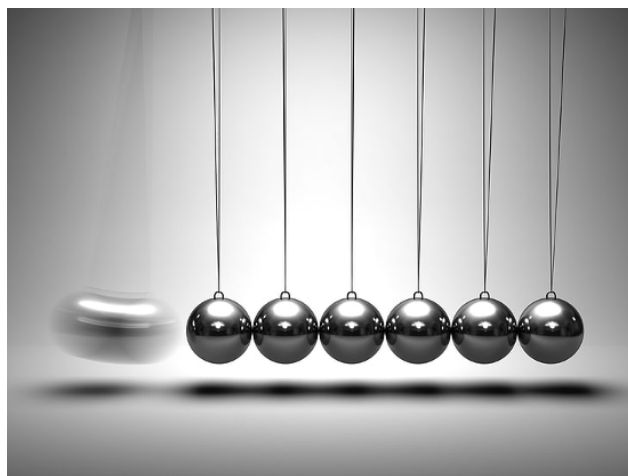


European Network for Nonsmooth Dynamics



**9th Annual Symposium, Toulouse
20th – 22nd September, 2022
LAAS – CNRS, Toulouse, France**

ENNSD Steering Committee:

Vincent Acary, INRIA Grenoble, France

Olivier Bruls, University of Liège, Belgium

Remco Leine, University of Stuttgart, Germany

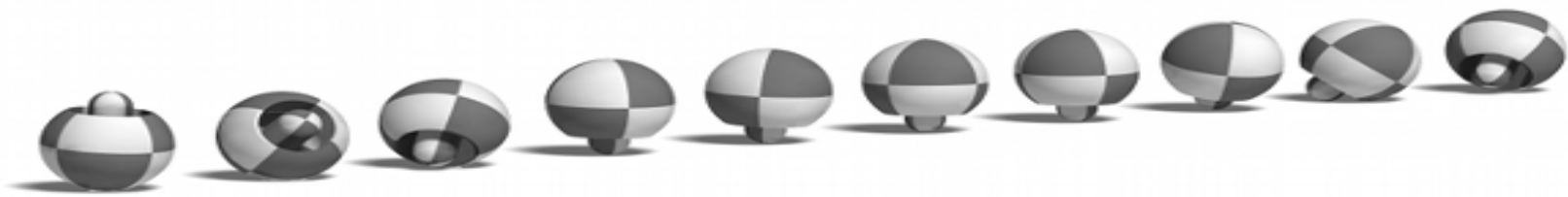
Scientific program and organization:

Aneel Tanwani, CNRS – LAAS, Toulouse, France

Funding Acknowledgements:

ANR CONVAN

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About ENNSD

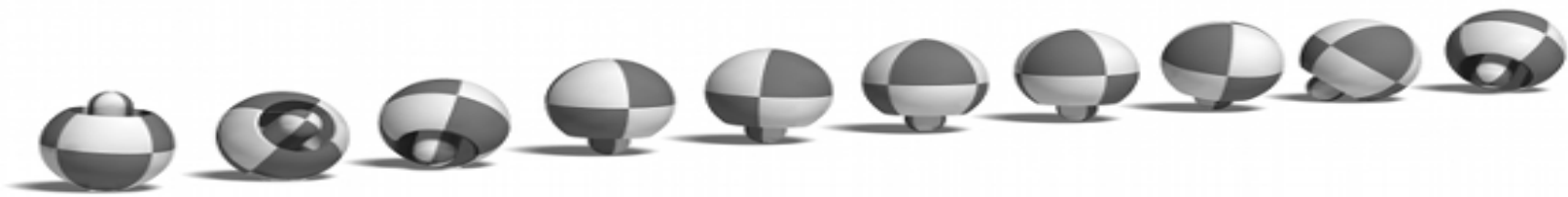
Nonsmooth dynamics is an active area of research which relates to the study of dynamical systems where the state trajectories are not necessarily a smooth (differentiable) function of time. The research in this area is strongly related to nonlinear dynamics (stability theory, bifurcation theory, chaos), nonsmooth optimization and uses mathematical notions from nonsmooth analysis, convex analysis and measure theory. With the passage of time, we see more interaction between nonsmooth dynamics and other areas of research. In particular, these systems have also gathered significant interest in the field of systems and control theory, where the problems related to stability analysis and control design for nonsmooth systems present some examples of active research.

The goals of the European network for nonsmooth dynamics (ENNSD) are to promote research on aforementioned topics, and in particular,

- provide a cooperation platform for researchers specialized in nonsmooth dynamics
- promote the research focussed on nonsmooth dynamics and its applications
- improve networking activities (summer school, workshops or conferences)
- disseminate the knowledge from the academic community to industry

The research carried out by members of ENNSD focuses on modeling of nonsmooth phenomenon in physical systems, such as, mechanical systems with impacts and friction; mathematical analysis from proving existence of solutions to analyzing evolution of system trajectories; building numerical tools for simulations and experiments; and designing control laws to achieve desired performance. The goal of these events is to share the latest developments on related topics.

