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Level-Set Enhanced Frictional Kernel Contact Algorithm for Impact and Penetration Modelling

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Conventional contact algorithms used in mesh-based methods such as FEM require the potential contact surface to be pre-defined. However, for impact and penetration problems, the contact surfaces change constantly, and, moreover, free surfaces form due to material separation. As a consequence, the contact surfaces cannot be pre-defined. In this work, we introduced a kernel contact algorithm that utilizes the interaction of Eulerian kernel functions between contacting bodies to naturally serve as the non-penetration condition in the semi-Lagrangian Reproducing Kernel Particle Method (SLRKPM) [1, 2]. Therefore, the interaction forces generated from the kernel function interaction constitute the contact forces.

The stick-slip condition between contacting bodies can be mimicked by introducing a lay of artificial elasto-plastic material, such that, with the isotropic hardening assumption and a proper yield function [1], this plasticity model represents the Coulomb's friction law. For computational efficiency, the frictional interaction forces between pairs of particles from different bodies were projected onto the normal and tangential directions of the contact surface. The tangential component of the interaction force was then corrected to be proportional to the normal component, following the Coulomb friction law.

A Lagrangian level set was introduced for an implicit representation of the contact surface to calculate the contact surface formed by two groups of particles without pre-defined boundary surfaces. The numerical examples on sliding block, Hertz contact, and Taylor bar impact problems verified the accuracy of the proposed frictional kernel contact algorithm. For balancing computational efficiency and accuracy in the penetration modelling, we considered different contact scenarios and assigned to each scenario different kernel contact algorithms. We demonstrated the effectiveness of the proposed method by modelling the penetration of a projectile into a concrete plate, as show in Figure 1. The numerical results show agreements with experimental data.

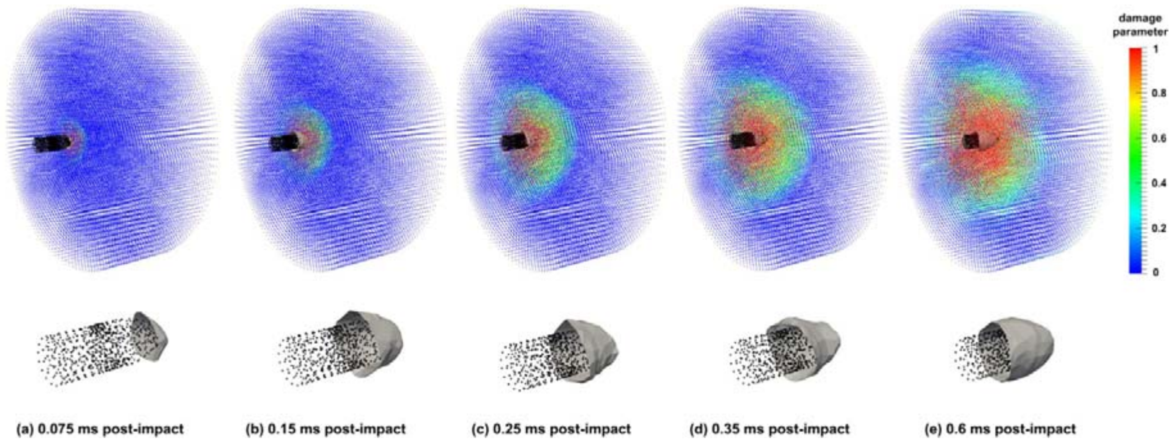

Figure 1 Progressive penetration processes and predicted contact surfaces by the RKPM SL formulation with the proposed frictional kernel contact algorithm

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