Automatic Mesh Relaxation Control Using Mesh Quality Measures

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Abstract

The multi-material ALE method provides the means to continue calculations past where high material deformations would cause a purely Lagrangian formulation to fail. The simplest strategy, when the Lagrangian mesh motion becomes too distorted, is to globally relax the mesh within the region of interest. This forces a multi-material treatment for all the material interfaces within the region, regardless of whether they individually merit it. The ideal situation would be for interfaces to become multi-material only where the mesh is sufficiently distorted to warrant it, thus maintaining the accuracy benefits of the Lagrangian interface tracking wherever possible.

This work aims to develop an intelligent algorithm that will automatically restrict the mesh relaxation to when and where it is really necessary for preventing mesh tangling and maintaining solution integrity. The main step is to introduce a measure of element quality which, in conjunction with user specified quality thresholds, selects where to allow the mesh to relax. A number of quality metrics have been considered, the simplest being the reciprocal of the element shear.

In practice a two-threshold strategy is used. If the element quality drops below the first higher threshold, then only the non-interface nodes are allowed to relax. Only if the mesh quality continues to drop, falling below the second lower threshold, are the interface nodes allowed to relax. This approach attempts to repair potential mesh tangling by relaxing the mesh internal to materials, before ultimately resorting to relaxing interfaces.

The above scheme has been implemented in the 3D ALE code PEGASUS. Its performance will be illustrated for a series of projectile penetration simulations, where the aim is to automatically restrict the relaxation of the material interfaces to the high deformation region immediately surrounding the penetration.