Modeling of flexible particles with the Virtual Element Method

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ABSTRACT

In Discrete Element Method (DEM) it is usually assumed that particles are rigid bodies. Due to that, most DEM applications consider flexibility of particles as being embedded in the interface law. As a common example one can mention the Hertzian contact between spheres, which provides a nonlinear relationship between the contact normal force and the penetration between the original (undeformed) spheres. The same idea can also be applied for super ellipsoids [1], adapting the interface law according to local curvatures of contacting particles. Many linear spring interface models also consider the flexibility of particles in an approximate way. When moving into applications of polyhedral particles, interface laws are more complex and a physical sound interpretation is not easily possible. The interface laws act as a penalty approach to numerically enforcing the non-penetration constraint they usually cannot model properly local flexibility effects.

In the context of polyhedra, one can be interested in overall flexibility of particles, not necessarily restricted to the embedded in interface laws. In this context, our proposal is to model polyhedral particles as flexible bodies by usingthe Virtual Element Method (VEM). With VEM polyhedrals can be modelled as single elements. With that, one can create a model that represents the overall flexibility of each single particle. It is possible to employ the stiffness related to the numerical stabilization VEM to match a desirable overall stiffness for a given particle in a certain strain direction. With that, even a coarse mesh can reproduce the flexibility of an assembly of particles.

We provide examples of the VEM modeling for various shapes of particles. One example is a hopper discharging flexible particles. We also see promising applications of the method in the context of micromechanics of soft glass materials and in the study of particle jamming considering the flexibility effects (see e.g. [3]).

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**REFERENCES**

[1] C. Wellmann and P. Wriggers. A two-scale model of granular materials. Computer Methods in Applied Mechanics and Engineering, 205-208(1):46–58, 2012.

[2] A. Gay Neto and P. Wriggers. Discrete Element Model for General Polyhedra. Computational Particle Mechanics, -(-):–, 2021 (submitted).

[3] R. T. Bonnecaze and M. Cloitre. Micromechanics of Soft Particle Glasses, p. 117–161. Springer Berlin Heidelberg, Berlin, Heidelberg, 2010.