PhD position opened

Kriging-assisted constrained optimization

July 13th 2012

Field of studies : applied mathematics and/or computer science.
Starting time : Fall 2012 (3 years funding).
Advisors : Rodolphe Le Riche (CNRS permanent research associate), Xavier Bay and Eric Touboul (assistant professors).
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Laboratory : France, Saint-Etienne, ENSM-SE, Henri Fayol Institute, DEMO department.
Salary : 1700 euros/month.

Related research program : this PhD is part of the French research program NumBBO (analysis, improvement and evaluation of Numerical BlackBox Optimizers), funded by the French National Research Foundation (ANR, « Agence Nationale de la Recherche »). The NumBBO program is a joint work between INRIA TAO and DOLPHIN, and TU Dortmund (Germany). This PhD will be based in the DEMO team of the Henri Fayol Institute at the Ecole des Mines de Saint-Etienne. The team has a long experience in metamodel assisted optimization gained through the past ANR/OMD, ANR/OMD2, ANR/ID4CS and DICE projects.

Scientific context for the PhD

Numerical optimization is a fundamental part of engineering sciences. It is involved in optimal design, optimal control and model identification. Numerical blackbox optimization methods, interpreting a problem as a blackbox where the only available information is the obtained function value for some query points, are the methods of choice when models are too complex to be mathematically tractable. This is the most often encountered situation where the optimized model is a given simulation software, like a finite element program.

This model is typically computationally expensive. Optimization should then iteratively 1) build a statistical model of the expensive model, 2) use the statistical model to guide the search. Kriging (i.e., conditioned random process) is the statistical model of choice in this context [1,2].

PhD Objectives

The overall objective of this work is to improve optimization approaches for expensive to evaluate functions. This is of primary practical importance for all optimization applications.
More specifically, this PhD research will have two objectives
1) Investigate how covariance kernels, which are at the heart of the kriging statistical models, should be built in the context of optimization (as opposed to data modeling). This investigation will be both theoretical and experimental thanks to the COCO (COmparing Continuous Optimizers, [3]) platform.
2) Most practical optimization problems have constraints. The second objective of this PhD will be to study how to handle constraints in kriging-based optimization.

Project scientific originalities

- Although the project is not directly made to solve a specific industrial test case, it is based on lessons learned from many previous industrial collaborations (OMD, OMD2, ID4CS, DICE to name a few).
- The COCO platform allows massive testing and comparison of optimizers. It will shed new

lights on kriging-based optimizers.

- Kriging parameters (hence kernels) will be studied in the dynamic context of optimization as opposed to the static context of data-mining.
- Optimization constraints have received little attention so far in kriging-based methods (excepted in [4], and partly in [5] and [6]).

References

[1] Donald R. Jones. A taxonomy of global optimization methods based on response surfaces. J. of Global Optimization, 21:345–383, December 2001.

[2] D. Ginsbourger, R. Le Riche, and L. Carraro. Kriging is well-suited to parallelize optimization. In Y. Tenne and C.-K. Goh, editors, Computational Intelligence in Expensive Optimization Problems, pages 131–162. Springer, 2010.

[3] N. Hansen, A. Auger, S. Finck, and R. Ros. Real-parameter black-box optimization benchmarking 2009: Experimental setup. Technical Report RR-6828, INRIA, 2009.

[4] Michael J. Sasena. Flexibility and Efficiency Enhancements for Constrained Global Design Optimization with Kriging Approximations. PhD thesis, Univ. of Michigan, 2002.

[5] V. Picheny, D. Ginsbourger, O. Roustant, and R.T. Haftka. Adaptive designs of experiments for accurate approximation of a target region. Journal of Mechanical Design, 132(7), 2010.

[6] Vincent Dubourg. Adaptive surrogate models for reliability analysis and reliability based design optimization. PhD thesis, Univ. Blaise Pascal Clermont Ferrand II, France, 2011.

Candidate profile :
• Applied mathematics (optimization) or computer scientist (with a taste for optimization and learning algorithms).
• The candidate should like collaborating with other research teams (other partners of the NumBBO projects).
• The candidate should like programming (in R and C).