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Multi-objective optimization under uncertainty using the hyper-volume expected improvement

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ABSTRACT

The design of real engineering systems requires the optimization of multiple quantities of interest. In the electric motor design, one wants to maximize the average torque and minimize the torque variation. A study has shown that these attributes vary for different geometries of the rotor teeth. However, simulations of a large number of designs cannot be performed due to their high cost. In many problems, design optimization of multi-objective functions is a very challenging task due to the difficulty to evaluate the expectation of the objectives. Current multi-objective optimization (MOO) techniques, e.g., evolutionary algorithms cannot solve such problems because they require hundreds of thousands of function evaluations. Therefore, an alternative methodology must be used to identify a Pareto front, a set of optimal designs of MOO. Recent extensions of Bayesian global optimization are able to do exactly that. The idea is to replace the expensive objective functions with cheap-to-evaluate probabilistic surrogates trained using few input-output pairs and to sequentially query designs that maximize the improvement of the Pareto front. For these purposes, we developed SMOOT, a Rappture tool built on a NanoHUB platform. It enables experimentalists to optimize their expensive processes without a need to understand the optimization methodology and guides them to make better decisions in order to find optimal designs.

KEYWORDS

Gaussian process regression, Bayesian global optimization, expected improvement, uncertainty quantification, expected improvement over the dominated hyper-volume