

17 – 18 November 2022

**Workshop on Polynomial Optimization
and Applications in Control and Energy**

Workshop on Polynomial Optimization and Applications in Control and Energy

CWI, Euler room, Amsterdam

17-18 November 2022

Thursday 17 November

09.30 – 10.30	Didier Henrion (LAAS-CNRS Toulouse, and Czech Technical University, Prague) <i>The moment-SOS hierarchy for polynomial optimization and volume approximation</i>
10.30 – 11.00	Break
11.00 – 12.00	Milan Korda (LAAS-CNRS Toulouse, and Czech Technical University, Prague) <i>The moment sum-of-squares hierarchy in dynamical systems and control: basics and new results for calculus of variations and PDEs</i>
12.00 – 13.30	Lunch
13.30 – 14.30	Matteo Tacchi (EPFL Lausanne) <i>Towards efficient uniform measure approximation</i>
14.30 – 14.45	Break
14.45 – 15.45	Claudio de Persis (RU Groningen) <i>On learning controllers from data for polynomial systems</i>
15.45 – 16.00	Break
16.00 – 17.00	Amir Ali Ahmadi (Princeton University) <i>Learning dynamical systems with side information or safety constraints</i>
17.00 – 18.30	Reception

Friday 18 November

09.30 – 10.30	John Simpson-Porco (University of Toronto) <i>Understanding the power flow solution space: History, practice, theory, and recent progress</i>
10.30 – 11.00	Break
11.00 – 12.00	Sergio Grammatico (TU Delft, Delft Center for Systems and Control) <i>Generalized Nash equilibrium seeking</i>
12.00 – 13.30	Lunch
13.30 – 14.30	Claudia d'Ambrosio (LIX Paris) <i>On separable polynomial optimization and its applications</i>
14.30 – 14.45	Break
14.45 – 15.45	Mathias Staudigl (Maastricht University) <i>Distributed Random-Block Coordinate descent methods with applications to the decentralized computation of locational marginal prizes</i>
15.45 – 17.00	Discussions and closing

Thursday 17 November

- 09.30 – 10.30 [Didier Henrion](#) (LAAS-CNRS Toulouse, and Czech Technical University, Prague)
The moment-SOS hierarchy for polynomial optimization and volume approximation
In this tutorial talk, we first explain the basic principles of the moment-SOS hierarchy for solving polynomial optimization problems. Then, we describe how it can be adapted to the problem of approximating the volume of semialgebraic sets.
- 11.00 – 12.00 [Milan Korda](#) (LAAS-CNRS Toulouse, and Czech Technical University, Prague)
The moment sum-of-squares hierarchy in dynamical systems and control: basics and new results for calculus of variations and PDEs
This talk will give an overview of the applications of the moment sum-of-squares hierarchy in the fields of dynamical systems and control. We will explain how a number of problems such as optimal control, region of attraction or invariant set computation can be cast as linear programming problems in the space of Borel measures and how these linear programs can be approximated using the moment-sum-of-squares hierarchy of semidefinite programming problems with guaranteed convergence. The talk will finish by describing the latest results on the use of this approach for variational problems and partial differential equations, addressing the additional theoretical challenges arising.
- 13.30 – 14.30 [Matteo Tacchi](#) (EPFL Lausanne)
Towards efficient uniform measure approximation
Computing the measure of a set is a very difficult problem in general, that arises for example when addressing chance constraints in energy systems optimization. In particular, chance constraints can be added to the optimal power flow problem, to account for uncertainty in modelling and measurements. In this talk, I will focus on approximating the uniform measure of a set, using polynomial optimization. More precisely, the Lasserre hierarchy framework allows to approximate this measure with solutions to a sequence of convex optimization problems of increasing size. However, in practice the convergence of this scheme is quite slow... until one enhances the problem with a PDE constraint, resulting in a drastic accuracy improvement.
- 14.45 – 15.45 [Claudio de Persis](#) (RU Groningen)
On learning controllers from data for polynomial systems
We consider the problem of stabilizing polynomial systems whose precise dynamics is unknown but for which input-state samples of finite length are available. We formulate stability certificates in the form of data-dependent sum-of-squares programs, whose solution provides a stabilizing controller and a Lyapunov function.
- 16.00 – 17.00 [Amir Ali Ahmadi](#) (Princeton University)
Learning dynamical systems with side information or safety constraints
We present conic optimization-based algorithms for learning a dynamical system from limited trajectory data and subject to 'side information' or 'safety constraints'. Side information represents contextual knowledge about the system and is inferred

from domain-specific expertise or principles of a scientific discipline. In the first half of the talk, we show how sum of squares optimization can exploit side information to learn more accurate models when data is limited. Safety constraints, which arise e.g. in safety-critical control and robotics applications, restrict the set of allowable queries to the unknown dynamical system to those whose future trajectories are guaranteed to remain in a given (safe) set.

