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Anisotropic mesh adaptation and effects on the conditioning of unstructured finite element solvers

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Abstract

Over the past decades the growing need for high fidelity flow simulations paved the way to promising techniques such as anisotropic mesh adaptation in finite elements (FE) frameworks. The aim of the work is twofold.

First we present a multi-dimensional mesh adaptation method inspired by the work of Mesri [1], which produces optimal meshes for quadratic functions, positive semi-definite. The method generates anisotropic adaptive meshes as quasi-uniform ones in some metric space, with the tensor metric being computed based on an estimate of the interpolation error. The L^p-norm of the estimated error is then minimized in order to get an optimal mesh.

Secondly we apply the proposed method to numerical examples, namely diffusion and advection-diffusion [2] problems. We investigate the impact of anisotropic adapted meshes on the conditioning of the stiffness matrix, that stems from the FE discretized problem.

The results show that, using a simple Jacobi diagonal scaling as proposed by Kamenski [3], we can strongly reduce (or even delete) the gap between isotropic and anisotropic meshes, in term of conditioning. This indicates that, especially if the mesh concentration is near the boundary, the impact of anisotropy on the performances of the solver is better than what is commonly feared.

Keywords: anisotropic mesh, metrics, interpolation error, conditioning, diagonal scaling, preconditioning, finite elements, mesh adaptation.

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