Anisotropic 3D Delaunay Mesh Adaptation for High Speed Compressible Flow

X.Z. Xie, E. Remaki, O. Hassan, K. Morgan and N.P.Weatherill

Civil and Computational Engineering Centre
School of Engineering
Swansea University
Swansea SA2 8PP
Wales, UK
o.hassan@swansea.ac.uk

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Abstract

There have been significant developments in unstructured mesh based procedures for the solution of problems involving high speed compressible flows. The principal advantages of this approach are well known and centre, mainly, on the observation that it provides a powerful tool for the discretisation of domains of complex shape. An additional feature is that adaptive mesh procedures can be readily implemented, allowing the solution quality to be enhanced.

In compressible flow problems, small regions of rapid change in the solution are frequently embedded in large regions of smooth solution. To simulate correctly the interaction of these discontinuities, an appropriately fine mesh is required. The use of adaptive refinement techniques becomes imperative to avoid the need for an overall fine mesh and, hence, reduce the cost of these simulations. The success of this process will depend on the ability to define a suitable error indicator, which must be capable of determining an improved distribution of the mesh parameters for use by the mesh generator. In addition, a mesh generator which is capable of the generation of stretched elements.

In this work, error indicators based upon the use of interpolation theory are used to provide an indication of the accuracy of the computed solution. A single key variable, or a combination of variables, are subjected to the error indication process. As well as detecting discontinuities in the solution, the procedure also provides information about any directionality which may be present. Unstructured mesh adaptation is then accomplished by the generation of customised meshes that enable flow features to be captured in an optimal manner and maintain the order of convergence of the solution algorithm. Delaunay triangulation with a modified in-circle criterion which enable the generation of highly stretched meshes in two and three dimensions is described. The general purpose error indicator is used on the solution obtained on an initial mesh to produce an anisotropic metric map at every point of the initial mesh which can then be used to govern the mesh sizing for the new mesh. Various applications in 2D and 3D are will be shown to demonstrate the robustness and efficiency of the method on practical examples.

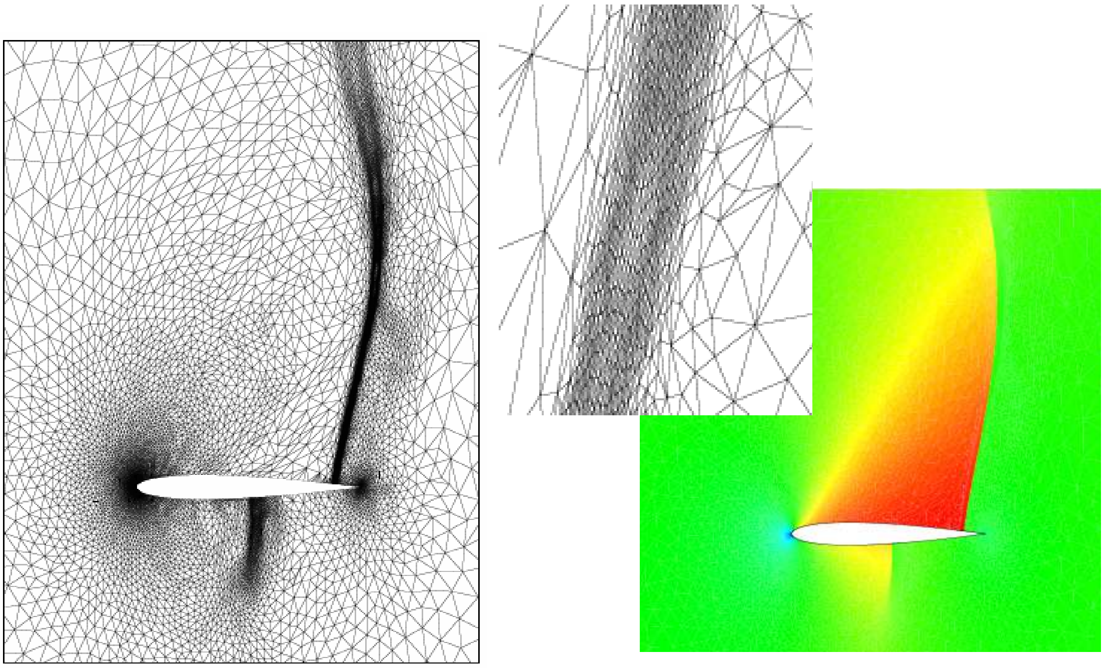

Figure 1: 2D Anisotropic Mesh Adaptation: Naca0012 (M = 0.85 – α = 2.79°)

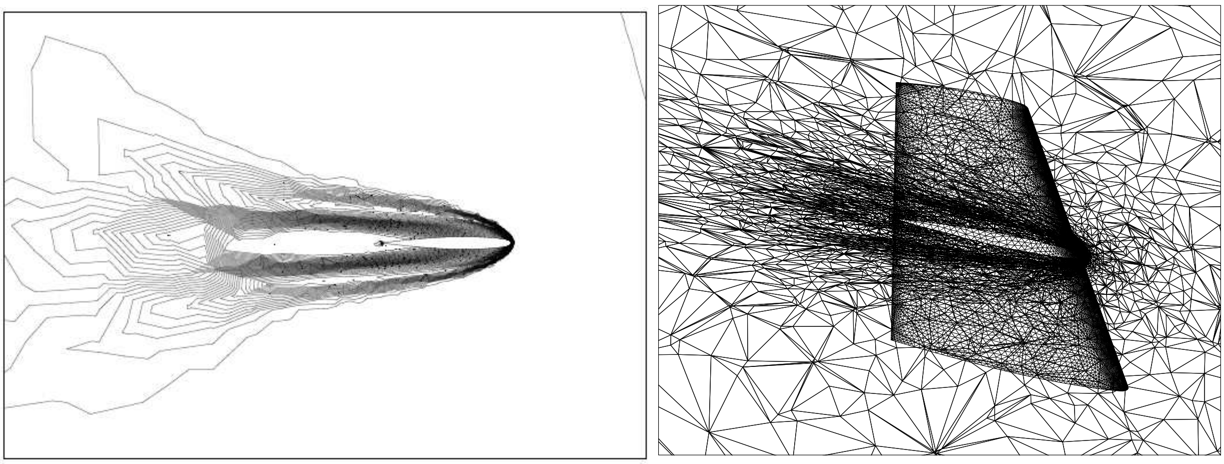

Figure 2: 3D Anisotropic Mesh Adaptation: Onera M6 Wing (M = 0.85 – α = 3.19°)