Physics dependent de-featuring, is it a prerequisite for mesh generation?

Oubay Hassan and Ruben Sevilla

The use of numerical simulation as a design tool in engineering is nowadays routinely practiced. The initial stage of the simulation process is the generation of an appropriate mesh that is designed to capture the required physics. Mesh generation algorithms require water tight geometries as a starting point. Many automatic software have been developed in the last decades that are capable of ensuring water tightness with a minimum user interventions. However, when dealing with complex objects that contains multi-scale features it is often necessary to manually remove small features which are in the 'expert' opinion of the analyst will not have a measurable effect on the solution of the physical system under consideration.

The major drawback of this de-featuring stage is the requirement for manual interaction with CAD systems or geometry cleaning tools. Furthermore, the de-featuring has to be repeated for every physical system that is required to be considered in the design, i.e fluid dynamics, electromagnetics, acoustics, heat and radiation, structure mechanics, etc. In addition, the de-featuring is often dependent on the level of approximation considered for the simulation of the physical system, i.e Euler, Reynolds average or LES in the case of fluid dynamics. In the case of electromagnetics and acoustics simulations, the de-featuring is dependent on every frequency of the required range the designer has to consider.

In this presentation we propose an automatic unstructured mesh generation technique using a variant of the advancing front method whereby mesh fronts coincident with the NURBS boundary match the exact geometric definition from CAD independently on the element size. The method allows the possibility to have elements much larger than small geometric features, reducing the overall number of elements required and removing the need for physic dependent de-featuring. The method used to extend the generation technique to high order meshes, based on the approach presented in [1], will also be presented. The presentation will highlight the use of NURBS-Enhanced Finite Element Method [2] to incorporate the resulting meshes within Finite Element codes. Finally, examples will be shown to demonstrate the effectiveness of the proposed method.

The example in Figure 1 shows the simulation of the scattering on an electromagnetic wave by a complex geometry containing small features. In a traditional FE framework, this simulation requires either de-featuring of the geometry or the use of extremely refined meshes if small geometric features are relevant for the correct prediction of the physics.

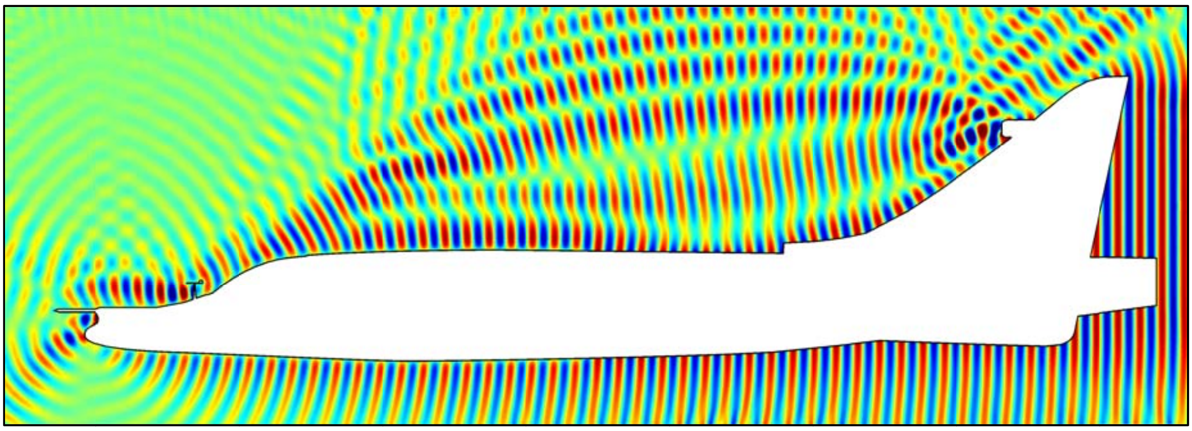

Figure 1. *Scattering of an electromagnetic wave by a complex geometric configuration containing small geometric features.*

Figure 2 shows the mesh required to simulate the problem using tradition FE (left) and the meshes that can be generated using the proposed approach (right). It can be observed that the size of the elements is completely independent on the geometric complexity and the size of small features.

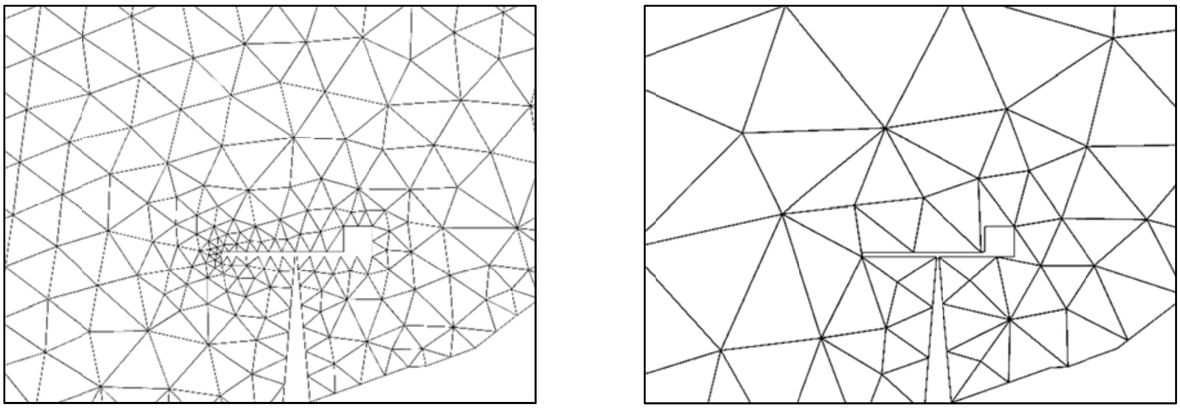

***Figure 2**. Mesh produced with a standard FE mesh generator (left) showing the required mesh refinement to capture small geometric features and mesh produced with the new approach (right) showing coarse elements capturing complex boundary geometric features.*

References

[1] Z. Q. Xie, R. Sevilla, O. Hassan and K. Morgan, *The generation of arbitrary order curved meshes for 3D finite element analysis*, Computational Mechanics, 51 (3); 361-374 (2013)

[2] R. Sevilla, S. Fernández-Méndez and A. Huerta, *NURBS-Enhanced Finite Element Method (NEFEM): A seamless bridge between CAD and FEM*, Archives of Computational Methods in Engineering, 18 (4); 441-484 (2011)