ONERA

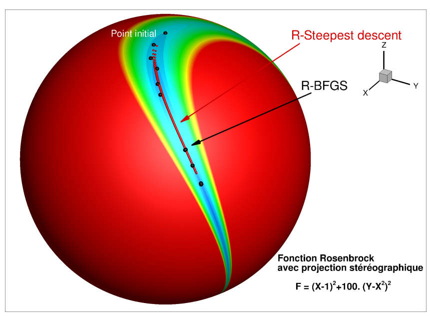
THE FRENCH AEROSPACE LAB

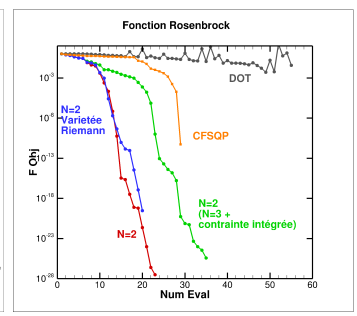
DOCTORAL THESIS : Constrained Optimization by Approximate Riemannian BFGS Approach - *Application to optimum-shape design in aerodynamics*

Objective : To develop and evaluate a new type of constrained-optimization algorithms and perform a computational demonstration in optimum-shape design in aerodynamics.

Broyden, Fletcher, Goldfarb and Shanno are the authors of a classical optimization method, named after them "BFGS" (see e.g. `https://fr.wikipedia.org/wiki/BFGS`). The method is based on the sole evaluation of the function and its gradient, and has super-linear convergence by means of the iterative construction of the Hessian matrix. When minimizing a quadratic function in n variables, the Hessian approximation is exact after n iterations ; thereafter, the method identifies to Newton's method and thus converges in one additional iteration. However, the standard method applies to unconstrained problems only. A so-called Riemannian extension (R-BFGS) has been proposed for constrained problems (Chunhong Qi *et al*), based on the definition of differential-geometry operators, "retraction" and "transport". However these operators necessitate the knowledge of formal expressions for the constraints in order to define paths along the geodesics. In engineering applications, such as those in optimum-shape design in aerodynamics, such formal expressions are not available in case of functional constraints. For such cases, we have proposed an approximate Riemannian approach. This new approach is to be further developed, theoretically analyzed and numerically tested in the course of this thesis.

Preliminary numerical experiments have been made to minimize the classical Rosenbrock function over the unit sphere and evaluate the robustness of the new method. These tests confirmed that super-linear convergence could be achieved indeed.





The thesis should have two components of comparable importance : a formal component of numerical analysis and an application component in optimum-shape design in aerodynamics. Concerning the application side, the doctoral student will utilize the Onera software platform *elsA*, and benefit from the expertise of experienced researchers, and will develop the extensions required by the numerical feasibility demonstration (channel, airfoil, and 3D configuration test-cases) [1]

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Direction : Didier Bailly, DAAP (contact person ; Didier.Bailly@onera.fr) and Jean-Antoine Désidéri, Inria and Onera associate (academic thesis director).
Prerequisites : Degree from Engg. school, or Masters's degree in Applied Mathematics or Aeronautical/Mechanical Engg., knowledge in standard scientific computing programming languages (Fortran, C++, Python).
Stipend : about 1600 euros monthly.

1. (For a detailed description in French, see : `http://sites.onera.fr/formationparlarecherche/sites/sites.onera.fr.formationparlarecherche/files/sujet_de_these_R-BFGS_candidats.pdf`.)