A general method for modelling deformable structures in DEM

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ABSTRACT

The work presented in this paper focuses on the implementation of a deformable discrete element called PFacet (particle facet) in the open source framework YADE [1]. For this purpose, the work of Bourrier et al. [2] on deformable cylinders has been extended. A PFacet element is geometrically constructed by the Minkowski sum of a triangular facet and a sphere. It is composed of three nodes (spheres) and three connections (cylinders). The deformation of a PFacet is defined by the positions and orientations of its nodes. The constitutive behaviour of the PFacet element is simulated via an ordinary interaction law acting between the three nodes defining the element.

The newly developed PFacet elements allow the modelling of arbitrary deformable structures, such as membranes and containers. This is achieved by connecting the elements (i.e. they have at least one node in common) and introducing definitions for all possible contacts. The latter include the handling of sphere–PFacet, cylinder–PFacet and PFacet–PFacet contacts. For a sphere–PFacet interaction, a virtual sphere is introduced and defined as the projection of the sphere–PFacet contact point in the plane containing the PFacet nodes. The displacement and the rotation of the virtual sphere are then interpolated between the three nodes. The contacts between cylinder–PFacet and PFacet–PFacet are decomposed as sphere–PFacet and cylinder–cylinder interactions. In this way, contact detection remains straightforward given the simple primitives (sphere, cylinder, thick facet). In addition, the introduction of a virtual sphere at the contact points allows the use of any classical sphere–sphere interaction law. A conventional elastic-plastic contact model is used to model the latter and an additional beam-like behaviour is introduced for connected elements.

Finally, the consistent integration of contact history and contact for arbitrary movements of the objects is discussed. The method allows a consistent representation of sliding contacts along the outer surface and across many elements. This is critical for modelling frictional or cohesive-frictional interactions between objects. The efficiency and capabilities of the newly developed PFacet model are shown by simulating complex soil–interaction and self-contact problems.

REFERENCES

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