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Mesh adaptation and the future of shell computations

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ABSTRACT

Mesh adaptation methods have proved to be an important tool for users of the Finite Element Method. They permit to reach a desired accuracy at minimal cost by refining the mesh only where needed. It has also been clearly demonstrated (e.g.,[1]) that anisotropic adaptation enables an otherwise impossible resolution of shocks or boundary layers for fluid mechanics computations. We want to point out that it can be employed for shell problems. Mesh adaptation requires two basic components:

- an error estimator,
- a procedure to generate or to modify the mesh according to the indicator.

We shall first present the mesh adaptation method developed at GIREF and how it implements these components.

The error indicator is based on a re-interpolation of a FEM solution by a higher order differentiable approximation. It is therefore problem independent. This is related to the Zienkiewicz and Zhu's[5] estimator or more closely to the work of Zhimin Zhang [4] on polynomial preserving recovery.

Experience has shown that this yielded an efficient technique even if it partially emanates from heuristic ideas. The important point is that it can be computed knowing only the numerical solution. This procedure can be extended to curved surfaces.

As to the mesh adaptation process itself, we have chosen a mesh modification procedure instead of a mesh generation one as employed by [2]. The method is based on four elementary operations, acting locally on patches of elements:

- moving nodes,
- swapping edges,
- adding nodes,
- removing nodes.

The first two operations are done in order to minimise the error on a patch of elements while the last two are employed to reach a desired accuracy.

We shall describe these operations and present numerical results showing the potential of he method for advancing fronts and boundary layers.

This brings us to shells where boundary layers are an important and common feature ([3]). The above technique has been extended to curved surfaces. One must then add a geometrical error criterion: The mesh should represent the geometry wih sufficient accuracy. Operators can also become more complex. For example, edge swapping can create folds if some care is not taken.This is illustrated by a few simple cases.

REFERENCES

[1] Dompierre J., Vallet M.-G., Bourgault Y., Fortin M. , Habashi W.G., Anisotropic mesh adaptation: towards user-indepedent, mesh-independent and solver-independent CFD. Part III: unstructured meshes, Int. J. Numer. Meth. Fluids 39 (2002) 675-702.

[2] George P.L. and Hecht F., Handbook of Grid Generation, chap. 20: Nonisotropic grid., Editor J.F. Thompson, B.K. Soni, N.P. Weatherill, CRC Press.

[3] Sanchez-Palencia E., General properties of thin shell solutions, propagation of singularities and their numerical incidence. in *Computational Fluid and Solid Mechanics*, Bathe KJ (ed.),454455, Elsevier: Amsterdam, 2001.

[4] Zhimin Zhang *, Ahmed Naga, Validation of the a posteriori error estimator based on polynomial preserving recovery for linear elements, *International Journal for Numerical Methods in Engineering*, **61**, 1860 - 1893, 2004.

[5] Zienkiewicz, O.C., Zhu, J.Z. , A simple error estimator and adaptive procedure for practical engineering analysis, *International Journal for Numerical Methods in Engineering* , **24**, 337-357, 1987.