COMPUTATIONAL RESEARCH in BOSTON and BEYOND SEMINAR

Reference map technique: a fully Eulerian method for fluid-structure interactions

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ABSTRACT:

Fluid-structure interactions (FSI) are abundantly observed in contexts ranging from swimming in the pool, to industrial level manufacturing, to bacteria collective motion on a petri dish. However, the governing equations are only analytically trackable in the simple cases, making simulations key to understand this fantastic class of problems. Conventional computational methods often create a dilemma for fluid-structure interaction (FSI) problems. Typically, solids are simulated using a Lagrangian approach with a grid that moves with the material, whereas fluids are simulated using an Eulerian approach with a fixed spatial grid. FSI methods often require some type of interfacial coupling between the two different perspectives. We present a fully Eulerian FSI method that addresses these challenges. The method makes use of reference map, which maps the solid in the current space to the reference space. Reference map is a common concept in finite strain theory, but it has been under-utilized as a primary variable for solid and FSI simulations. A challenge in applying the reference map technique (RMT) in FSI is to extrapolate reference map values from grid cells occupied by the solids to unoccupied grid cells, in order to calculate derivative using finite difference schemes. This challenge becomes more acute when applying RMT to simulations in 3D. We develop an extrapolation algorithm based on least-square linear regression that is suitable for parallelization. We show examples to demonstrate that RMT is well suited for simulating soft, highly-deformable materials and many-body contact problems. Joint work with Nicholas Derr and Chris H. Rycroft *(SEAS, Harvard University)* and Ken Kamrin *(Mechanical Engineering, MIT)*.

FRIDAY, JULY 10, 2020
12:00 PM – 1:00 PM

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