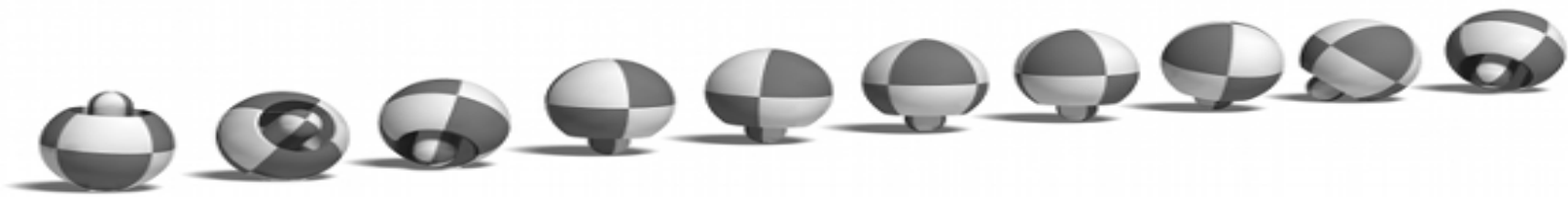
Further information about different events and research related resources can be found at <https://tripop.gitlabpages.inria.fr/ennsd/>



Annual symposium and speakers

Each year, ENNSD organizes an annual symposium in September with scientific presentations on different aspects of research on nonsmooth dynamics. This year, we are hosting the 9th edition of this symposium. The speakers participating this year are:

- Paul Armand (University of Limoges, FR)
- Hedy Attouch (University of Montpellier, FR)
- Olivier Bruls (University of Liège, BE)
- Justin Carpentier (INRIA Paris, FR)
- Giuseppe Capobianco (FAU Erlangen-Nürnberg, DE)
- Moritz Diehl (University of Freiburg, DE)
- Mahyar Fazlyab (Johns Hopkins University, USA)
- Sigurdur Hafstein (University of Iceland, IS)
- Maurice Heemels (TU Eindhoven, NL)
- Didier Henrion (CNRS – LAAS, FR)
- Raphael Jungers (Université Catholique de Louvain, BE)
- Remco Leine (University of Stuttgart, DE)
- Felix Miranda-Villatoro (INRIA Grenoble, FR)
- Armin Nurkanovic (Univ. of Freiburg, DE)
- Michele Palladino (University of L'Aquila, IT)
- Aude Rondepierre (IMT & INSA Toulouse, FR)



Schedule of the symposium

- **Session 1: Opening and Keynote**

Tuesday 20th September, 09h45 – 12h00

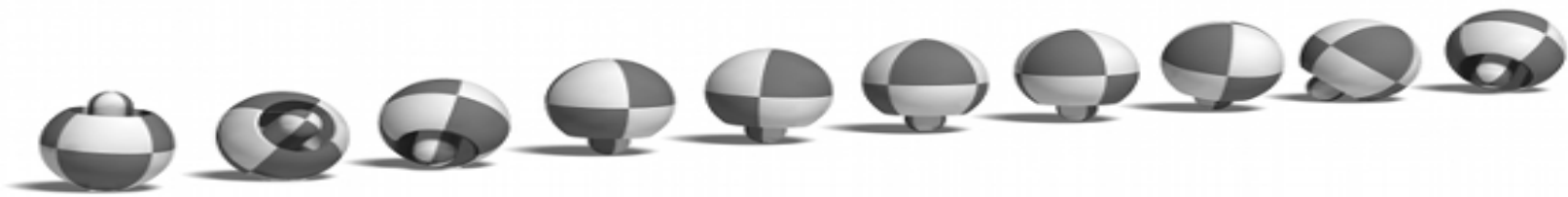
09h45–10h30	Welcome reception
10h40–10h55	<i>Opening remarks about ENNSD</i>
11h00–12h00	<i>Acceleration of first-order optimization algorithms via damped inertial dynamics</i> <i>Hedy Attouch (IMAG Université Montpellier, CNRS, FR)</i>

- **Lunch break** : Grand hall du LAAS

- **Session 2: Optimization and dynamical systems**

Tuesday 20th September, 14h00 – 17h00

14h00–14h50	<i>FISTA is an automatic geometrically optimized algorithm for strongly convex functions</i> <i>Aude Rondepierre (IMT & INSA Toulouse, FR)</i>
14h50–15h40	<i>Provable guarantees for neural network-driven dynamical systems</i> <i>Mahyar Fazlyab (Johns Hopkins University, USA)</i>
15h40–16h10	Refreshments
16h10–17h00	<i>Second order cone programming for frictional contact mechanic using interior point algorithm</i> <i>Paul Armand (University of Limoges, FR)</i>



