Structural Engineering Seminar Series

CEE 595 S

Octree Discretizations, Neural Geometric Representations, and Immersed Approaches for Scalable PDE Solvers

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Abstract:

High-fidelity simulation on complex geometries remains constrained by meshing and geometry handling. I will discuss our efforts in building scalable PDE solvers using adaptive, incomplete octrees, with immersed boundary approaches, and introducing a geometry pipeline based on implicit neural representations (INRs).

We explore both Immersogeometric Analysis (IMGA) and the Shifted Boundary Method (SBM) on adaptive incomplete octrees. We evaluate geometric flexibility, accuracy and scalability alongside well-known challenges like cut-cell conditioning, high-order quadrature on slivers, and load balancing at scale. The second part connects SBM to neural signed-distance fields: INRs provide continuous geometry queries (distance, normals) on demand, eliminating explicit meshing and remeshing. Several benchmarks in fluid and solid mechanics (e.g., cavity flows with obstacles, porous/gyroidal structures, and scanned shapes) illustrate accuracy and throughput comparable to mesh-based pipelines.

This is collaborative work with A. Krishnamurthy, M-C. Hsu (Iowa State), G. Scovazzi (Duke), and H. Sundar (Tufts), and is funded by NSF, USDA-NIFA, and DoD.

Bio:

Baskar Ganapathysubramanian is is the Anderlik Professor of Engineering at Iowa State University. He received a B.Tech. from IIT Madras and a Ph.D. from Cornell University. He directs a curiosity-driven computational sustainability group focused on scientific computing, applied mathematics, and machine learning with applications to food, energy, and healthcare systems (me.iastate.edu/bglab). He is Director of the NSF/USDA-funded AI Institute for Resilient Agriculture (aiira.iastate.edu) and Associate Director of the Translational AI Center at Iowa State University.

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1310 Yeh Student Center