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MESHFREE, PERIDYNAMIC, AND PARTICLE METHODS: ADVANCEMENTS AND APPLICATIONS

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ABSTRACT

Simulations involving fracture, localization, shocks, and fluid-like plastic flow require a departure from traditional Lagrangian finite elements. Meshfree, peridynamic, and particle methods have proven successful here, using point-based approximations without fixed mesh connectivity. They offer a natural framework for problems that would otherwise require erosion, mesh-moving, and remeshing with traditional methods.

Their approximations allow controllable continuity and completeness, offering flexibility in incorporating enrichments that capture the physics of various problems. Peridynamic methods can likewise model systems with or without discontinuities and share many features with meshfree and particle methods. All are versatile enough to naturally embed and couple machine-learning techniques.

This session aims to promote collaboration among academia, government/national labs, and industry to share recent advances and lessons learned and to facilitate knowledge transfer. Contributions are solicited on all subjects related to these methods, including:

-Fundamental theoretical and algorithmic developments, including mixed formulations and cell-based schemes

-Integration with machine learning, AI, and data-driven analysis; Ritz and PINN approaches

-HPC and efficient solvers, including multigrid

-VR physics, real-time simulation, digital twins, visual computing, and reduced-order modeling

-One-to-one comparisons of meshfree and mesh-based methods in challenging applications

-Strong and weak discontinuities, e.g., strong shocks, crack propagation, and material interfaces

-Industry and lab applications where these methods outperform conventional ones, such as natural disasters, manufacturing, additive manufacturing, and cardiovascular/ biomechanics

-Treatment of extreme distortion, fragmentation, contact, and impact

-Novel discretizations such as wavelets, multiresolution, and enriched methods for composite microstructures, fluid-structure interaction, multi-phase, and multi-scale problems

-Enhanced collocation and integration, including variationally consistent integration, strong-form collocation, and solutions to rank, kernel, and zero-energy mode instability

-Parallel computing, including GPUs, APUs, heterogeneous architectures, and large-scale simulations