SAMCO: Surrogate-Assisted Multi-Criteria Optimization

The Surrogate-Assisted Multi-Criteria Optimization workshop "SAMCO" will take place from February 29, 2016 till March 4, 2016 at the Lorentz Center in Leiden, The Netherlands.

Background

Multi-Criteria Optimization: In many optimization tasks, different conflicting aims, such as quality and cost, do exist. Due to changing customer groups and needs, no a priori preference information is available in most cases. Hence, we are interested in finding a set of solutions that reflects the optimal trade-offs among the conflicting optimization criteria. Based on this information, a suitable solution can be chosen for each costumer group. This kind of problem is called a (set-based) multi-criteria optimization (MCO) problem.

Stochastic Approaches to Multi-Criteria Optimization: MCO problems frequently occur in many application areas such as engineering, economics, and medical sciences. One approach to solve such problems are Evolutionary Algorithms (EAs). EAs are optimization techniques that improve a population of solutions (individuals) over time by random changes in terms of recombination and mutation and the process of selecting the best solutions for survival. They have the inherent advantage that they directly evolve a set of solutions. Evolutionary Multiobjective Optimization algorithms (EMOA) applying specialized selection operators for multi-criteria problems have been developed since the mid-1980s and are applied frequently in industrial applications. However, EMOAs often require a huge amount of fitness/objective function evaluations, as they rely on a guided random process to find satisfying solutions.

Surrogate-Assisted Optimization: For single-objective problems restricting to the optimization of only one (aggregated) objective function, the use of surrogate models is an established means to reduce the number of function evaluations. Beginning with the seminal Efficient Global Optimization paper of Jones et al. in 1998, sequential surrogate-assisted optimizers became accepted for solving problems with expensive black box evaluations. In such sequential approaches, an initial experimental design is used to estimate the response surface of the problem by means of a surrogate model, such as polynomial regression, artificial neural networks, kriging, or radial basis functions. The next solution for evaluation is chosen based on a suitable figure of merit, which is derived from the model. A straightforward figure is the estimated objective value, but also combinations with the local uncertainty of the model for improving the exploration over the search space are used.

The most popular figure of merit is the expected improvement. Based on the estimated mean and variance of a local Gaussian distribution (provided e.g. by means of a kriging model), an integration over the improvement and its respective probability is performed. For kriging models, this integration can be computed in closed form. The expected improvement has proven its suitability in many applications.

Objectives of the Workshop

With the upcoming SAMCO workshop, we aim at bridging the research in the two areas of set-based multi-criteria and surrogate-assisted optimization. The intersection of these topics is an emerging research area, but work in the field is still very heterogeneous and distributed over different countries and faculties. Therefore, our workshop brings together researchers from all backgrounds and allows new concepts connected to SAMCO to be discussed under a holistic perspective. In particular, we plan five key aspects of SAMCO to be addressed.

❶ Benchmarking

Most research on surrogate-assisted multi-criteria optimization is driven by specific applications in the respective fields. Hence, the proposed algorithms are mainly tested on their respective application task. A comparison of the different approaches is thus hard to accomplish and the young field of SAMCO lacks the existence of generally accepted benchmarks. The workshop will try to improve this situation by providing an opportunity to discuss the problem in general and find/define such benchmarks.

❷ Theoretical Aspects

Due to the focus on practical applications, theoretical aspects of the approaches are often neglected. Hence, we want to foster the awareness to investigate theoretical aspects more deeply. In particular, the work on set-based optimization and performance indicators, which was a focus of the previous Lorentz Center workshop `SIMCO: Set- and Indicator-based Multi-Criteria Optimization', can act as a baseline for first considerations.

❸ Beyond one model per objective function: higher-level surrogate approaches

The more methodological research areas considered in the workshop concern the choice of the surrogate model and the respective figure of merit (also called infill criterion). Due to the enormous impact of the paper of Jones et al., most methods use kriging and expected improvement. With respect to multiple objectives with different response surfaces and the specific requirements of set- and indicator-based optimization, new variants of models and infill criteria seem promising.

❹ Ensembles of surrogate models

Another methodological research area, covered by the workshop, is the combination of different surrogate models, in so-called ensemble methods. Not only can the problem at hand be modeled with different types of surrogate models, but also the granularity of the problem description can be different and simpler. Cheaper to evaluate models can be combined with more detailed, expensive models. When and how to use ensemble methods will be therefore another topic of the workshop.

❺ Overview of existing libraries and approaches

Last but not least, the workshop aims at collecting existing approaches and libraries to prepare an overview of SAMCO approaches. A joint article that summarizes the collected approaches and libraries is strongly aspired by the whole scientific community in the field and will serve as a major outcome of the workshop.

The Lorentz Center

The Lorentz Center in Leiden (NL) is an international center that coordinates and hosts workshops in the sciences, based on the philosophy that science thrives on interaction between creative researchers. Lorentz Center workshops focus on new collaborations and interactions between scientists from different countries and fields, and with varying seniority.

http://www.lorentzcenter.nl/aim.php

Scientific Organizers

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