Ji, Zhe; **Fu, Lin**; **Hu, Xiangyu**; **Adams, Nikolaus**

A consistent parallel isotropic unstructured mesh generation method based on multi-phase SPH.

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Summary: In this paper, we propose a consistent parallel unstructured mesh generator based on a multi-phase SPH method. A set of physics-motivated modeling equations are developed to achieve the targets of domain decomposition, communication volume optimization and high-quality unstructured mesh generation simultaneously. A unified density field is defined as the target function for both partitioning the geometry and distributing the mesh-vertexes. A multi-phase Smoothing Particle Hydrodynamics (SPH) method is employed to solve the governing equations. All the optimization targets are achieved implicitly and consistently by the particle relaxation procedure without constructing triangulation/tetrahedralization explicitly. The target of communication reduction is achieved by introducing a surface tension model between distinct partitioning sub-domains, which are characterized by colored SPH particles. The resulting partitioning diagram features physically localized sub-domains and optimized interface communication. The target of optimizing the mesh quality is achieved by introducing a tailored equation-of-state (EOS) and a smooth isotropic kernel function. The mesh quality near the interface of neighboring sub-domains is improved by gradually removing the surface-tension force once a steady state is achieved. The proposed method is developed basing on a new parallel environment for multi-resolution SPH to exploit both coarse- and fine-grained parallelism. A set of benchmarks are conducted to verify that all the optimization targets are achieved consistently within the current framework.

MSC:

65N50	Mesh generation, refinement, and adaptive methods for boundary value problems involving PDEs
65D18	Numerical aspects of computer graphics, image analysis, and computational geometry
65N55	Multigrid methods; domain decomposition for boundary value problems involving PDEs
76M28	Particle methods and lattice-gas methods

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Keywords:

parallel mesh generator; high performance computing; smoothing particle hydrodynamics; domain decomposition

Software:

Intel TBB; Triangle; CUDA; TetGen; Netgen; DualSPHysics

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