tailored to these practical challenges and presents promising numerical results. Finally, it discusses perspectives on incorporating parametric uncertainties into the controller design to achieve a more realistic setting.

Abstracts

[16:10-16:40] **Linear AC Power Flow for Optimal Transmission Switching**

Abstract: Optimal transmission switching (OTS) has been considered as a feasible action to achieve a variety of operational objectives, including congestion minimization, cost reduction, and wildfire risk minimization, among others. In an OTS problem, transmission lines are taken in or out of service, increasing the system operator's degrees of freedom. The state of a transmission line can be conveniently modeled as a binary variable. The resulting combinatorial nature of OTS, combined with the nonconvexity of the full AC power flow equations, yields a challenging computational problem: ACOTS. The DC model is used as a simplification of the power flow equations, yielding a tractable mixed-integer linear optimization problem, DCOTS, that can be used not only to obtain suboptimal solutions to ACOTS but also as an intermediate step for approximate solution methods. Our work introduces a linear AC power flow model to an OTS formulation, yielding a linear ACOTS (LACOTS) problem. Despite its widespread use in the power systems community, this linear AC formulation is not commonly adopted as a baseline for OTS problems. Through theoretical analysis and numerical experiments, we demonstrate the power of this model as a linear surrogate for the nonlinear AC power flow equations. Work in progress: analyzing the differences between a DCOTS solution and an LACOTS across several test cases.

[16:50-17:20] **Computationally efficient MIP-MPC for a three-phase electric arc furnace**

Abstract: This work addresses the control challenges of Electric Arc Furnace (EAF) electrical systems, where the complexity of three-phase dynamics and the discrete tap changer operations often hinder the effectiveness of conventional control methods and limit the real-time applicability of optimization-based approaches. To address these issues, we introduce a novel control framework based on Mixed-Integer Model Predictive Control (MI-MPC) specifically tailored for EAF applications. A comprehensive electrical model is developed to capture the intricate interaction effects within the system. A bilevel optimization strategy is employed to tackle the computational demands of the mixed-integer problem, allowing for real-time control of transformer powers and electrode currents. The effectiveness of our approach is validated through Software-in-the-Loop (SIL) simulations, which demonstrate superior performance over classical control method and optimization-based approaches using standard mixed-integer programming solvers.