- **Session 3: Stability analysis and Lyapunov functions**

Wednesday 21st September, 09h00 – 12h30

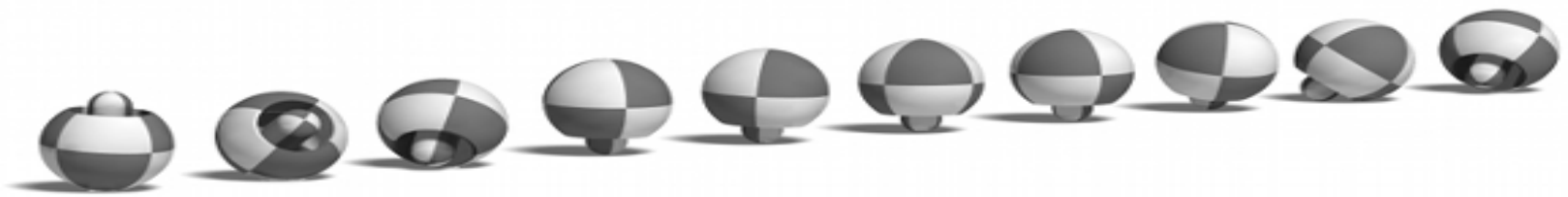
09h00–09h45	<i>Computation of Lyapunov functions for switched systems and differential inclusions</i> <i>Sigurður Hafstein (University of Iceland, IS)</i>
09h45–10h30	<i>Path-complete Lyapunov functions: graph-theory and algebraic geometry for controlling complex systems</i> <i>Raphaël Jungers (Université Catholique de Louvain, BE)</i>
10h30–11h00	Coffee break
11h00–11h45	<i>Polynomial sums of squares for stability analysis of conic complementarity systems</i> <i>Didier Henrion (LAAS–CNRS, University of Toulouse, FR & Czech Tech. University, CZ)</i>
11h45–12h30	<i>Novel projection-based controllers to overcome fundamental performance limitations</i> <i>Maurice Heemels (TU Eindhoven, NL)</i>

- **Lunch break :** Grand hall du LAAS

- **Session 4: Control synthesis: optimality, numerics, and regulation**

Wednesday 21st September, 14h00 – 17h30

14h00–14h45	<i>Finite elements with switch detection (FESD) for numerical optimal control of Fillippov systems</i> <i>Armin Nurkanovic (University of Freiburg, DE)</i>
14h45–15h30	<i>Time-freezing for optimal control of systems with state jumps</i> <i>Moritz Diehl (University of Freiburg, DE)</i>
15h30–16h00	Refreshments
16h00–16h45	<i>Modeling and control of contact interactions in robotics</i> <i>Justin Carpentier (INRIA Paris, FR)</i>
16h45–17h30	<i>A nested set-valued controller for robust output regulation</i> <i>Felix Miranda-Villоторо (INRIA Grenoble-Alpes, FR)</i>

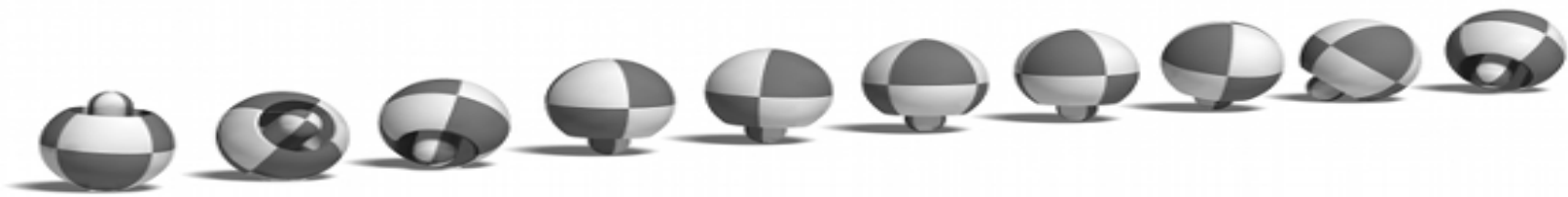


- **Session 5: Modeling, analysis, and solvers**

Thursday 22nd September, 09h00 – 12h00

09h00–09h45	<i>On the spatial nonsmoothness of beam-to-beam contact problems: Analytical and numerical approaches</i> <i>Olivier Brüs (University of Liège, BE)</i>
09h45–10h15	Coffee break
10h15–11h00	<i>Modeling the root growth: an optimal control approach</i> <i>Michèle Palladino (University of L'Aquila, IT)</i>
11h00–11h45	<i>PyNSD: solvers, algorithms and benchmark systems for nonsmooth dynamics</i> <i>Giuseppe Capobianco (University of Erlangen, DE) & Remco Leine (University of Stuttgart, DE)</i>
11h45–12h00	<i>Closing remarks</i>

- **Lunch break :** Hall Georges Giralt



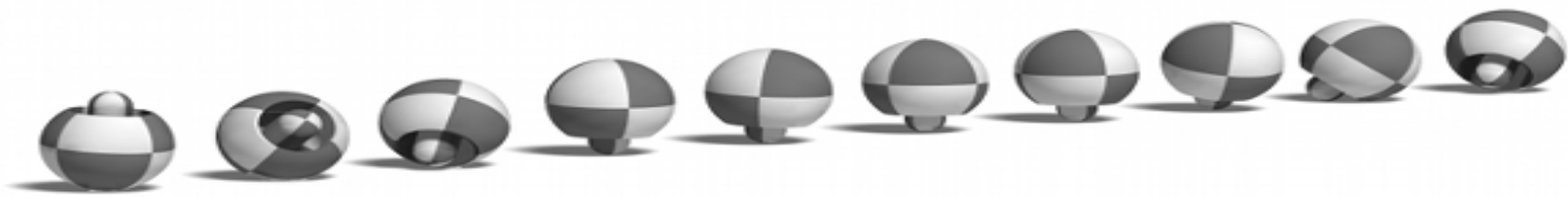
Collection of Abstracts

1. **Title: Acceleration of first-order optimization algorithms via damped inertial dynamics**

