Evaluation of contact force models for ellipsoidal particles

Kejun Dong[1]*, Kamyar Kildashti[1], and Bijan Samali[1]

[1]Centre for Infrastructure Engineering, Western Sydney University, Australia

*Presenting & Corresponding author: Kejun.Dong@westernsydney.edu.au

Abstract

Discrete element method has been widely used in the numerical modelling of granular materials. However, how to model the non-spherical particles is a still a challenging problem. The major difficulty lies in calculating the overlap between two non-spherical particles as well as calculating the contact force and torque from the overlap.

Ellipsoidal particles have been used as a typical kind of non-spherical particles in DEM simulations. There are generally three kinds of methods used to calculate the overlap and contact force between two ellipsoidal particles, namely, geometrical potential (GP), common plane (CP) and overlap region (OR) methods. These three methods are based on different physical concepts and hence will give different results not only on the contact force magnitude, but also on the contact point and contact plane that are required in applying the contact force on the particle. However, previous evaluations of these methods were mainly focused on the stability and speed of the algorithms, but few on the accuracy. In fact, there are limited data for the contact force between two ellipsoidal particles available in literature. In recent studies, Finite Element Method (FEM) at sub-particle scale has been used to generate the accurate contact force for evaluating the force models used in DEM. Yet previous studies often focused on comparing contact force magnitude and were only conducted at several specific orientations, which did not give a comprehensive evaluation.

In this paper, we compared three methods in terms of the contact force magnitude, contact point and contact plane for two ellipsoids with different aspect ratios. Particularly, using the orientation discretization concept, we presented the differences of three methods in a more comprehensive way. In addition, we compared the results directly to the FEM predicted results. The studies showed that GP method generally gives a more accurate contact force magnitude, OP method gives more accurate contact point and contact plane, and OR method gives the results between those of OP and GP methods. On the other hand, the differences in the contact force magnitude and contact point are relatively small, whereas the difference in the contact plane can be very significant. Therefore, using CP method to obtain the contact point and contact plane is recommended, though GP method is more commonly used in the current DEM simulations. Our studies not only give a more comprehensive evaluation on the contact force models for ellipsoidal particles but also pave a solid way to compare and verify the contact force models for general non-spherical particles, which can help improve the accuracy of DEM for non-spherical particles.

Keywords: Discrete element method; Ellipsoidal particles; Contact force; Orientation Discretization; Finite element method