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Adaptive finite elements with large aspect ratio : theory and practice

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ABSTRACT

Adaptive finite elements with large aspect ratio allow complex finite element simulations to be performed with fewer vertices. The refinement and coarsening criteria are based on anisotropic a posteriori error estimates which rely on the anisotropic interpolation estimates. The goal of such estimates is to circumvent the usual smallest angle condition, see for instance the papers of Kunert [1] and co-workers or those of Formaggia and Perotto [2,3].

Anisotropic error estimates are nowadays available for various academic problems such advection-diffusion, Stokes, the heat equation but also for more challenging problems such as CFD or crystal growth [4,5]. Due to recent developments in anisotropic mesh generation, three dimensional anisotropic adaptive algorithms have been implemented, showing that complex simulations can be performed on workstations rather than clusters.

The adaptive strategy will first be presented for the Laplace problem in two space dimensions [6]. The error estimator involves the equation residual and the error gradient in the directions of maximum and minimum stretching. The error gradient is approached using Zienkiewicz-Zhu post-processing. It is shown that the error estimator is equivalent to the true error provided the error in the directions of maximum and minimum stretching is equidistributed. An adaptive algorithm is then proposed, with goal to equidistribute the error in the directions of maximum and minimum stretching. It is checked numerically that the effectivity index (the ratio between the estimated and the true error) does not depend on the aspect ratio on such adapted meshes.

Numerical results will be proposed for crystal growth with phase field and for supersonic flows around aircrafts [7].

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