Bayesian optimization in effective dimensions via kernel-based sensitivity indices

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Abstract:

Optimization of high dimensional functions under constraints and reliability assessment are key engineering problems, but they often come at a prohibitive cost since they usually involve a complex or expensive computer code. To overcome this limitation, analysts frequently rely on a preliminary dimension reduction by identifying which parameters drive the most the function variations: non-influential variables are set to a fixed value and optimization or reliability procedures are carried out with the remaining, significant, variables. Yet, the classical influence measures, which are meaningful for regression problems, do not account for the specific structure of optimization or reliability problems and can even lead to inaccurate solutions.

In this work, we describe a recent sensitivity index defined through a kernel-based dependency measure, the Hilbert Schmidt Independence Criterion [2]. This HSIC measure is designed to characterize whether a design variable matters to reach low values of the objective function and to satisfy the constraints. Such sensitivity criterion can readily be extended to reliability levels.

Finally, inspired by recent works in Gaussian Process-based optimization, where the authors only optimize on a randomly drawn subset of relevant variables at each iteration [1], we use this sensitivity measure to guide the selection. Our method either picks variables in a probabilistic manner where the subset of effective variables is drawn at random with probabilities equal to the normalized HSIC measures, or in a deterministic one keeping only the variables whose normalized HSIC measure is above a given threshold. We also provide different strategies to deal with the negligible inputs and apply our method on several examples from optimization benchmarks, as in Figure 1, to demonstrate how clever variable selection can efficiently improve the optimization.

References

[1] Cheng Li, Sunil Gupta, Santu Rana, Vu Nguyen, Svetha Venkatesh, and Alistair Shilton. High dimensional bayesian optimization using dropout. *preprint arXiv:1802.05400*, 2018.

[2] Adrien Spagnol, Rodolphe Le Riche, and Sébastien Da Veiga. Global sensitivity analysis for optimization with variable selection. *arXiv preprint arXiv:1811.04646*, 2018.

Short biography – Adrien Spagnol is a second-year PhD student in applied mathematics at Safran Tech, in collaboration with the Ecole des Mines de Saint-Etienne. He received a master's degree in structural and mechanical engineering from the French Institute of Mechanics in Clermont-Ferrand (France).

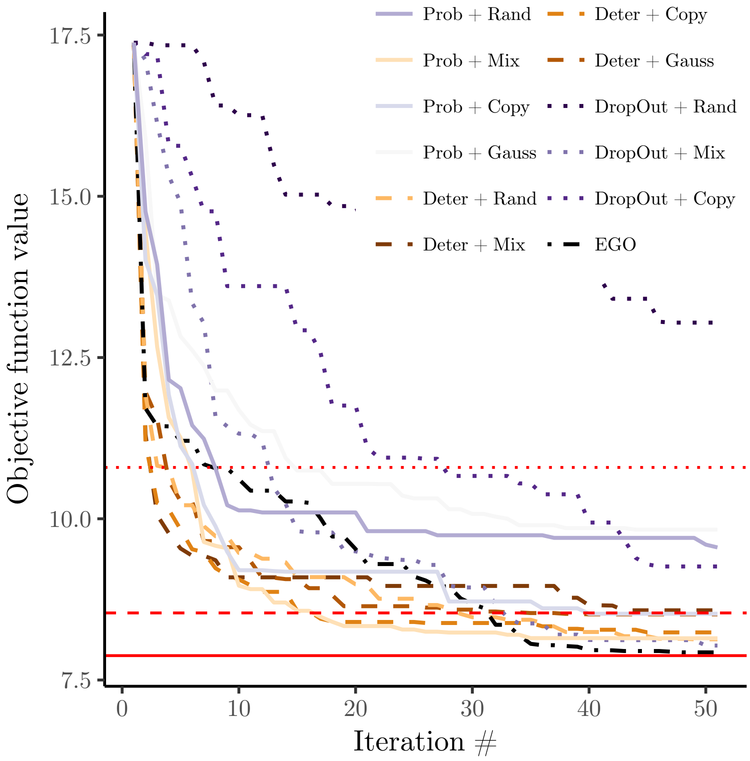

Figure 1: Median results of the different algorithms for the Borehole function. The red lines correspond to the easy, medium and hard goals (from top to bottom) for this test case, which are defined as the 90%, 50% and 10% quantiles of the final results of all algorithms.