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FreeFem++: a versatile tool to solve opimization problem in finite element methods

***Frédéric Hecht[1]**

UPMC Univ Paris 06 UMR 7598,
Laboratoire Jacques-Louis Lions, F-75005, Paris, France
E-mail: Frederic.Hecht@upmc.fr http://www.ann.jussieu.fr/~hecht

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ABSTRACT

I will present FreeFEm++ and how to use to build a optimization process in CFD. This optimization example is the classic reduction drag problem around a multi-corp wing. We will all show how to add novel technics as mesh adaptation with anisotropy , fast sparse linear solver.

FreeFem++ is a free software to solve bidimensional and tridimensional PDE's and the characteristics of FreeFem++ are:

• Problem description (real or complex valued) by their variational formulations, with access to the internal vectors and matrices if needed.

• Multi-variables, multi-equations, static or time dependent, linear or nonlinear coupled systems; however the user is required to describe the iterative procedures which reduce the problem to a set of linear problems.

• Easy geometric input by analytic description of boundaries by pieces in 2d; however this software is not a CAD system; for instance when two boundaries intersect, the user must specify the intersection points.

• Automatic mesh generator, based on the Delaunay-Voronoi algorithm in 2d. Inner point density is proportional to the density of points on the boundary [1].

• Metric-based anisotropic mesh adaptation in 2d. The metric can be computed automatically from the Hessian of any FreeFem++ function [2].

• High level user friendly typed input language with an algebra of analytic and finite element functions.

• Multiple finite element meshes within one application with automatic interpolation of data on di•erent meshes and possible storage of the interpolation matrices.

• A large variety of triangular finite elements : linear and quadratic Lagrangian elements, discontinuous P1 and Raviart-Thomas elements, elements of a non-scalar type, mini-element,. . . (but no quadrangles).

• Tools to define discontinuous Galerkin formulations via finite elements P0, P1dc, P2dc and keywords: jump, mean, intalledges.

• A large variety of linear direct and iterative solvers (LU, Cholesky, Crout, CG, GMRES, UMFPACK) and eigenvalue and eigenvector solvers.

• Near optimal execution speed (compared with compiled C++ implementations programmed directly).

• Online graphics, generation of ,.txt,.eps,.gnu, mesh files for further manipulations of input and output data.

• Many examples and tutorials: elliptic, parabolic and hyperbolic problems, Navier-Stokes flows, elasticity, Fluid structure interactions, Schwarz's domain decomposition method, eigenvalue problem, residual error indicator, ...

• An parallel version using mpi

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