Part 1: Polyhedral finite elements using optimization-based shape functions
Part 2: Multiscale material-model error estimation and model adaptivity

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Abstract

Part 1: A finite element formulation for general polyhedra is presented for applications in nonlinear solid mechanics. The polyhedra can have an arbitrary number of vertices or faces. Shape functions are constructed using both harmonic and maximum entropy coordinates. The shape functions exhibit the Kronecker-delta property at the nodes of the element, thus facilitating the imposition of displacement boundary conditions. A consistent quadrature scheme is developed that ensures a stable finite element formulation. Verification examples are presented.

Part 2: Two fundamental sources of error in solid mechanics modeling are (1) the assumption of a separation-of-scales in homogenization theory and (2) the use of a macroscopic material model that represents the complex nonlinear processes occurring at the microscale. These approximation errors may be particularly significant in welded regions of a structure and for additively manufactured metallic structures. In order to quantify these approximation errors on macroscale quantities-of-interest, we adopt a multiscale *a posteriori* error-estimation framework. The modeling error may be reduced by adapting the macroscale material model.

Bio

Joe Bishop received his Ph.D. in Aerospace Engineering from Texas A&M University in 1996. His graduate research was in the mechanics of composite materials and mechanisms of material damping. From 1997 to 2004 he worked in the Synthesis & Analysis Department of the Powertrain Division of General Motors Corporation, performing thermal-structural analysis of internal combustion engines with a focus on predicting high-cycle fatigue performance of the base engine. He joined Sandia National Laboratories in 2004 in the Engineering Sciences Center. He has worked on diverse topics including pervasive-fracture, penetration, geologic CO_2 sequestration, additive manufacturing, residual stress measurement, polyhedral finite elements, and multiscale error estimation. He is currently the manager of a modeling and simulation department.

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