Speaker: Hedy Attouch, IMAG Université Montpellier, CNRS, France

Email: hedy.attouch@umontpellier.fr

Abstract: We report recent progress regarding the acceleration of first-order algorithms for convex continuous optimization in a general Hilbert space framework. We rely on the damped inertial dynamics driven by the gradient of the function to be minimized, and on the algorithms obtained by temporal discretization. The fast optimization properties come from the design of the damping term. We focus on first-order methods, which means that the description of the dynamics and algorithms calls only for first-order differential information on the function to be minimized. Nonsmooth optimization is addressed via splitting algorithms taking into account smooth terms by gradient methods, and non-smooth terms by proximal methods. First-order methods play a central role in solving large-scale optimization problems in machine learning, data science, and image processing. They have regained popularity as data sets and problems are ever increasing in size. We review classical results, from Polyak's heavy ball with friction method to Nesterov's accelerated gradient method. We analyze the subtle tuning of the vanishing viscous damping coefficient $\frac{\alpha}{t}$ in the Su-Boyd-Candès dynamic approach of the Nesterov method. Based on Lyapunov analysis, we report recent results for the case $\alpha > 3$ which provide the convergence rate of values $o\left(\frac{1}{t^2}\right)$ and the convergence of the trajectories (resp. iterates). We complete this portrait of first-order accelerated gradient methods by considering the Ravine method of Gelfand and Tsetlin, which shares convergence properties very similar to Nesterov's method, and has often been confused with the latter. Then, we show that the high-resolution ODE of the Nesterov and Ravine methods makes appear the geometric damping driven by the Hessian of the function to be minimized. Indeed, the introduction of geometric damping controlled by the Hessian brings significant progress in the performance of the algorithms. This gives rise to new first-order methods that significantly dampen the oscillations that occur naturally with inertial systems. Besides the above results based on viscous damping, we present some results based on dry friction damping, which, as a remarkable property, provides finite-time stabilization of trajectories/iterations. Finally, we present some first recent results concerning the extension of the above results to the stochastic framework, and the stochastic differential equation approach to solve convex optimization problems with a noisy gradient input.



2. **Title: FISTA is an automatic geometrically optimized algorithm for strongly convex functions**

Speaker: Aude Rondepierre, IMT & INSA Toulouse, France

Email: aude.rondpierre@math.univ-toulouse.fr

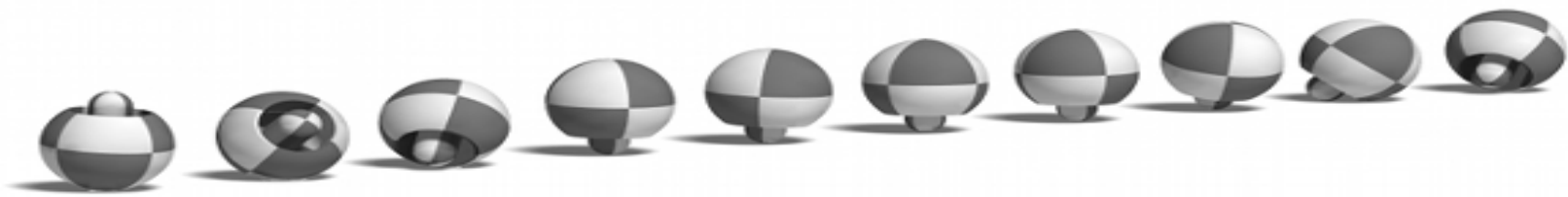
Abstract: In this talk we are interested in the famous FISTA algorithm. We show that FISTA is an automatic geometrically optimized algorithm for functions satisfying a quadratic growth assumption. This explains why FISTA works better than the standard Forward-Backward algorithm (FB) in such a case, although FISTA is known to have a polynomial asymptotical convergence rate while FB is exponential. We provide a simple rule to tune the friction parameter within the FISTA algorithm to reach an ϵ -solution with an optimal number of iterations. These new results highlight the efficiency of FISTA algorithms, and they rely on new non asymptotic bounds for FISTA.

3. **Title: Provable guarantees for neural network-driven dynamical systems**

Speaker: Mahyar Fazlyab, Johns Hopkins University, USA

Email: mahyarfazlyab@jhu.edu

Abstract: Neural Networks (NNs) have become increasingly effective at many difficult machine-learning and control tasks. However, the nonlinear and large-scale nature of neural networks makes them hard to analyze and, therefore, they are mostly used as black-box models without formal guarantees. In particular, NNs can be too sensitive to input perturbations. This issue becomes even more complicated when NNs are used in learning-enabled closed-loop systems, where even a small perturbation can substantially impact the system being controlled. In this talk, we present a variety of tools based on mixed-integer optimization, convex optimization and robust control that can provide useful certificates of stability, safety, and robustness for NN-driven systems.



4. **Title: Second order cone programming for frictional contact mechanic using interior point algorithm**

Speaker: Paul Armand, Université de Limoges, Laboratoire XLIM UMR CNRS n°7252

Email: paul.armand@unilim.fr

Collaborators: Vincent Acary (INRIA Rhône-Alpes, projet TRIPOP), Hoang Minh Nguyen (INRIA Rhône-Alpes), Maksym Shpakovych (Université de Limoges, Laboratoire XLIM).

