PhD thesis offer (CIFRE)

Optimization under uncertainty – Application to robust design

Entity

Safran is an international high-technology group, a leading manufacturer in the fields of Aerospace (propulsion and equipment), Defense and Security. Operating worldwide, the Safran Group has 69,000 employees and logged sales of 15.4 billion euros in 2014. Comprising a number of companies, the Group holds, alone or in partnership, world or European leadership positions in its markets. To keep pace with its fast-evolving markets, Safran undertakes extensive research and development programs which, in 2014, totaled investments of €2 billion. Safran is listed on Euronext Paris and on the CAC 40 index.

Context

In the general field of optimization, optimization under uncertainty aims at accounting for the potential variability of some design parameters in the original optimization problem. Such variability may come from limited knowledge on physical parameters (preliminary design stage) or uncertainty on external phenomena (environment, precise properties of materials). The worst-case approach was originally introduced in the 50's, where all the uncertain parameters are fixed at their worst-case value. However the conservatism of the solution will discard designs that are less optimal in the worst-case sense but are superior in the most likely scenarios. In this PhD thesis, the goal is to adopt an innovative point of view for optimization under uncertainty.

Research focus

The goal of the PhD thesis is to address several practical limitations arising when an industrial robust design problem must be modeled as a mathematical optimization problem. More precisely, two main lines of research have been identified:

1) *Formulation of a robust design problem*
   The biggest challenge in optimization under uncertainty for industrial systems consists in expressing the operational needs into a standard problem with objectives and constraints. For example, does robust optimization imply optimizing the mean of the performance criterion when the uncertain parameters vary? Its standard deviation? Or maybe a compromise between the two? Depending on this choice, the optimal design will certainly be different.

We propose here to investigate multi-objective formulations, which would account for several robust criteria. Ideally the obtained Pareto front would include solutions to various formulations, thus permitting to identify which formulations lead to particular areas of the Pareto front and what kind of optimal designs they imply. The objective will be to build such a multi-objective problem and study from a theoretical point of view the link between the Pareto front and the robust formulations.

2) *Sensitivity analysis*

In industrial cases, the number of design variables and uncertain parameters is usually large, ranging from a few tens to several hundreds. In order to facilitate both the exploration and the optimization of such systems, it is generally mandatory to reduce the number of variables to keep the most influential ones only.

Recent advances make to possible to perform this selection efficiently when the goal is to identify which variables impact the mean level of a criterion. However they perform poorly for optimization problems, where it would be more relevant to detect the variables that influence the areas where the criterion tends to be optimal. Similarly, in robust optimization the question is to define the impact of an uncertain parameter on the probability constraints. This research line will focus on the definition of new sensitivity indices dedicated to optimization and extend them to the optimization under uncertainty framework.

Supervising team & practical details

The PhD thesis is a CIFRE contract proposed by Safran Tech, the new corporate research center of Safran located in Magny-Les-Hameaux, "Plateau de Saclay" area near Paris, France.

The supervising team will include

- Sébastien Da Veiga, researcher at Safran
- Rodolphe Le Riche & Olivier Roustant, Mines Saint-Etienne

Applicant profile

Candidates should have completed a Master in Applied Mathematics, Operational Research or related disciplines. The applicant should demonstrate both theoretical and computational skills. CV and cover letter in English or French should be sent to sebastien.daveiga@safran.fr