The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5 – 9 June 2022, Oslo, Norway

A DISCRETE ELEMENT METHOD FOR GRANULAR SOLIDS WITH A LEVEL SET SHAPE DESCRIPTION

Jérôme Duriez*[1], Cédric Galusinski[2], Frédéric Golay[3] and Stéphane Bonelli[4]

[1] INRAE, Aix Marseille Univ, RECOVER, Aix-en-Provence, France, jerome.duriez@inrae.fr
https://www6.paca.inrae.fr/recover/Qui-sommes-nous/Membres-du-laboratoire/Pages-personnelles/Jerome-DURIEZ

[2] IMATH, Université de Toulon, CS 60584 83041 Toulon Cedex 9, France, cedric.galusinski@univ-tln.fr

[3] IMATH, Université de Toulon, CS 60584 83041 Toulon Cedex 9, France, frederic.golay@univ-tln.fr

[4] INRAE, Aix Marseille Univ, RECOVER, Aix-en-Provence, France, stephane.bonelli@inrae.fr

Key Words: *Granular materials, Discrete Element Method (DEM), Level Set.*

Granular materials are widespread in the environment, e.g. in the form of soils, as well as in many industrial processes. Flowing like fluids in some instances, they are also able to sustain shear stresses at rest, adopting a highly complex mechanical behaviour. The complexity stems from the discrete nature of the material microstructure and local phenomena such as contact gain and loss, or inter-particle friction. These phenomena may be directly captured in multi-scale approaches adopting the Discrete Element Method (DEM) [1] and its particle-scale point of view, provided that the microstructure is properly described. In particular, particle shape is a key feature controlling for instance the possibility for static equilibrium under given loads.

Following [2], it is herein proposed to describe shape as the zero level set (LS) of the distance function to a particle's surface. Doing so, no closed-form expression is required for the distance function. Instead, a Fast Marching Method [3] first outputs for any kind of surfaces a discrete set of distance values that is expressed on a particle-attached grid. After implementation in the open-source code YADE [4,5], the precision and computational costs of the method are first carefully discussed on a reference case with ideal spherical particles [6]. Seeking an important precision, time costs for execution and memory requirements increase here by one or two orders of magnitude with respect to classical DEM with spherical particles but can be reduced adopting simple, OpenMP, parallel computation or optimized grids. Time costs are also shown to be smaller than a possible use of convex polyhedra. The versatility of the approach is then illustrated on more complex shapes, e.g. superquadrics and 3D scanned rock aggregates.

REFERENCES

[1] P.A. Cundall and O.D.L. Strack, A discrete numerical model for granular assemblies. *Géotechnique*, Vol. **29**, pp. 47—65, 1979.
[2] R. Kawamoto, E. Andò, G. Viggiani and J.E. Andrade, Level set discrete element method for three-dimensional computations with triaxial case study. *J. of the Mech. Phys. Solids*, Vol. **91**, pp. 1—13, 2016.
[3] J.A. Sethian, Level set methods and fast marching methods, *Cambridge University Press*, 1999.
[4] V. Šmilauer et al., *Yade Documentation*, 3rd ed. The Yade Project, 2021.

[5] J. Duriez and C. Galusinski, A Level Set-Discrete Element Method in YADE for numerical, micro-scale, geomechanics with refined grain shapes. *Computers & Geosciences*, Vol. **157**, 104936, 2021
[6] J. Duriez and S. Bonelli, Precision and computational costs of Level Set-Discrete Element Method (LS-DEM) with respect to DEM. *Computers and Geotechnics*, Vol. **134**, 104033, 2021.