Bayesian multi-objective optimization with noisy evaluations using the Knowledge Gradient

Bruno Barracosa, Julien Bect, Héloïse Baraffe, Juliette Morin, Gilles Malarange, Emmanuel Vazquez

Bayesian Multi-objective Optimization with Noisy Evaluations using the Knowledge Gradient

Bruno Barracosa[1,2] Julien Bect[2] Héloïse Baraffe[1]
Juliette Morin[1] Gilles Malarange[1] Emmanuel Vazquez[2]

[1]EDF R&D, France, bruno.tebbal-barracosa@edf.fr
heloise.baraffe@edf.fr, juliette.morin@edf.fr , gilles.malarange@edf.fr

[2]Laboratoire des Signaux et Systèmes (L2S)
CentraleSupélec, CNRS, Univ. Paris-Sud, Université Paris-Saclay, France,
julien.bect@centralesupelec.fr, emmanuel.vazquez@centralesupelec.fr

Keywords: Bayesian optimization, global optimization, multi-objective optimization, noisy optimization, simulation optimization

We consider the problem of multi-objective optimization in the case where each objective is a stochastic black box that provides noisy evaluation results. More precisely, let $f_1, \dots f_q$ be q real-valued objective functions defined on a search domain $\mathbb{X} \subset \mathbb{R}^d$, and assume that, for each $x \in \mathbb{X}$, we can observe a noisy version of the objectives: $Z_1 = f_1(x) + \varepsilon_1, \dots, Z_q = f_q(x) + \varepsilon_q$, where the ε_is are zero-mean random variables. Our objective is to estimate the Pareto-optimal solutions of the problem:

$$\min f_1, \dots, f_q . \tag{1}$$

We adopt a Bayesian optimization approach, which is a classical approach when the affordable number of evaluations is severely limited—see, e.g., [1], in the context of multi-objective optimization. In essence, Bayesian optimization consists in choosing a probabilistic model for the outputs Z_i and defining a sampling criterion to select evaluation points in the search domain $\mathbb{X}$.

Here, we propose to discuss the extension of the Knowledge Gradient approach [2] for solving the multi-objective problem (1). For instance, such an extension has been recently proposed by Astudillo and Frazier [3].

References

[1] V. Picheny, Multiobjective optimization using Gaussian process emulators via stepwise uncertainty reduction. *Statistics and Computing*, 25(6):1265–1280, 2015.

[2] P. Frazier, W. Powell and S. Dayanik, The Knowledge-Gradient Policy for Correlated Normal Beliefs. *INFORMS Journal on Computing*, 21(4):599–613, 2009.

[3] R. Astudillo and P. I. Frazier, Multi-Attribute Bayesian Optimization under Utility Uncertainty. In *Proceedings of the NIPS Workshop on Bayesian Optimization*, 2017.