Anisotropic mesh adaptivity for FSI applications with 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.

In a previous work [1], an algorithm based on local mesh modifications has been proposed to overcome the issues. 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.

Here, we extend this approach to anisotropic meshes. We consider an anisotropic mesh metric field that represents the desired size of the mesh [2]. 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 $L_e = 1$.

Recent works (see for instance [3]) have shown that local mesh adaptation techniques can generate anisotropic meshes which are efficient in capturing boundary layers in fluid computations. In this work, we use the algorithm described in [1] to maintain such a mesh while the boundary undergoes large displacements or deformations, enabling FSI computations to handle both boundary layers and large deformations.

References

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