Low-cost optimization under uncertainty through box representation of robustness measures

M. Rivier
ArianeGroup - Inria Bordeaux Sud-Ouest

Supervisor(s): P.M. Congedo (Inria Bordeaux Sud-Ouest) and S. Robidou (ArianeGroup)

Ph.D. expected duration: May 2017 - April 2020

Adress: Team CARDAMOM, Inria Bordeaux Sud-Ouest, Talence, 33405 Cedex, France
ArianeGroup, Le Haillan, 33185 Cedex, France

Email: `mickael.rivier@inria.fr`
`mickael.rivier@ariane.group`

Abstract:

This work is devoted to tackle multi-objective optimization under uncertainty problems using the SABBa framework (Surrogate-Assisted Bounding-Box approach). It aims at efficiently dealing with robust optimization problems with approximated robustness measures. The basic ingredient of this framework is the Bounding-Box (BB) approach, which has been formulated in [2] and [1]. A Bounding-Box (or conservative box) is defined as a multi-dimensional product of intervals centered on approximated objectives and containing the associated true values. In SABBa, it is supplemented with a surrogate-assisting strategy, which is very effective in order to reduce the overall computational cost associated to the BB approach, notably at the end of the optimization.

In [3], we have provide a mathematical proof of the robustness of the framework and of its convergence under some assumptions. It has been shown that the Bounding-Box approach yields a strong coupling between the costly convergence of the uncertainty quantification (UQ) process and the quality of the associated design. Intuitively, UQ refinement is only performed on promising designs, while non-efficient ones are frozen as soon as they are dominated. This allow a quick convergence of the optimization algorithm toward the most promising area. The surrogate-assisting strategy is then automatically refined in this area, leading to a very quick convergence of the uncertainty-based optimization process.

This paper is focused on the extension of SABBa to reliability-based constrained optimization problems. This implies a redefinition of the Boxed Pareto dominance introduced in [3], which will be discussed in details. The behavior of the algorithm will be explored both in separated and coupled spaces by comparing against some recent method [4] permitting to naturally correlate quantities of interest in the design dimensions. In order to compare strategies from a quantitative point of view, the convergence of the algorithm will be measured by means of Hausdorff distance to the Pareto optimal set. This distance is extended to aleatory Pareto optimal designs by considering boxes as uniform distributions on the robustness measures. The indicator of interest is then the expected modified Hausdorff distance.

Several comparisons on analytical and applicative test cases will be provided against the classical nested-loop strategy both on true function evaluations and on metamodels built a priori.

References

[1] Francesca Fusi and Pietro Marco Congedo. An adaptive strategy on the error of the objective functions for uncertainty-based derivative-free optimization. *Journal of Computational Physics*, 309:241–266, February 2016.

[2] Miha Mlakar, Tea Tusar, and Bogdan Filipic. Comparing solutions under uncertainty in multiobjective optimization. *Mathematical Problems in Engineering*, 2014:1–10, 2014.

[3] Mickael Rivier and Pietro Marco Congedo. Surrogate-assisted bounding-box approach for optimization problems with approximated objectives. *RR-INRIA*.

[4] Jize Zhang, A.A. Taflanidis, and J.C. Medina. Sequential approximate optimization for design under uncertainty problems utilizing kriging metamodeling in augmented input space. 315, 11 2016.

Short biography – Mickael Rivier got his master degree and engineering diploma from ENSEIRB-MATMECA in 2016. He is now doing his PhD at Inria Bordeaux Sud-Ouest and ArianeGroup in the field of applied mathematics. His main focus is on optimization under uncertainty and management of the associated computational cost.