LMGC90

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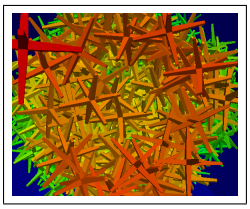
Résumé — LMGC90 is an open platform dedicated to the modeling of large collections of interacting objects (2D/3D). It aims at modeling objects of any shape with various mechanical behavior and to take into account interaction laws as complex as necessary. Furthermore multiple physics couplings (thermal effects, fluids, *etc*) are progressively taken into account.

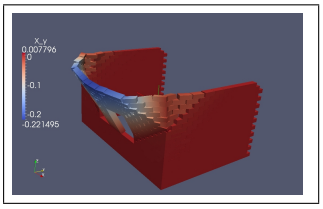
Mots clés — contact, dynamics, multiple physics, DEM, FEM, Open source

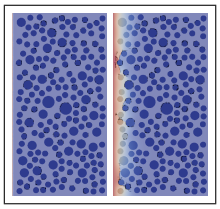
1 Some Fields of Application



Granular Material, from rheology to structure : a typical use of LMGC90 concerns the study of the rheology of granular materials. As an example the figure shows a sample made of the deposit of non-convex rigid bodies.

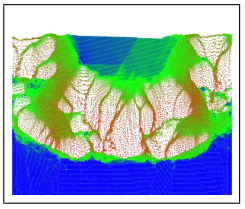
Masonry structures : modeling allows assessing the stability and the safety of masonry structures under static loads or dynamical natural risk (earthquake, landslide, etc) taking into account the influence of the design pattern and the joint behavior.

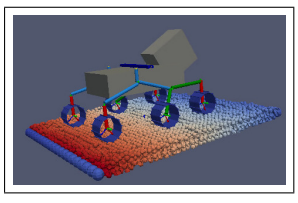




Fracture of heterogeneous media : Using a Frictional Cohesive Zone Model or eigen-erosion method, fracture can be modeled, at microscopic or mesoscopic scale, from initiation to post-failure. Recent developments permits to take into account effects of the thermal solicitations.

Multiple physics couplings : Various physics may be considered at different scales such as thermal coupling, fluid particle interaction, electrical conductivity. Furthermore modeling multiphase flow in deformable porous is also available.





Coupling with Multi-Body-System : simulations with software such as Robotran to correctly simulate the behavior of controlled complex systems in interaction with a large number of particles are also possible.

2 Main features

Pre-processing :

A built-in scriptable preprocessor aims at defining geometries, material properties,
numerical modeling options, boundary conditions, etc.
Specific drivers are available for granular materials, masonry structures and finite element models.
External tools may be used as Gmsh or Resoblok.

Modeling : A framework to describe complex 2D/3D bodies collections.

Shape of objects may be described with simple convex primitives (disk, polygon, sphere, polyhedron, etc), compound of primitives or general triangulated surface. Contact detection is performed for any combination of primitives.
Bulk behavior of objects may be rigid or deformable (small or large transformation and corotational) by means of the finite element method. Various behavior laws are available (mainly provided by Matlib) : elastic, hyper-elastic, viscous, elasto-plastic, etc. Thermal effects and other physics (e.g. fluid dynamics, flow in porous media) can be taken into account.
A large set of **interaction laws** is available, e.g. frictional contact, cohesion (capillarity, damage, brittle, etc), wire, rod.
Thanks to multiple discretizations, physics couplings can be performed at different scales through upscaling/downscaling methods.

Analysis :

Mainly based on the **Non Smooth Contact Dynamics** method : non smooth dynamic framework, implicit time integration, implicit contact solvers (GSNL, GPCP, Siconos-Numerics).
Thanks to a modular architecture other strategies may also be implemented : quasi-static, explicit dynamics.
Applications with a large number of interacting bodies are reachable through multi-threading (OpenMP) or domain decomposition parallel computing(MPI).

User Interface :

All stages of a simulation are finely driven by Python scripts ; moreover Python interface provides an access to LMGC90 database, which offers the possibility to manage complex simulations. Python driving language allows customized simulations. However advanced developments benefit from a Fortran90 modular software design which preserves performance.
Postprocessing is managed by LMGC90 ; plotting are performed by external tools (MatPlotLib, Grace, etc). Vtk files are written for visualization, any tool supporting vtk format (ParaView, Mayavi, etc) can be used.

An open platform :

Dedicated to scientists for research developments and applications. Past two years contributors : F. Dubois, R. Mozul, M. Renouf, L. Bichet, F. Peralès, E. Delaume, F. Cherblanc, F. Rozar, D. Ambard, N. Docquier, O. Lantsoght.
Enable coupling capabilities with external software (Finite Element : Code_Aster, Pelicans, Gmsh) and libraries (Physical Models : MatLib ; Linear Algebra : Lapack ; Contact detection : Rapid ; Contact solvers : Siconos-Numerics ; Multi-Body-System : Robotran).

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