In the second half of this talk, we show that linear, second-order cone, and semidefinite programs can succeed in safely learning dynamical systems in certain natural settings. Joint work with Bachir El Khadir (first half), and with Abraar Chaudhry, Vikas Sindhvani, and Stephen Tu (second half).

17.00 – 18.30 Reception

Friday 18 November

9.30 – 10.30 [John Simpson-Porco](#) (University of Toronto)

Understanding the power flow solution space: History, practice, theory, and recent progress

The power flow equations describe the balance and flow of electrical power in a synchronous AC power system, and are either explicitly or implicitly embedded within most essential power system analysis, control, and optimization problems. The solution space of these equations is remarkably rich, and the study of power flow solvability has attracted the attention of not only power engineers, but of control theorists, physicists, and applied mathematicians. Intimately connected to the study of solutions is the practical problem of actually computing them, and in this context the dynamic behaviour of iterative numerical algorithms begins to interact with the physics of power flow. This talk will outline what is known regarding the solution space of the power flow equations, including a history of analysis approaches, solution techniques, and theoretical results from the 1970's to the present, including results by the speaker and his collaborators. Emphasis will be placed on how the marriage between 'soft' power systems domain knowledge and rigorous mathematics has shaped our understanding of power flow, and how it likely will continue to do so.

11.00 – 12.00 [Sergio Grammatico](#) (TU Delft, Delft Center for Systems and Control)

Generalized Nash equilibrium seeking

Generalized Nash equilibrium seeking problems arise in several application domains, e.g. in energy systems and automated driving, where autonomous agents aim at optimizing their individual objective functions subject to operational constraints and limited information. In this talk, we review the available theory and computational methods for generalized Nash equilibrium seeking and discuss recent research directions.

13.30 – 14.30 [Claudia d'Ambrosio](#) (LIX Paris)

On separable polynomial optimization and its applications

In this talk, we focus on separable polynomial optimization problems. Separability is a property that could be exploited in several ways, from devising effective algorithms for global optimization to identifying strong underestimators. Finally, we overview applications concerning the approximation of complex functions through separable polynomial optimization.

14.45 – 15.45 [Mathias Staudigl](#) (Maastricht University)

Distributed Random-Block Coordinate descent methods with applications to the decentralized computation of locational marginal prizes

Energy markets and distribution networks are undergoing a dramatic reformation thanks to the increased deployment of distributed energy resources. In order to ensure that the distributed generation of energy resources leads to socially and economically beneficent outcomes, decentralized coordination mechanisms are called upon, which are robust to misspecified data and communication across transmission lines. In this talk, we present a novel randomized block coordinate descent minimization strategy that has the potential to achieve exactly these requirements. Our numerical scheme is novel construction, lying between the celebrated Chambolle-Pock primal-dual algorithm and Tseng's accelerated proximal splitting method. We study its asymptotic convergence and complexity, and report its performance on an AC-OPF problem on a radial distribution network with second-order cone relaxations.

15.45 – 17.00 Discussions and closing

Event location

Amsterdam Science Park Congress Center, Euler Room. Location next to the entrance of CWI. Address [CWI](#), Sciencestraat Park 125, 1098 XG Amsterdam.