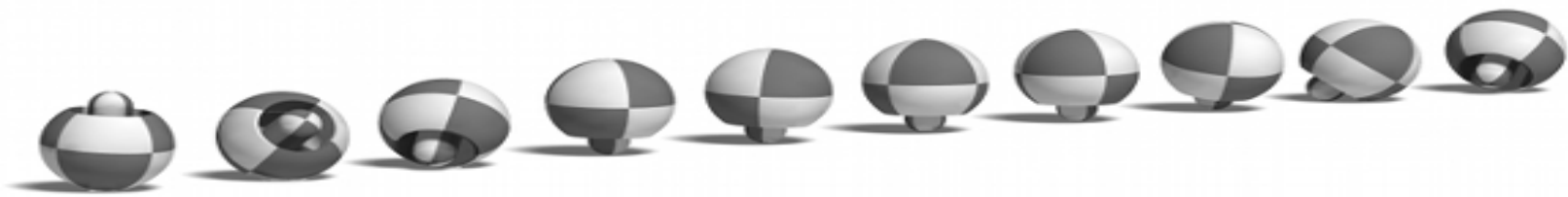
Abstract: We report some experiments with Siconos¹, an open-source software for modeling and simulating non-smooth dynamical systems. The objective is to efficiently and robustly solve some mechanical models of one-sided contact problems with Coulomb friction. “Efficiently” means that we want to recover an optimal solution with high precision and as quickly as possible. In practice, we must solve systems of non-smooth variational inequalities. Currently, Siconos uses mainly first order methods for the numerical solution of these systems. These methods are very robust, but suffer from a linear rate of convergence and are therefore too much slow to recover accurate solutions in a reasonable time. As these variational inequalities systems lead to the solution of an optimization problem with second order cone constraints, a natural idea is to apply second order optimization methods to speed up the convergence. We will present in detail a primal-dual interior point algorithm for minimizing a convex quadratic function with second order cone constraints. We will show, with some examples, that well known implementations of this algorithm such as SDPT3 [2] or the Matlab function `coneprog`², do not provide solutions satisfactorily in terms of computation time and accuracy. The major difficulty in implementing this type of algorithm comes from the fact that at each iteration of the algorithm, a change of variable (called “scaling”) must be performed to guarantee the non-singularity of the linear system to be solved, as well as to recover a symmetric system. While this scaling strategy is very nice from a theoretical point of view, it leads to a huge deterioration of the conditioning of the linear system when approaching the optimal solution and therefore to all the numerical difficulties that result from it. We will detail the numerical algebra that we have developed in our implementation, in order to overcome these problems of numerical instability. In the last part of the presentation, we will present the work in progress on the solution of the models resulting from the problems with rolling friction.

[1] Acary V., Brémond M., Huber O. (2018) On Solving Contact Problems with Coulomb Friction: Formulations and Numerical Comparisons. In: Leine R., Acary V., Brüls O. (eds) Advanced Topics in Nonsmooth Dynamics. Springer, Cham.

[2] Tütüncü, R. H. ; Toh, K. C. ; Todd, M. J. Solving semidefinite-quadratic-linear programs using SDPT3. Computational semidefinite and second order cone programming: the state of the art. Math. Program. 95 (2003), no. 2, Ser. B, 189–217.

¹<https://nonsmooth.gricad-pages.univ-grenoble-alpes.fr/siconos>

²<https://fr.mathworks.com/help/optim/ug/coneprog.html>



5. **Title: Computation of Lyapunov functions for switched systems and differential inclusions**

Speaker: Sigurdur Hafstein, University of Iceland, Iceland.

Email: shafstein@hi.is

Abstract: In dynamical systems, Lyapunov functions can be used to prove the asymptotic stability of sets, i.e. attractors, and estimating their basins of attraction. In switched systems and differential inclusions the situation is very similar. We will discuss the theory a little and then describe an algorithm to parameterize continuous and piecewise affine Lyapunov functions by linear programming.

6. **Title: Path-complete Lyapunov functions: graph-theory and algebraic geometry for controlling complex systems**

Speaker: Raphael Jungers, Université Catholique de Louvain, Belgium.

Email: raphael.jungers@uclouvain.be

Abstract: I'll present recent results on Path-Complete control, a meta-optimization technique aiming at designing efficient optimization programs, initially introduced for stability analysis, but later generalized to other control problems. These optimization programs are conveniently represented by an automaton. If we understand correctly now the characterization of all valid automata for stability analysis, many elementary questions remain open.

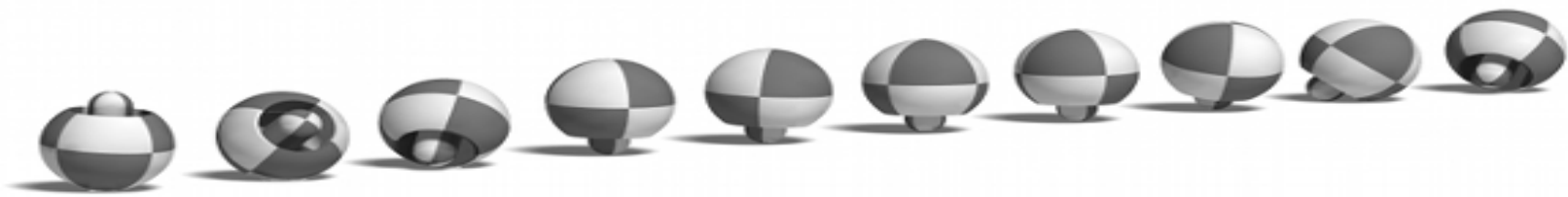
For practical purpose, it is crucial to understand when a particular optimization program is less conservative than another one. I'll focus on this problem, which is essentially an algebraic geometry problem. I will mention recent advances, which take into account the used template of candidate Lyapunov functions in the comparison problem. We solve the problem for several templates, making use of tools from automata theory (simulation,...), graph theory (Hall's marriage theorem), and convex geometry (duality,...).

