# Séminaire ISIR

Mercredi 4 octobre 2017 à 15H00

**Alessandro Saccon**

Campus Jussieu, 4 place Jussieu, Paris
**Salle de réunion H20**

# Reference Spreading Hybrid Control – Exploiting Dynamic Contact Transitions in Robotics Applications

**Abstract :** Many of the tasks that we, as humans, perform on a daily basis require physical inter- action with our surrounding. Example tasks include object grasping and manipulation, walking, jumping, and climbing in environments with complex spatial geometry. One of the ambitions in robotics is creating machines that can easily and reliably perform such tasks, with the aim of alleviating mankind from performing necessary activities that are, however, either boring or dangerous for our life and health. While advances in the robotics field have been substantial in the latest fifty years, performing locomotion and manipulation tasks that involve contact transitions at relative high speed still poses many challenges. Besides the limitations and challenges in perception and actuation design, witnessed in current technology, a key challenge is to create a suitable control framework to reach human-like performance when dealing with dynamic contact transitions.

The behavior of a robotic system performing locomotion and manipulation tasks can be described employing the theoretical framework of hybrid dynamical systems with state-triggered jumps. In the context of robotics system, state jumps correspond to the fast velocity changes occurring in making and braking contacts with the environment. Control and trajectory tracking for dynamical systems with state-triggered jumps is complicated due to the inevitable time mismatch between desired and closed-loop contact transitions that calls for a redefinition of the concept of tracking error. The study of the trajectory tracking problem is a relatively recent and active field of research in the control community, with possible impact on other research fields, beyond robotics.

This talk will review the fundamentals of a control approach for the stabilization of hybrid systems with state-triggered jumps that goes under the name of reference spreading hybrid control [1, 2]. The talk will also discuss the application of reference spreading hybrid control for the closed-loop motion stabilization of mechanical and robotic systems undergoing dynamic contact transitions, by means of numerical simulations and real-world experiments [3, 4, 5].

**References :**

[1] A. Saccon, N. van de Wouw, H. Nijmeijer, Sensitivity analysis of hybrid systems with state jumps with application to trajectory tracking. IEEE Conference on Decision and Control (CDC), 3065–3070, 2014.

[2] M. Rijnen, A. Saccon, H. Nijmeijer, On optimal trajectory tracking for mechanical systems with unilateral constraints. IEEE Conference on Decision and Control (CDC), 2561-2566, 2015.

[3] G.P. Incremona, A. Saccon, A. Ferrara, H Nijmeijer, Trajectory tracking of mechanical systems with unilateral constraints: Experimental results of a recently introduced hybrid PD feedback controller. IEEE Conference on Decision and Control (CDC), 920–925, 2015.

[4] M.W.L.M. Rijnen, A.T. van Rijn, H. Dallali, A. Saccon, H. Nijmeijer, Hybrid Trajectory Tracking for a Hopping Robotic Leg. IFAC PSYCO, pp. 107–112, 2016.

[5] M. Rijnen, E. de Mooij, S. Traversaro, F. Nori, N. van de Wouw, A. Saccon, H. Nijmeijer, Control of Humanoid Robot Motions with Impacts: Numerical Experiments with Reference Spreading Control. IEEE ICRA 2017.

Institut des Systèmes Intelligents et de Robotique
UPMC – CNRS / UMR 7222
Pyramide Tour 55 - Boîte courrier 173
4 Place Jussieu – 75252 PARIS cedex 05 – France
Tél. : +33 (0)1 44 27 51 31 / 51 41
Fax : +33 (0)1 44 27 51 45

**Short bio :** Dr. Alessandro Saccon received the laurea degree cum laude in computer engineering and the Ph.D. degree in control system theory from the University of Padova, Italy, in 2002 and 2006. His thesis received the Claudio Maffezzoni best PhD thesis award by the Politecnico di Milano. After the completion of his PhD studies, he held until 2009 a research and development position at University of Padova in joint collaboration with Ducati Corse working on control and optimization methods for the exploration of the dynamics of racing motorcycles for virtual prototyping studies using multi-body models and numerical optimal control methods. From 2009 until 2012, he held a post-doctoral research position at the Instituto Superior Técnico, Lisbon, Portugal, sponsored by the Portuguese Science and Technology Foundation (FCT), working on motion planning, dynamics, and control of autonomous robotic vehicles. Since 2013, he is an Assistant Professor on nonlinear control and robotics at the Department of Mechanical Engineering, Eindhoven University of Technology, the Netherlands. His areas of expertise include modeling, analysis, and control multi-body systems, geometric mechanics, nonlinear control theory, and numerical optimal control for exploration of trajectory space of complex and highly manoeuvrable nonlinear systems. Recent work has focused on the development of optimal constrained motion planning strategies for multiple autonomous robotic vehicles, robotics systems with unilateral position constraints, and control of mechanical systems subject to rigid contacts and impacts.