A surrogate-based evolutionary algorithm for highly constrained design problems

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CCS CONCEPTS

•**Mathematics of computing** → **Evolutionary algorithms;**

KEYWORDS

surrogate-based optimization, infill sampling criteria, feasibility, probabilistic support vector machine, multi-point, constrained design problems.

ACM Reference format:
Charlotte Beauthier, Paul Beaucaire, and Caroline Sainvitu. 2017. A surrogate-based evolutionary algorithm for highly constrained design problems. In *Proceedings of GECCO '17 Companion, Berlin, Germany, July 15-19, 2017,* 1 pages.
DOI: http://dx.doi.org/10.1145/3067695.3082538

ABSTRACT

A globally effective approach to optimization problems based on computationally expensive high-fidelity computations lies in the exploitation of surrogate models. They act as cheap-to-evaluate alternatives to the original model reducing the computational cost, while still providing improved designs. The Surrogate-Based Optimization (SBO) paradigm consists of accelerating the optimization process by essentially exploiting surrogates for the objective and constraint evaluations, with a minimal number of function calls to the high-fidelity model for keeping the computational time within affordable limits. In order to be useful within an industrial context (as turbomachinery applications), it is crucial that this SBO process is capable of efficiently handling highly constrained design problems.

This work presents an SBO framework focusing on the research of feasible regions through an exploitation of both interpolation/regression and classification surrogate models. This strategy is implemented in the integrated optimization platform Minamo, Cenaero's in-house design space exploration and multi-disciplinary optimization platform, see [3]. For highly constrained problems, one of the key ingredients towards the eventual location of the global optimum indeed first lies in the identification of the potential feasible region(s).

In this work, the information retrieved from interpolation/regression surrogates (cheap-to-evaluate alternatives to the original high-fidelity models used both for the evaluation of objective and constraint functions) and classification surrogates (via Probabilistic Support Vector Machines (PSVM), used to identify feasible regions, see e.g. [2]) is blended in order to devise efficient Infill Sampling Criteria (ISC) that extract a maximum knowledge from a minimal number of simulations. This promotes an enhanced balance between exploitation, exploration and feasibility, which may be considered as the Graal quest for SBO. Baert et al. [1] have demonstrated the proposed strategy on a complex industrial design problem based on NASA Rotor 37. The performance of this innovative SBO framework will be illustrated here on widely used nonlinear constrained benchmark problems available in the literature. Good performance both in terms of identification of feasible regions and objective gains will be demonstrated.

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GECCO '17 Companion, Berlin, Germany

DOI: http://dx.doi.org/10.1145/3067695.3082538