7. **Title: Polynomial sums of squares for stability analysis of conic complementarity systems**

Speaker: Didier Henrion, LAAS-CNRS University of Toulouse, France, and Czech Technical University Prague, Czech Republic.

Email: henrion@laas.fr

Abstract: We consider a class of nonlinear systems with state constraints. They are described by a differential equation whose vector field has discontinuous behaviour on the boundary of the constraints so that the state trajectory is forced to evolve within the prespecified set. We model these systems as complementarity systems $dx(t)/dt = f(x(t)) + y(t)$ for a given Lipschitz function f , where $x(t)$ belongs to a given closed convex cone K , $y(t)$ belongs to the dual cone K^* , and $x(t)$ and $y(t)$ are mutually orthogonal for all times t . We prove that if the origin is globally exponentially sta-



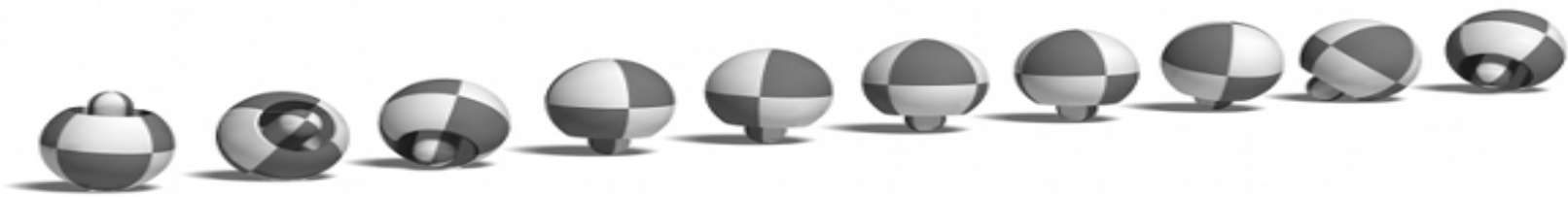
ble, then our complementarity system has a continuously differentiable cone-copositive Lyapunov function, i.e. a function which is positive on K and whose derivative along system trajectories is negative on K . This implies that such Lyapunov functions can be computed numerically using polynomial sum of squares and semidefinite optimization. Joint work with Marianne Souaiby and Aneel Tanwani.

8. **Title: Novel projection-based controllers to overcome fundamental performance limitations**

Speaker: Maurice Heemels, TU Eindhoven, Netherlands.

Email: W.P.M.H.Heemels@tue.nl

Abstract: In this talk I will discuss a new hybrid control element, which I got very excited about recently! For this new element, we coined the term ‘hybrid integrator-gain system’ or HIGS for short. HIGS is a projection-based integrator designed to avoid the limitations typically associated with linear integrators. In fact, I will show that HIGS-based control can be used to overcome well-known fundamental performance limitations related to linear time-invariant (LTI) control systems. The main design philosophy behind HIGS is built on keeping the sign of its input and output equal, thereby inducing less phase lag than a linear integrator, much like the famous Clegg integrator. The HIGS achieves the reduced phase lag by projection of the controller dynamics instead of using resets of the integrator state, which forms a potential benefit of this new control element. To formally analyze HIGS-controlled systems and projection-based controllers in general, I will present appropriate mathematical frameworks for describing these novel systems. The modelling frameworks are based on both piecewise linear systems and extensions of projected dynamical systems. Using these frameworks, HIGS-controlled systems are proven to be well-posed in the sense of existence and forward completeness of solutions, under suitable assumptions. Moreover, I will propose initial approaches for analyzing (input-to-state and incremental) stability of the resulting hybrid closed-loop systems. Various case studies will illustrate the main results.



9. **Title: Finite Elements with Switch Detection (FESD) for numerical optimal control of Filippov systems**

Speaker: Armin Nurkanović, University of Freiburg, Germany.

