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Simulation of Elastic Bodies through Discrete Element Method, Coupled with a Nested Overlapping Grid Fluid Flow Solver

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Abstract : In this work, a finite volume fluid flow solver is coupled with a discrete element method module for the simulation of the dynamics of free and elastic bodies in interaction with the fluid and between themselves. The open source fluid flow solver, caffa3d.MBRi, includes the capability to work with nested overlapping grids in order to easily refine the grid in the region where the bodies are moving. To do so, it is necessary to implement a recognition function able to identify the specific mesh block in which the device is moving in. The set of overlapping finer grids might be displaced along with the set of bodies being simulated. The interaction between the bodies and the fluid is computed through a two-way coupling. The velocity field of the fluid is first interpolated to determine the drag force on each object. After solving the objects displacements, subject to the elastic bonding among them, the force is applied back onto the fluid through a Gaussian smoothing considering the cells near the position of each object. The fishnet is represented as lumped masses connected by elastic lines. The internal forces are derived from the elasticity of these lines, and the external forces are due to drag, gravity, buoyancy and the load acting on each element of the system. When solving the ordinary differential equations system, that represents the motion of the elastic and flexible bodies, it was found that the Runge Kutta solver of fourth order is the best tool in terms of performance, but requires a finer grid than the fluid solver to make the system converge, which demands greater computing power. The coupled solver is demonstrated by simulating the interaction between the fluid, an elastic fishnet and a set of free bodies being captured by the net as they are dragged by the fluid. The deformation of the net, as well as the wake produced in the fluid stream are well captured by the method, without requiring the fluid solver mesh to adapt for the evolving geometry. Application of the same strategy to the simulation of elastic structures subject to the action of wind is also possible with the method presented, and one such application is currently under development.

Keywords : computational fluid dynamics, discrete element method, fishnets, nested overlapping grids
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