A MODIFICATION OF THE CROUZEIX-RAVIART ELEMENT VALID FOR NON-LINEAR FINITE DEFORMATION SOLID MECHANICS

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The 4-node quadrilateral in two-dimensions and the 8-node hexahedron in 3-dimensions are the favored tools for the finite element analysis of solid mechanics problems where full- or near-incompressibility, finite deformation, and/or non-linear material models are present. Such techniques as hourglass control allow these elements to model phenomena with a high ratio of accuracy and stability to expense.

Unfortunately, the creation of adequate quadrilateral/hexahedral meshes generally requires significant and tedious user intervention. Alternatively, low order triangular/tetrahedral meshes (3-node triangles/4-node tetrahedra) may be employed. It is well known however that these elements may exhibit seriously degraded accuracy, especially in cases involving significant bending and/or near incompressibility, where such elements are subject to severe locking.

On the other hand, the linear, partially discontinuous Crouzeix-Raviart element does not lock, but suffers from an inability to repress certain local rigid-body motions[1]. Recent work has established a method to stabilize this element[2]. However, this work is formulated on the basis of linear elasticity, with an additional penalty term. It is unclear how to extend this work generally to problems involving finite rotations and/or non-linear material models.

In this work, the idea of the lifting function from Arnold, et. al[3] has been applied to the Crouzeix-Raviart element, producing an element which is stable and does not lock. The lifting function has been utilized to produce additional strain fields, which provide a natural means to extend the model to finite deformations and non-linear material models. The model may be tuned to provide good behavior in bending. Numerical examples are presented and future work is discussed.

References

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[3] D. N. Arnold, F. Brezzi, B. Cockburn, and L. D. Marin "Unified Analysis of Discontinuous Galerkin Methods for Elliptic Problems", *SIAM Journal of Numerical Analysis*, v. 39, no. 5, p. 1749-1779, 2002.