ME Seminar

A Conforming Virtual Element Method on Embedded Domains with Shape-Agnostic Element Agglomeration

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ABSTRACT

In this talk, I will introduce the virtual element method (VEM) and present a conforming cut-cell embedded domain method (coined as cutVEM) that is based on the construction of agglomerated virtual elements. The VEM is a stabilized Galerkin method that is accurate on general convex and nonconvex polytopal meshes, and is notably robust on n-sided polygons (n > 3) with short edges. On cutting a two-dimensional finite element mesh with a line or curve, poorly-shaped triangles (interior angles close to 0 deg. and/or 180 deg.) can arise, which must then be resolved. To do so, we agglomerate such `bad' triangles with their neighbors to create polygons having four or more edges. Th stability ratio (inverse of the condition number of the stiffness matrix) is used as the criterion in the agglomeration algorithm. Agglomeration may alter the number of elements and their connectivities, but preserves the number of mesh vertices and hence the degree of freedom count. Furthermore, since a conforming mesh is utilized in cutVEM, essential boundary conditions are strongly enforced and natural boundary conditions are weakly enforced for material discontinuities, which mirrors the finite element method. CutVEM addresses the key limitations and challenges that are present in current embedded domain methods (e.g., cutFEM, cutIGA, and finite cell)---ill-conditioning of basis functions, numerical integration over cut-cells, and imposition of Dirichlet boundary conditions. Heat conduction problems (homogeneous and discontinuous conductivity coefficient) with Dirichlet as well as mixed (Dirichlet and Neumann) boundary conditions on immersed geometries will be presented to demonstrate the sound accuracy and optimal rate of convergence of cutVEM. This is joint work with Ramsharan Rangarajan at IISc Bangalore.

ABOUT THE SPEAKER

Sukumar holds a Ph.D. (1998) in Theoretical and Applied Mechanics from Northwestern University. He was a post-doctoral fellow at Northwestern University in 1999 and a research associate at Princeton University in 2000, before joining UC Davis in 2001, where he is currently a Professor in Civil and Environmental Engineering. Sukumar is a Regional Editor of International Journal of Fracture, and a member of the Editorial Boards of Computer Methods in Applied Mechanics and Engineering and Finite Elements in Analysis and Design. Sukumar's current research emphasis is on novel discretization methods (such as virtual element methods on polygonal and polyhedral meshes) for deformation and fracture of solid continua, and on scientific machine learning to solve partial differential equations on complex geometries.

Date: Tuesday, 8th September 2026, 04.00 PM,

Venue: MMCR, ME Department