Email: armin.nurkanovic@imtek.uni-freiburg.de

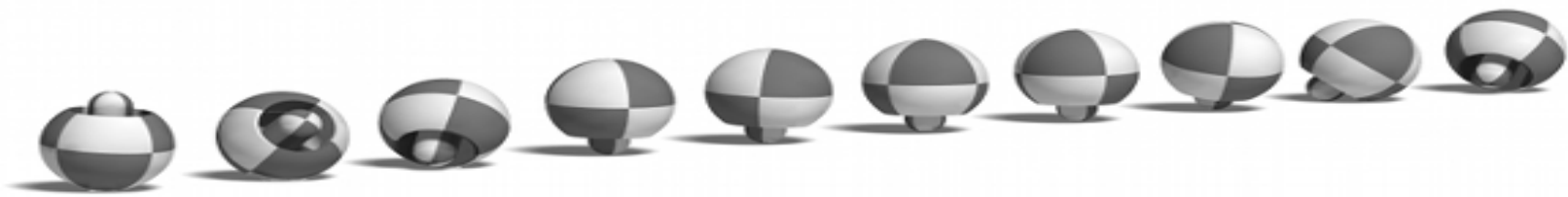
Abstract: The method of the Finite Elements with Switch Detection (FESD) is a numerical discretization method for piecewise smooth systems. We regard the Filippov convexification of these systems and a transformation into dynamic complementarity systems introduced by Stewart. FESD is based on solving of nonlinear complementarity problems and able to automatically detect the nonsmooth events in time. If standard Runge-Kutta (RK) methods are naively applied to a nonsmooth ODE, the accuracy is at best of order one. In FESD, we let the integrator step-size to be a degree of freedom. Additional complementarity conditions, that we call cross complementarities, enable exact switch detection, hence FESD is able to recover the high order accuracy which the RK methods enjoy for smooth ODE. Additional conditions called step equilibration allow the step-size to change only when switches occur and thus avoid spurious degrees of freedom. Convergence results for the FESD method are presented, local uniqueness of the solution and convergence of numerical sensitivities are proven. The efficacy of FESD is demonstrated on several simulation and optimal control examples. In an optimal control problem benchmark with FESD we achieve up to five orders of magnitude more accurate solutions than a standard approach for the same computational time.

10. **Title: Time-freezing for optimal control of systems with state jumps**

Speaker: Moritz Diehl, University of Freiburg, Germany.

Email: moritz.diehl@imtek.uni-freiburg.de

Abstract: This talk presents a novel reformulation and numerical methods for optimal control of dynamical systems with state jumps. The systems with state jumps are transformed into piecewise smooth systems. The main idea of the time-freezing reformulation is to introduce a clock state and an auxiliary dynamic system whose trajectory endpoints satisfy the state jump law. When the auxiliary system is active, the clock state is not evolving, hence by taking only the parts of the trajectory when the clock state was active, we can recover the original solution. We show how the time-freezing reformulation is used for mechanical systems with friction and impacts (both elastic and inelastic) and for hybrid systems with hysteresis. We detail how to recover the solution of the original system and show how to select appropriate auxiliary dynamics. For numerically solving optimal control problems we can now apply the recently proposed Finite Elements with Switch Detection (FESD) method. This enables the treatment of a broad class of nonsmooth systems in a unified way.



11. *Title:* **Simulation and control of nonsmooth contact interactions in robotics**

Speaker: Justin Carpentier, INRIA Paris, France.

Email: `justin.carpentier@inria.fr`

Abstract: Robots have to perpetually create or break contact with their surroundings in order, for instance, to move or manipulate objects. These contact interactions are subject to complex physical phenomena captured by well-known physics principles (Coulomb friction models, maximum principles, etc.). Yet, from a computational perspective, these physical principles remain difficult to capture and control, especially when dealing with complex interactive systems such as poly-articulated robots (e.g., humanoids, quadrupeds, etc.).

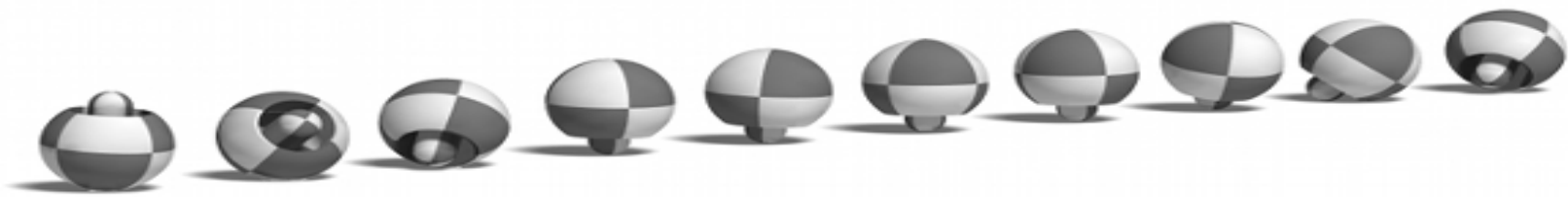
The goal of this talk is to showcase recent progress we have made in the field of robotics to simulate and control these complex contact systems and their interactions with the world. In the first part, I will introduce a unified approach for efficiently solving nonlinear complementary problems associated with contact problems, involving both rigid and compliant contact interactions. In the second part, I will show that randomized smoothing techniques can help to apprehend and control nonsmooth contact interactions in the context of optimal control. It will also be the occasion to draw some interesting connections between optimal control and reinforcement learning.

12. *Title:* **A nested set-valued controller for robust output regulation**

Speaker: Felix Miranda-Villatoro, INRIA Grenoble, France.

Email: `felix.miranda-villatoro@inria.fr`

Abstract: We propose a set-valued controller with a signum multifunction nested inside another one. We prove that the controller is well posed and achieves robust ultimate boundedness in the presence of mismatched, non-vanishing disturbances. Even more, the selected output can be made arbitrarily small. Also, by applying an implicit/explicit Euler scheme similar to the one introduced by Acary and Brogliato (2010) for matched disturbances, we derive a selection strategy for the discrete-time implementation of the set-valued control law. Simulations demonstrate that the discrete scheme diminishes chattering substantially, compared with a fully explicit method.



