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ANISOTROPIC 3D DELAUNAY MESH ADAPTATION FOR HIGH SPEED COMPRESSIBLE FLOWS

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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, narrow regions of rapid change in the solution are frequently embedded in large regions of smooth flow. To simulate correctly the interaction of these high gradient regions, an appropriately fine mesh is required. The computational efficiency can be improved by the use of adaptive refinement techniques that avoid the need for an overall fine mesh. 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. An additional requirement is the use of a mesh generator which is capable of producing 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, is 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 enables the generation of highly stretched meshes in two and three dimensions is described. The general purpose error indicator is applied to 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. Initial 2D and 3D results are shown in

Figure 1, for a NACA0012 at a Mach number of 0.85 and 2.79 degrees angle of attack, and in Figure 2, for an ONERA M6 wing at a Mach number of 0.85 and 3.19 degrees angle of attack. Addititonal 2D and 3D results will be presented to demonstrate the robustness and efficiency of the method.

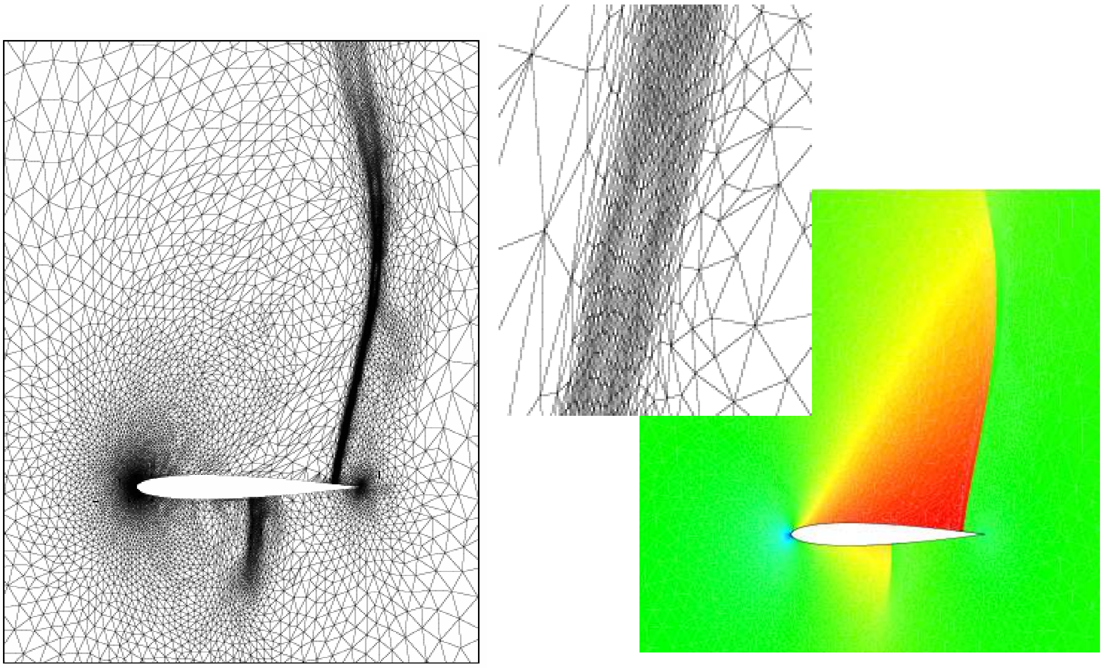

Figure 1: 2D anisotropic mesh adaptation for the problem of flow over a NACA0012 aerofoil at a free stream Mach number of 0.85 and 2.79 degrees angle of attack.

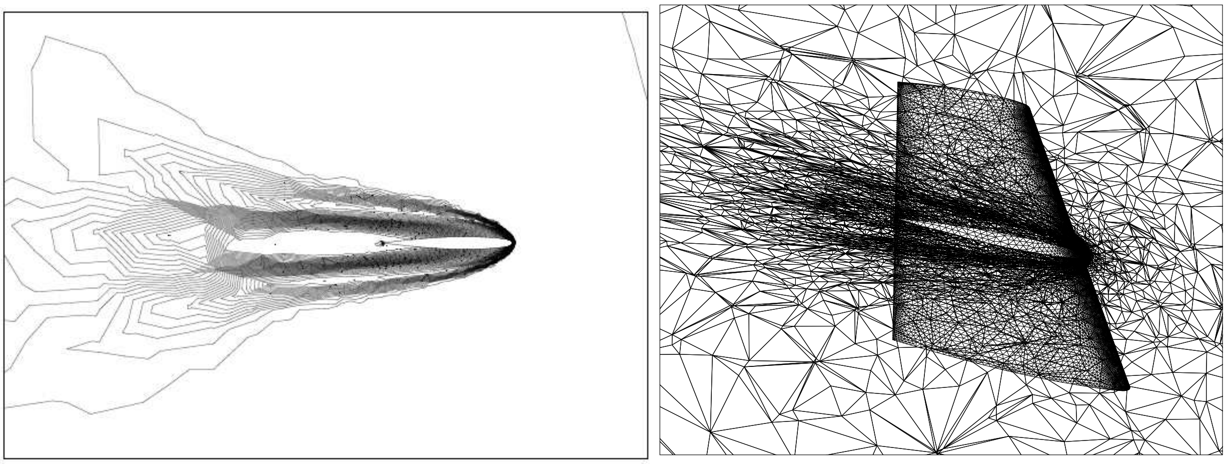

Figure 2: 3D anistropic mesh adaptation for the problem of flow over an ONERA M6 wing at a free stream Mach number of 0.85 and 3.19 degrees angle of attack.