6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11-15 June 2018, Glasgow, UK

Comparing Gradient-Based optimization Methods with surrogate-assisted stochastic methods

Mohamed H. Aissa[1*], Arnaud Chatel[1] and Tom Verstraete[1]

[1] Von Karman Institute for Fluid Dynamics (VKI), Chausse de Waterloo 72, 1640 Rhode-Saint-Gense, Belgium, {aissa, chatel,Verstraete}@vki.ac.be

Two main families of optimization algorithms are established: the first, stochastic global optimization, is purely explorative but shows deceptive convergence rates for high-dimensional problems; the second, Gradient-based method, converges much faster but is rather exploitative. Stochastic methods need, indeed, metamodels such as Kriging to have a better convergence. Those metamodels can profit from gradients to predict more accurately global optima. Gradient-enhanced Kriging (GeK) requires indeed fewer samples to reach similar accuracy levels than ordinary kriging. Recalling that samples are time-consuming simulations (e.g. CFD, FEM ..), the reduction of the number of samples is highly beneficial.

It has been however repeatedly reported that the GeK becomes too time-consuming for high-dimensional problems [1]. To solve this issue, we propose a GPU implementation of the GeK using cuSolver and cuBlas libraries achieving a speedup of 5x- to 10x. An adjoint solver is used to provide the gradients of the objective function wrt the design variables. These derivatives are forwarded along with the CFD design evaluation to the Gradient-enhanced surrogate. As a sampling refinement criteria, the surrogate uses the weighed Expected Improvement which is tuned initially toward exploration and gradually favors more exploitation.

This work compares the performance under similar computational budget of the gradient-based optimization using adjoint solver and the metamodel-assisted Differential Evolution method using Gradient-Enhanced Kriging. The test case is the inlet guide vane LS89 which has been previously optimized with pure GBM [2] and hybrid methods [3]. Preliminary results suggest that the GeK has a comparable performance with some hybrid methods while outperforming GBM on the proposed testcase

REFERENCES

[1] Laurenceau, J., et al. *Comparison of gradient-based and gradient-enhanced response-surface-based optimizers.* AIAA journal 48.5 (2010): 981-994.

[2] Torreguitart, I.S., Verstraete, T., Mller, L. *Optimization of the LS89 Axial Turbine Profile Using a CAD and Adjoint Based Approach*, ETC12, April 3-7, Stockholm, Sweden, 2017.

[3] A Chatel, I.S., Verstraete, T., G.Coussement, Mller, L. *Single-point Optimization of the LS89 Turbine Cascade using a Hybrid Algortihm* Proceedings of ASME Turbo Expo 2018, June 11-15, 2018, Oslo, Norway [accepted]