Advanced Uncertainty Quantification methods in Multi-objective and Multi-Disciplinary Optimization

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1 Context

This PhD position is attached to the NEXTAIR project (Multi-disciplinary digital enablers for NEXT-generation AIRcraft design and operations), a research network funded by the European Commission through the HORIZON funding stream.

The main goal of this research program is to develop and demonstrate innovative design methodologies, data-fusion techniques, and smart health-assessment tools enabling the digital transformation of aircraft design, manufacturing, and maintenance. In particular, NEXTAIR will improve the efficiency of uncertainty quantification and robust optimization techniques to effectively account for manufacturing uncertainty and operational variability in the industrial multi-disciplinary design of aircraft and engine components.

NEXTAIR brings together 16 partners from 6 countries with diverse expertise: digital tools, advanced modeling and simulation, artificial intelligence, machine learning, aerospace design, and innovative manufacturing. The NEXTAIR consortium comprises nine research organizations, four leading aeronautical companies, and two high-Tech SMEs with expertise in scientific computing and data intelligence for industry.

2 Objectives

Uncertainties can strongly impact the performances and make the solution of deterministic optimization problems suboptimal or even infeasible. Therefore, Optimization under Uncertainty (OuU) is an essential axis of research to meet the need for efficiency, reliability, and cost optimality. In NEXTAIR, academia and industry are joining efforts to develop new methodologies for OuU. Optimization under Uncertainty is a broad domain that includes several modeling paradigms: Stochastic Programming; Reliability-Based Design Optimization (based on probabilistic and worst-case feasibility constraints); Robust Design Optimization (for averaged or worst-case solutions, possibly within a multi-objective framework).

The Platon project-team is devoted to developing novel methods tackling constrained multi-objective optimization, mainly following derivative-free strategies and with particular attention to cost-efficient. Specifically, we look for an optimal trade-off between computational cost and accuracy, targeting problems involving complex and expensive numerical solvers. Platon also explores representations of model outputs and optimization objectives, including the design of computer experiments to achieve best estimates at the lowest or prescribed computational budget. In particular, we develop approaches dedicated to optimization and reliability problems that adapt the accuracy as the optimization proceeds.
This thesis aims at multi-objective optimization in the presence of system and operational uncertainties, along with three complementary directions. A first research effort will focus on defining and implementing uncertainty measures and metrics in the optimization objectives. In particular, the PhD candidate shall explore quantile, variance, and conditional value at risk (CVaR) formulation of robust multi-objective optimization. The second research direction will concentrate on designing efficient computational strategies to estimate robustness metrics, especially for high-dimensional uncertainty sources and multiple types of objectives. The third research direction will concern the determination of the Pareto front in uncertain multi-objective problems. The PhD candidate shall investigate the combination of stochastic gradient methods and random-search strategies to exhibit the set of Pareto optimal points.

3 Supervision

The PhD candidate will be supervised by P.M. Congedo (Inria) and Olivier Le Maître (CNRS), experts in uncertainty quantification methods (see http://www.pietrocongedo.altervista.org/ and http://olemaitre.perso.math.cnrs.fr/).

This thesis will be held in the Platon team at the Center for Applied Mathematics (CMAP) from Ecole Polytechnique and the Center Inria Saclay Île-de-France.

Inria is the only French public research body fully dedicated to computational sciences. It is a national operator in research in digital sciences and is a primary contact point for the French Government on digital matters. Under its founding decree as a public science and technology institution, jointly supervised by the French ministries for research and industry, Inria’s missions are to produce outstanding research in the computing and mathematical fields of digital sciences and to ensure the impact of this research on the economy and society in particular. Inria covers the entire spectrum of research at the heart of these activity fields and works on digitally-related issues raised by other sciences and by actors in the economy and society at large. Beyond its structures, Inria’s identity and strength are forged by its ability to develop a culture of scientific innovation, to stimulate creativity in digital research. Throughout its 8 research centres and its 180 project teams, Inria has a workforce of 3 400 scientists with an annual budget of 265 million euros, 29% of which coming from its own resources.

4 Duration of the Project and of the Recruitment

The recruitment of the PhD candidate will be of 36 months.

Starting date: September to December 2022.

5 Type of contract

The PhD candidate will be offered a three year full-time funded contract by Inria.

Duration: 36 months, Gross salary: 38,000 euros per year.

Work location: [Platon Inria project-team] Center for Applied Mathematics at Ecole Polytechnique (Palaiseau, France).

6 Requirements and Application Procedure

Candidates are required to have a Master’s degree in engineering, applied mathematics or a related discipline, and a specialization in computational fluid dynamics, uncertainty quantification, opti-
mization or related fields. Preferable qualifications for candidates include proven research talent, an excellent command of English, and good academic writing and presentation skills.

Applicants should submit a Curriculum Vitae, a covering letter as a single document detailing the knowledge, skills and experience you think make you the right candidate for the job, a list of your MSc courses and grades, copy of your Master’s thesis, a list of names of references and preferably a list of publications.

For further details and applications, please contact Pietro Marco Congedo (pietro.congedo@inria.fr). All applications should be emailed to pietro.congedo@inria.fr.