Workshop: Journées Annuelles du GDR MOA

Course Title:	Nonsmooth Systems: Models, Numerics, Stability and Control
Instructors:	Vincent Acary, INRIA Grenoble
	Samir Adly, Professor, Université de Limoges
	Aneel Tanwani, Chargé de Recherche, LAAS – CNRS, Toulouse.
Dates:	15-16 October, 2019.
Venue:	INSA Rennes, France.

Mathematical Backgrounds and Existence Theory (S. Adly, 3 hrs)

In this first part, we will provide some basic concepts from convex analysis, nonsmooth analysis and Lyapunov stability theory as well as some existence results that will be useful throughout this minicourse. We will also give an overview of some mathematical models that fit into the domain of nonsmooth dynamics. The main purpose is to give a quick but comprehensive snapshot of other classes of nonsmooth systems that can or cannot be captured by the models studied deeply in this minicourse.

Numerics and Simulation Tools (V. Acary (3 hrs))

In this second part, we will present the numerical methods and the simulation of the nonsmooth dynamical systems. Typical examples of such dynamical systems are the mechanical systems with unilateral constraints, (contact), Coulomb's friction and impacts such as masonry buildings, circuit breakers, robotic arms, the electrical circuits with ideal components or the sliding mode control applications. The talk will be mainly focused on Linear Complementarity Systems that model electrical circuits and the concepts of solutions that can be approximated: C^1 solutions, absolutely continuous solutions or solutions of bounded variation.
The numerical methods will be illustrated on the platform SICONOS: http://siconos.gforge.inria.fr for modeling and simulating nonsmooth dynamical systems in C++ and in Python.

Stability and Control (A. Tanwani, 3 hrs)

Motivated by the practical aspects of using nonsmooth systems in practical applications, this part of the course will address control related properties. In this regard, we will start with the notion of stability for nonsmooth dynamical systems, and discuss sufficient conditions using Lyapunov functions. We will in particular focus on complementarity systems and see how passivity-like conditions can be used, not only for proving existence of solutions, but also for proving asymptotic stability of the system.

Moving away from the analysis part, we will address some design related questions as well. The first question is to design controllers that can track a desired trajectory within the framework of nonsmooth systems. Sufficient conditions for design of such regulators is presented. Another instance of the design problem is the synthesis of state estimators for nonsmooth systems. This time, the estimator to be designed is such that it asymptotically tracks the state trajectory of a nonsmooth system. Examples will be provided to illustrate proposed methods.