AN ADAPTIVE SPACETIME DISCONTINUOUS GALERKIN FRAMEWORK FOR IMPLEMENTING COHESIVE DAMAGE MODELS

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The spacetime discontinuous Galerkin (SDG) method for elastodynamics [1] provides an effective numerical framework for implementing cohesive damage models, from the perspectives of both performance and ease of implementation. It uses piecewise–continuous basis functions defined on unstructured, nonconforming spacetime meshes to describe displacement solutions that can be discontinuous across every inter–element boundary. We weakly enforce jump conditions to address kinematic compatibility and balance of linear momentum. The discontinuous structure leads to exact balance of linear and angular momentum on every spacetime element and superior shock–capturing properties. When implemented on *causal* spacetime grids, the SDG method exhibits linear complexity in the number of elements, and it is relatively easy to parallelize. It also provides the necessary ingredients for introducing a cohesive damage model, as explained below.

The basic requirements for implementing a cohesive model in a finite element setting are: (1) a means to represent displacement jumps across the cohesive interface and (2) a means to enforce the cohesive traction–separation law. The SDG model meets both requirements with minimal modification. Clearly, the discontinuous SDG displacement model satisfies the former requirement without modification. In the method proposed in [1], the jump condition for momentum balance matches the interior trace of the momentum flux to a *target momentum flux* on each element boundary. Typically, boundary data or a local Riemann problem determines the target flux. In the case of a cohesive model, the momentum flux reduces to a surface traction, and the cohesive traction–separation law defines the target traction field on each element face along the cohesive interface — no special cohesive elements are needed.

Adaptive mesh refinement may be required to capture the bulk response, especially when shocks are involved. Adaptive meshing might also be needed to prevent algorithmic failure (when too few elements are assigned to the the cohesive process zone) and to ensure that the traction–separation law is modeled with sufficient accuracy to determine reliably the fracture work of separation. We use an adaptive, advancing–front mesh generator called Tent Pitcher [2] to propagate the mesh in time. Tent Pitcher takes advantage of the nonconforming and unstructured properties of SDG meshes to produce strongly graded grids that adapt simultaneously in time and space. We investigate two independent error indicators to control the adaptive refinement. The first is a dissipation–based indicator that ensures the accuracy of the bulk solution; the second ensures the accuracy of the discrete rendering of the traction–separation law. We present example applications involving fracture and dewetting of inclusions in a composite material.

References

[1] R. Abedi, B. Petracovici, R. Haber, A spacetime discontinuous Galerkin method for linearized elastodynamics with elementwise momentum balance, In review.

[2] R. Abedi, S. Chung, J. Erickson, Y. Fan, M. Garland, D. Guoy, R. Haber, J. Sullivan, S. Thite, Y. Zhou. Spacetime meshing with adaptive refinement and coarsening. In *Proc. Symp. Comp. Geom.*, p. 300–309, 2004.

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