Transient mesh adaptivity applied to domains undergoing large deformations

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When solving fluid-structure interaction problems, a common way to handle the displacements of the structural nodes inside the fluid domain is to reposition the fluid nodes and adopt an ALE formulation of the fluid equations. However, this method suffers from obvious limitations as nodes repositioning cannot always provide a valid mesh when significant displacements of the structure are considered.

A typical solution of this problem is to remesh the entire domain every time it is needed. Here, we rather use local mesh modifications to enable large mesh motions. Local mesh modifications have some advantages compared to global remeshing:

- local solution projection procedures can be easily set up that ensure the local conservation of conservative quantities,
- the mesh remains unchanged in most of the domain, allowing to adapt the mesh frequently,
- local mesh modifications can be performed in parallel, enabling transient adaptive simulation to run on parallel computers.

We present a 3D mesh adaptation procedure which makes use of a mesh metric field that represents the desired size of the mesh [1]. A mesh metric field is a smooth tensor valued field $\mathcal{M}(x, y, z)$ that allows one to compute an adimensional length for each edge e (defining a vector $\mathbf{e}$) as

$$L_e = \int_e \sqrt{\mathbf{e}^t \, \mathcal{M}(x, y) \, \mathbf{e}} \; dl.$$

The aim of the procedure is to modify an existing mesh to make it a mesh in which every edge is close to the size $L_e = 1$. The use of a tensor valued metric field allows the construction of anisotropic meshes.

We present an algorithm in which local mesh modification operators like edge splits, edge or face swaps, edge collapses and node relocations are applied until every edge of the domain has a dimensionless size in the interval $L_e \in [1/\sqrt{2}, \sqrt{2}]$. This interval prevents the algorithm to oscillate between coarsening and refinement operations.

This method was already applied to transient multiphase flow simulations in [2]. The mesh was adapted in order to deliver a better accuracy near the interface between the fluids. It is now redesigned to allow huge displacements of objects inside the domain and/or huge displacements of the boundaries of the domain.

References

[1] X. Li. *Mesh Modification Procedures for General 3-D Non-manifold Domains*. PhD thesis, Rensselear Polytechnic Institute, 2003.

[2] G. Compère, E. Marchandise, and J-F. Remacle. Transient adaptivity applied to free surface flows. *Journal of Computational Physics*, 227:1923–1942, 2008.

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