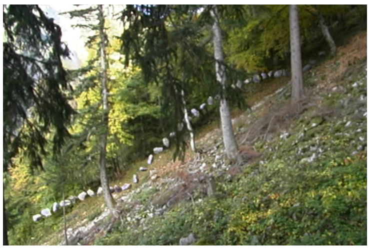
Internship subject
Non-smooth modeling and simulation of energy dissipation processes during rockfall.

September 28, 2018



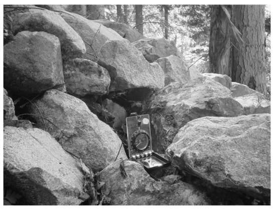
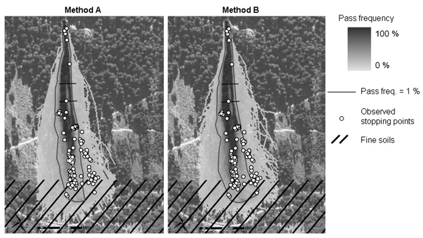


Fig. 16. A typical field situation in Zone 3, where the surface material should be characterised by size classes method.



Keywords:

Computational Mechanics, Contact and Impact Mechanics, Rockfall trajectory, Natural Hazard mitigation, Fracture.

Context

TRIPOP is a joint research team of Inria Grenoble Rhône-Alpes and of the Laboratoire Jean Kuntzmann and started in January 2018 as a follow up of the BIPOP team. The team is mainly concerned by the modeling, the simulation and the control of nonsmooth dynamical systems. Nonsmooth dynamics concerns the study of the time evolution of systems that are not smooth in the mathematical sense, *i.e.*, systems that are characterized by a lack of differentiability, either of the mappings in theirs formulations, or of theirs solutions with respect to time. In mechanics, the main instances of nonsmooth dynamical systems are multibody systems with Signorini's unilateral contact, set-valued (Coulomb-like) friction and impacts, or in continuum mechanics, ideal plasticity, fracture or damage. The members of the team have a long experience of nonsmooth dynamics modeling together with the development of simulation software. With the integration of Franck Bourrier as a new research member, a part of the activities of the theme is now focused in rockfall trajectory modeling and natural hazard mitigation.

Description of the internship subject

Rockfall is one of the most common natural hazards in mountainous regions. The assessment of this hazard, related with block detachment conditions and propagation, is essential for mitigation strategies that include hazard zones determination and protection structures design.

Block trajectory simulation models are routinely used for the quantitative assessment of rockfall hazard. In these models, one of the major difficulties is the development of physically consistent and field applicable approaches to model the interaction between the block and the natural terrain. The models either consider the block as a single material point or explicitly account for the fragment shape. The first approach, although largely empirical, has been extensively investigated and calibrated. Consequently, it is efficient for global hazard zoning purposes because of its reduced number of input parameters and its computational efficacy. However, it remains limited for a detailed analysis of the propagation process with the objective of designing protection structures. The second type of approaches, that explicitly accounts for the fragment shape, is either based on regularized Discrete Element Methods (DEM) or on nonsmooth contact dynamics methods. These approaches have not yet been extensively investigated and calibrated. They remain based on simple models of block interaction with the terrain that only partially integrate the energy dissipation processes. As a consequence, they remain almost not used in practice.

The objective of this internship is to improve the modeling of the dissipation processes occurring during the propagation of blocks through mountain slopes. These processes are related with momentum exchanges, friction at the interface, wave propagation through the soil, visco-plastic strains of the soil and the breakage of the rock. The novelty will consist in the development of contact laws with rolling friction, and with the integration of rock breakage due to impact.

The different phases of the internship will be :

- Formulation and numerical implementation of a novel contact law integrating rolling friction in the framework of second–order cone complementarity.
- Modeling of block breakage. The approach proposed will be based on the modeling of the block as an assembly of rigid or deformable tetrahedron linked by cohesive contact laws. The challenge relies on the implementation of relevant cohesive contact laws, able to reproduce at the macroscopic level the main fracture phenomena.

Required skills. Student profile

The internship candidate should have competences in solid mechanics and numerical modeling. A strong theoretical background in solid mechanics is mandatory. Furthermore, the applicant must show a strong interest for software development in computational Mechanics. He also has to be motivated by applied research in collaboration with researchers from different disciplines. A good level of English and subsequent writing capacities are also requested.

Additional information

- References

[1] Bourrier, F. and Hungr, O. (2013) Rockfall Dynamics: A Critical Review of Collision and Rebound Models, in Rockfall Engineering (eds S. Lambert and F. Nicot), John Wiley & Sons, Inc., Hoboken, NJ, USA. doi: 10.1002/9781118601532.ch6

[2] Numerical Methods for Nonsmooth Dynamical Systems: Applications in Mechanics and Electronics Vincent Acary, Bernard Brogliato Springer Verlag, 35, pp.526, 2008, Lecture Notes in Applied and Computational Mechanics, 978-3-540-75391-9

[3] A DEM model for soft and hard rocks: Role of grain interlocking on strength. L. Scholtes F. V. Donze. Journal of the Mechanics and Physics of Solids, Elsevier, 2013, 61 (2), pp.352-369.

- Environment
  - Team–Project and name of the team Leader: Tripop - Vincent Acary
  - Name of the supervisor and co-supervisor :

    * Vincent Acary (HdR, INRIA, Tripop) `vincent.acary@inria.fr`
    * Franck Bourrier (INRIA, Tripop and Irstea) `franck.bourrier@irstea.fr`

  - Domain : Applied Mathematics, Computation and Simulation
  - Research theme : Optimization and control of dynamic systems
  - Location : Research center Grenoble. Montbonnot
- How to apply ? Send a motivation, recommendation letters and CV to the supervisors.