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Non Smooth Contact Dynamics, a relevant framework to model divided media

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Résumé :

Cette contribution vise à expliquer l'intérêt de la méthode « Non Smooth Contact Dynamics » pour développer des stratégies numériques capables de modéliser le comportement des milieux divisés. Cette méthode a été utilisée avec succès pour modéliser des maçonneries sous séismes, la stabilité de massifs rocheux fracturés, les couplages multi-physiques, etc.

Abstract :

This contribution presents how the Non Smooth Contact Dynamics method (NSCD) is a powerful modelling framework to derive numerical strategies. NSCD has been successfully used to study the behaviour of granular materials and structures. It has been also used to study the behaviour of masonry under seismic load, rock mass stability, fracture, multiple physics coupling, etc.

Mots clefs : NSCD, DEM, Multiple-Physics, LMGC90

Various numerical strategies are available to deal with the dynamics of collections of bodies. Deriving a relevant numerical model raises many issues especially due to the fact that it mixes various time and space scales. In the present work we focus on a fully implicit method, the Non Smooth Contact Dynamics approach (NSCD), initiated by J.J. Moreau [1] and M. Jean [2], and implemented in the LMGC90 software. The interaction laws are written as multi mappings relating contact unknowns (impulse and relative velocity). In the frame of Convex Analysis proposed by J.J. Moreau dynamics is able to deal with non-smoothness; it is integrated with a first order scheme.

Impulses account for all events supposed to occur during a time step: external loads, single or numerous impacts between pairs or agglomerates of contacting bodies. An iterative contact solver is necessary in order to exhibit the values of the unknowns. The method allows reasonably large time steps.

Progressively the models simulated by non-smooth DEM become more complex:

- Interactions between contacting bodies may be physically quite complicated. Primary phenomena depicted by an interaction law are impenetrability of materials and dry friction. Other phenomena like rolling friction due to roughness, cohesive behaviour, local plastic deformation, viscous friction or wear should be also taken into account.
- Particle geometries become more complex introducing clusters of basic shapes, polyhedron or possibly non-convex shapes.
- Multiple physics couplings: chemistry, electrical or thermal effects.
- Multi-phase mixture: gas-grain or fluid-grain media.
- Complex grains behaviour: elasticity, plasticity, fracture, etc.
- Phase changing: solid/solids (fracture, sintering) or solid/fluid, etc.

As it will be detailed in this talk the Non Smooth Contact Dynamics method (NSCD) is a powerful modelling framework to derive numerical strategies. NSCD has been successfully used to study the behaviour of granular materials and structures. It has been also used to study the behaviour of masonry under seismic load, rock mass stability, fracture, multiple physics coupling, etc.

LMGC90 platform is a free collaborative software developed by several researchers, engineers, students: Michel Jean, Mathieu Renouf, Gilles Saussine, Alexandre Martin, Dominique Ambard, Cyril Bordreuil, Frédéric Pérales, etc.

Références

[1] J.J. MOREAU. Unilateral contact and dry friction in finite freedom dynamics, volume 302 of *International Centre for Mechanical Sciences, Courses and Lectures*. pp.1–82, J.J. Moreau, P.D. Panagiotopoulos, Springer, Vienna, 1988.

[2] M. JEAN. The Non Smooth Contact Dynamics Method, in *Computer Methods in Applied Mechanics and Engineering*, special issue on computational modelling of contact and friction, J.A.C. Martins, A. Klarbring (ed), 177, pp. 235 – 257, 1999.