13. **Title: On the spatial nonsmoothness of beam-to-beam contact problems: analytical and numerical approaches**

Speaker: Olivier Brüls, University of Liège, Belgium.

Collaborator: Armin Bosten, University of Liège, Belgium and Fraunhofer Institute for Industrial Mathematics, Kaiserslautern, Germany

Email: o.bruls@uliege.be

Abstract: In recent years, the interest in the simulation of systems with flexible slender structures experiencing contact has grown significantly. This talk addresses the spatial discontinuities which may appear in frictionless beam-to-beam contact problems.

This spatial nonsmoothness is first illustrated through a simple analytic example of a static cantilever beam pushed onto a rigid wall [1]. In the case of an Euler-Bernoulli beam, it is shown that the distributed contact force is equal to the load all along the contact region except at the boundary where a point load appears. On the contrary, for a Timoshenko beam, a distributed reaction force takes place and decays exponentially from the first contact point, but there is no point load. The rate of decay depends on the magnitude of the shear deformability.

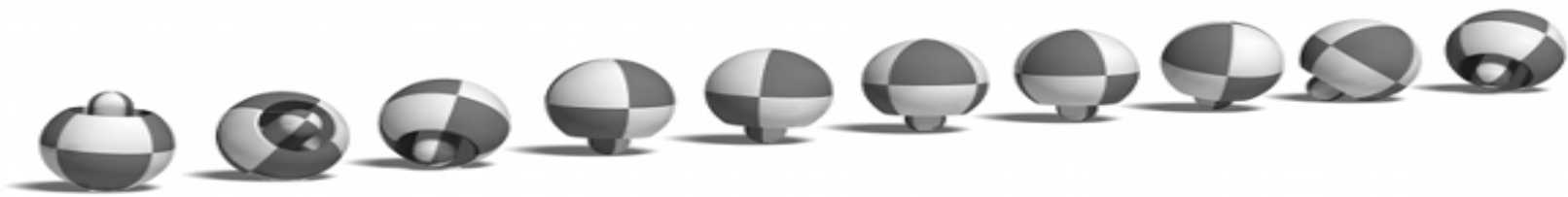
Then, the development of a suitable spatial discretization scheme is addressed. Following a mortar formulation [2], the non-penetration constraint is enforced in a weak sense using an augmented Lagrangian approach. The choice of the shape functions for the Lagrange multiplier field plays an important role in the numerical procedure.

Finally, the discussion is extended to the dynamic case which additionally involves temporal discontinuities such as velocity jumps and impacts. The nonsmooth generalized- α scheme [3] is selected for the time discretization. We show that the combination of the mortar approach and the NSGA offers an appropriate framework for the modelling of dynamic contact interactions among beams.

[1] A. Bosten, V. Denoël, A. Cosimo, J. Linn and O. Brüls, A beam contact benchmark with analytic solution, *ZAMM* (under review)

[2] A. Bosten, A. Cosimo, J. Linn, and O. Brüls. A mortar formulation for frictionless line-to-line beam contact. *Multibody Syst. Dyn.*, **54**:31-52, 2021.

[3] A. Cosimo, J. Galvez, F. J. Cavalieri, A. Cardona and O. Brüls. A robust nonsmooth generalized- α scheme for flexible systems with impacts. *Multibody Syst. Dyn.*, **48**:127-149, 2020.



14. **Title: Modeling the root growth: an optimal control approach**

Speaker: Michele Palladino, University of L'Aquila, Italy.

Email: michele.palladino@gssi.it, michele.palladino@univaq.it

Abstract: In this talk we will propose a new framework to model control systems in which a dynamic friction occurs. In particular, such a framework is motivated by the study of the movement of a robotic root tip in the soil. The model consists in a controlled differential inclusion with a dissipative, upper semi-continuous right hand side, which still preserves existence and uniqueness of the solution for each given input function $u(t)$. Under general hypotheses, we are able to derive the Hamilton-Jacobi-Bellman equation for the related free time optimal control problem and to characterize the value function as the unique, locally Lipschitz continuous viscosity solution.

15. **Title: PyNSD: solvers, algorithms and benchmark systems for nonsmooth dynamics**

Speaker: Giuseppe Capobianco, FAU Erlangen–Nürnberg, Germany.

Email: giuseppe.capobianco@fau.de

Collaborators: Jonas Harsch (University of Stuttgart, Germany) and
Remco Leine (University of Stuttgart, Germany)

Abstract: With PyNSD, we envision an open source project collecting solvers, algorithms and benchmark systems for nonsmooth dynamics. The main goal is to foster collaboration and to facilitate exchange of knowledge between research groups. PyNSD provides a common platform to test new algorithms and compare these to well established methods. Furthermore, the performance of different solvers can be tested on a set of benchmark problems. Moreover, thanks to didactic examples, PyNSD can be used for educational purposes. The general idea is that research groups from all over the world contribute to solvers, benchmark systems and didactic examples. In this talk, we present the status quo of the PyNSD project and discuss possible future developments.

List of participants

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