Numerical Methods for nonsmooth dynamical systems

Vincent Acary
Inria. Centre de recherche de Grenoble
vincent.acary@inria.fr
http://bipop.inrialpes.fr/people/acary

2017–2018
Contents

▶ Formulation of nonsmooth mechanical systems
▶ Time integration methods
▶ Solution of discrete problems
▶ Software: Siconos
Non-smooth dynamical systems

- Non-smooth solutions in time (jumps, kinks, distributions, measures)
- Non-smooth modeling and constitutive laws (set–valued mapping, inequality constraints, complementarity, impact laws)
Application fields.

- **Computational mechanics.** Plasticity. Unilateral contact, Coulomb friction and impacts: multi-body systems, robotic systems, frictional contact oscillators, granular materials.
- **Electronics.** Switched electrical circuits (digital/analog converters and power electronics, diodes, transistors, switches).
- **Computer science.** Hybrid and Cyber–physical systems
- **Bio-mathematics.** Gene regulatory networks
- **Transportation science.** Fluid transportation networks with queues.
- **Economy and Finance.** Oligopolistic market equilibrium

Nonsmooth approach is crucial for a correct modeling and an efficient simulation

Numerical Methods for nonsmooth dynamical systems Vincent Acary, Inria. Centre de recherche de Grenoble, vincent.acary@inria.fr, http://bipop.inrialpes.fr/people/acary
Sources of nonsmoothness

- Two largely different time-scales of evolution:
  1. a slow smooth dynamics (free flight of the bouncing ball)
  2. a very fast dynamics (events, transitions, impacts) that can be modeled as a punctual event.
Non-smooth dynamical systems

Difficulty
Standard tools of numerical analysis and simulation (in finite dimension) are no longer suitable due to the lack of regularity.

Specific tools

Examples of non-smooth dynamical systems
- Piecewise smooth systems
- Complementarity systems and differential variational inequality.
- Specific differential inclusions (Filippov, Moreau sweeping process, Normal cone inclusion).