Improvement on the Material Point Method with B-spline Basis Functions

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ABSTRACT

The material point method (MPM) is a meshless particle numerical method, developed for simulating the challenging problems involving large deformations, fragmentations, and/or material discontinuity [1]. Since its first report [2], the MPM has been applied in many applications [2], including high-speed impact and penetration, landslide, saturated porous media, fluid-structure interaction, etc. The quality of the original/standard MPM is, however, inherently impaired by "cell-crossing instability" and "quadrature error" [3], and therefore many efforts have been made to reduce the errors resulting from cell-crossing and quadrature calculation in the MPM. Here, the MPM using the B-spline basis functions (referred as to BSMPM) has been presented and used to simulate example problems for investigating and demonstrating its improved performance in solving transient dynamic problems. It is shown that the use of smooth B-spline basis functions leads to significantly reduced cell-crossing error in the BSMPM, and that the increse in the order of B-spline basis function (e.g., cubic and quartic B-spline basis functions) is demonstrated to effectively diminish the quadrature error in the calculation of internal forces and to improve the accuracy and convergence of the BSMPM. A uniaxial-strain impact example has been solved using the BSMPM and the Generalized Interpolation Material Point (GIMP). The stress waves obtained by the BSMPM are found to exhibit higher accuracy than those predicted by the the GIMP. This work suggests that the BSMPM could be an attractive alternative to the MPM and the GIMP for solving dynamic problems.

REFERENCES

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