Terminal-edge algorithms: an integrated approach for mesh generation

Maria-Cecilia Rivara*
Departamento de Ciencias de la Computación, Universidad de Chile
mcrivara@dcc.uchile.cl

Presentado en mned 2005
Métodos Numéricos para Ecuaciones Diferenciales Parciales
Buenos Aires, Argentina

1 Abtract

Unstructured meshes are widely used as basic tools for solving application problems by means of either the finite element or the finite volume methods. In recent years, we have developped terminal-edge algorithms for the refinement of non-Delaunay triangulations [1, 4, 5], which generalize previous longest-edge algorithms, as well as a new family of terminal-edge algorithms for improving Delaunay triangulations, including algorithms for automatic quality triangulation, for obtuse triangulation improvement [2, 3] as needed in finite volume methods, and for approximate quality triangulation [6]. These algorithms take advantage of the properties of two related concepts: the Lepp (longest-edge propagation path) of any triangle (tetrahedron) and its associated terminal-edges. Either for improving or refining a mesh, the algorithms use a terminal-edge point selection criteria as follows. For any target element to be improved or refined, the midpoint of an associated terminal-edge is selected for point insertion. Each terminal-edge is a special edge in the mesh which is the common longest-edge of every element (triangle or tetrahedron) that shares this terminal-edge in the mesh. In the case of the refinement algorithm, mesh refinement is performed by longest-edge bisection of all the elements that share the terminal-edge, which is a very local operation. In the case of the improvement algorithms, a constrained Delaunay triangulation is assumed, and terminal-edge midpoint insertion is performed by using a constrained Delaunay algorithm. The process is repeatedly performed until the target element is destroyed in the mesh. In 2-dimensions the refinement algorithms essentially guarantee that the quality of the input triangulation is maintained, while the improvement algorithms assure that a 30 degrees triangulation can be obtained.

In research in course we work on obtaining stronger results in 2-dimensions, the generalization of the results to 3-dimensions, the parallelization of terminal-edge refinement algorithms [7], the development of a meshing tool that integrates the algorithms in 3-dimensions [8]. In this talk, the

* *Financiado parcialmente por Proyecto Fondecyt 1040713*

algorithms, their mathematical properties, some implementation issues, as well as some of their possible extensions are discussed.

References

[1] M. C. Rivara. New longest-edge algorithms for the refinement and/or improvement of unstructured triangulations. *International Journal for Numerical Methods in Engineering*, **40**, 1997, 3313–3324.

[2] N. Hitschfeld and M.C. Rivara. Automatic construction of non-obtuse boundary and/or interface Delaunay triangulations for control volume methods. *International Journal for Numerical Methods in Engineering*, **55**, 2002, 803–816.

[3] N. Hitschfeld, L. Villablanca, J. Krause, and M.C. Rivara. Improving the quality of meshes for the simulation of semiconductor devices using Lepp-based algorithms. *International Journal for Numerical Methods in Engineering*, **58**, 2003, 333–347 .

[4] M. C. Rivara, N. Hitschfeld, and R. B. Simpson. Terminal edges Delaunay (small angle based) algorithm for the quality triangulation problem. *Computer-Aided Design*, **33**, 2001, 263–277.

[5] M. C. Rivara and M. Palma. New LEPP Algorithms for Quality Polygon and Volume Triangulation: Implementation Issues and Practical Behavior. *In Trends unstructured mesh generation*, Eds: S. A. Cannan . Saigal, AMD, **220**, 1997, 1–8.

[6] R.B. Simpson, N. Hitschfeld and M.C. Rivara, Approximate quality mesh generation, *Engineering with computers*, **17**, 2001, 287-298.

[7] M.C. Rivara, D. Pizarro, N. Chrisochoides, Parallel refinement of tetrahedral meshes using terminal-edge bisection algorithm, *Proceedings 13th International Meshing Roundtable, Sandia National Labs*, 2004, pp. 427-436.

[8] M C Rivara, A Caceres, C Lillo and N Hitschfeld-Kahler A study on terminal edge algorithms for the refinement / improvement of 3-dimensional triangulations. *Proceedings International Conference on Adaptive Modeling and Simulation ADMOS 2005*, P Diez and N.-E.Wiber (eds.). CIMNE, 2005, pp 402-409.