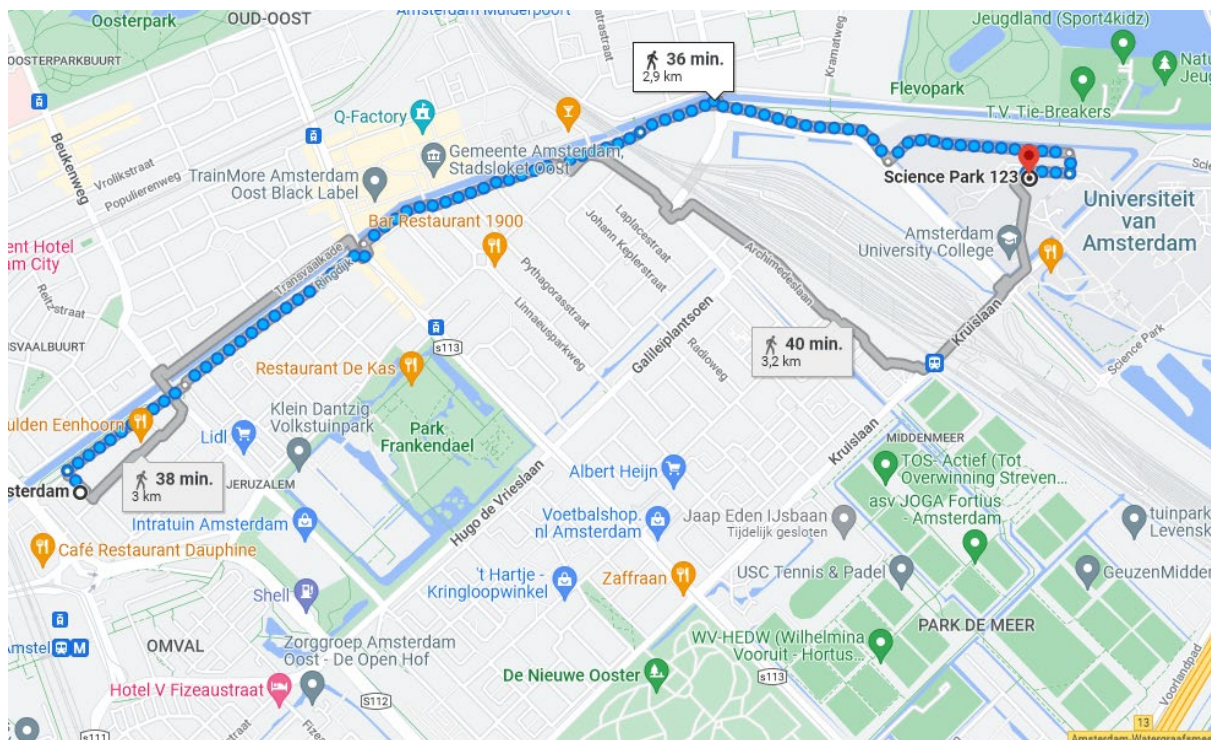
CWI is a 5 minutes' walk from Amsterdam Science Park Station. This station is served four times an hour from the directions Amsterdam Centraal – Schiphol and Almere – Amersfoort.

Walk through the tunnel after leaving the platform for the science park (northeast exit), cross the street (Carolina MacGillavrylaan) at the crosswalk and walk past the brown building of Amsterdam University College. You will be able to see CWI's main entrance on your left behind the parking lot.

Alternatively, bus 40 serves Amsterdam Science Park four times an hour from stations Amsterdam Amstel (train, metro, tram) and Amsterdam Muiderpoort (train, tram). Get off at bus stop 'Science Park' or 'Science Park Aer'. During rush hour bus 240 can be used, too. See also [public transport \(OV\) planner 9292](#).

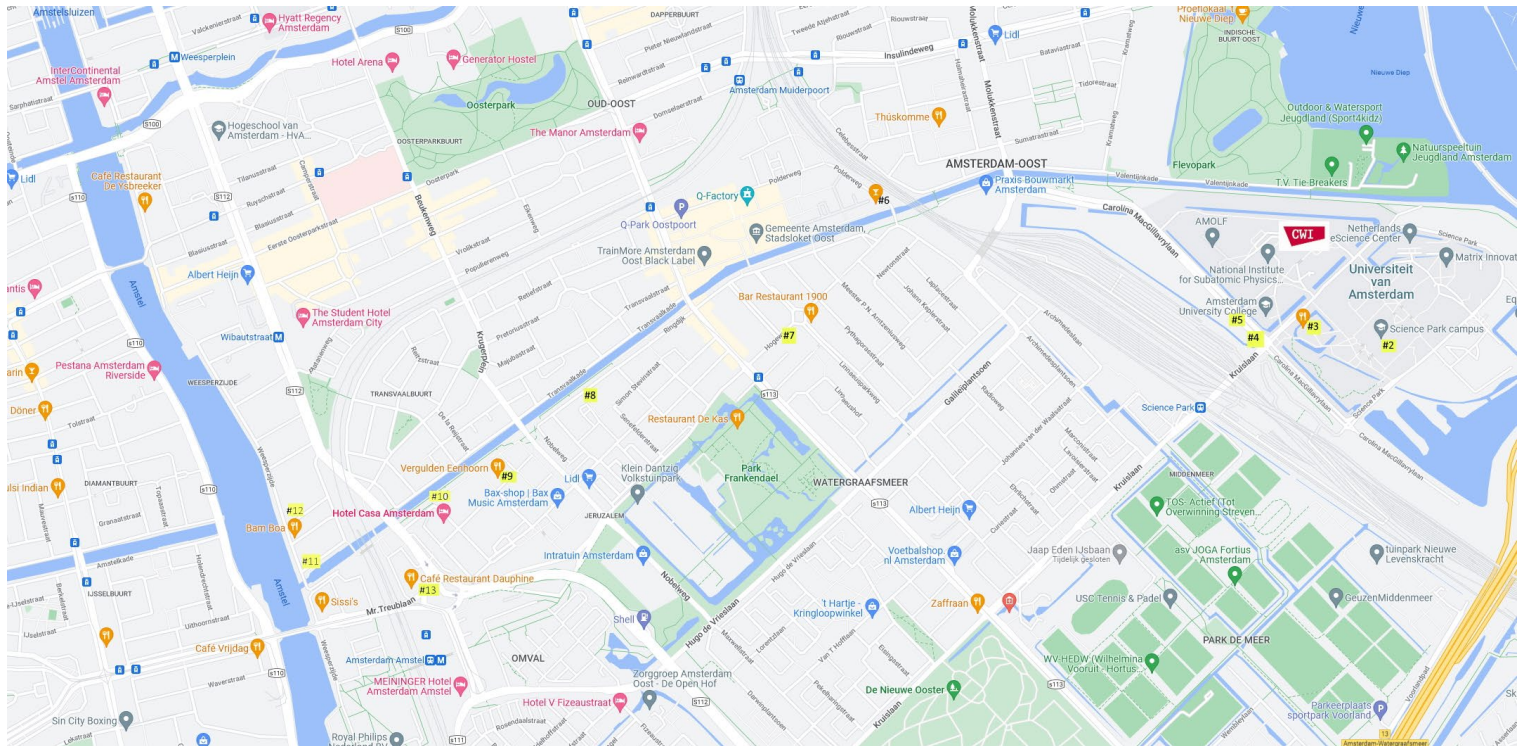
Accommodation

Interested participants may make a hotel reservation at [Hotel Casa](#). Hotel Casa (Eerste Ringdijkstraat 4, Amsterdam) is conveniently located near Amstel train station and from there you can walk, cycle or take the bus to CWI.



Organizers

[Monique Laurent](#) (CWI, Tilburg University) and [Bert Zwart](#) (CWI, TU Eindhoven). If you have any questions please feel free to contact the organizers or the secretary [Susanne van Dam](#), 020 592 4189.



Suggestions where to go out for lunch / dinner in the Eastern part of Amsterdam

Lunch

- #1 CWI restaurant, Science Park 123, 1098 XG
- #2 [UvA restaurant](#), Science Park 904, 1098 XH
- #3 [Restaurant Polder](#), Science Park 201, 1098 XH
- #4 [Maslow Café](#), Carolina MacGillavrylaan 3198, 1098 XK
- #5 [Spar shop](#), Carolina MacGillavrylaan 3192, 1098 XK (*selling snacks and sandwiches*)

Dinner

- #3 [Restaurant Polder](#), Science Park 201, 1098 XH
- #4 [Maslow Café](#), Carolina MacGillavrylaan 3198, 1098 XK
- #6 [Brasserie Poesiat & Kater](#), Polderweg 648, 1093 KP
- #7 [Il Borgo Ristorante Italiano](#), Hogeweg 40H, 1098 CD
- #8 [La Vallade](#), Ringdijk 23, 1097 AB
- #9 [De Vergulden Eenhoorn](#), Ringdijk 58, 1097 AH
- #10 [Restaurant EAST](#) and [Rooftop Bar GAPP](#) at Hotel Casa, Eerste Ringdijkstraat 2, 1097 BC
- #11 [Restaurant Weesper](#), Weesperzijde 144, 1091 ET
- #12 [Café-restaurant Hesp](#), Weesperzijde 130-131, 1091 ER
- #13 [Restaurant Dauphine](#), Prins Bernhardplein 175, 1097 BL