Ultra-large-scale Topology Optimization

PhD thesis proposal

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Scientific context: Since its initiation three decades ago, topology optimization (TO) has undergone tremendous development and is now used to conceive weight-efficient parts and smaller structures in all major mechanical engineering industries.

Despite its successes, still many outstanding challenges before TO approaches remain, including relevant physical modeling and simulation of large complex structures. Such topics as multi-scale TO of and with complex lattice structures, motivated by an extremely fine resolution of the additive manufacturing process, require ultra-high performance simulation and robust approaches. Giga-voxel resolution TO presently requires +10^6 CPU hours, which is hardly affordable for a majority of users, hence more efficient, possibly multi-scale, techniques must be developed and implemented. Therefore, to provide breakthroughs, algorithms have to be rethought entirely, possibly using machine learning or reduced order methods.

Research project: Rather than aiming at applications, the goal of the proposed Ph.D. thesis project is to explore and develop original numerical approaches, involving mathematical formulations, design of algorithms, further illustrated by software prototypes and validated on high-resolution versions of standard benchmarks of compliant structures and mechanisms. The focus is clearly on fostering future concepts for optimizing ultra-large-scale or ultra-complex models, including physically relevant aspects, such as stability, dynamics, material nonlinearity, multi-physics, and manufacturability.

The methodology will build on top of the Reduced-Order Modeling framework developed since several years by the Roberval Laboratory [1,2], also in collaboration with NPU (Xi'an) [3] and INSA de Rennes [4]. Multiscale aspects [5,6] and distributed and parallel computing [7] have been already explored, but full scalability of these approaches, coupling High Performance Computing and Reduced Order Modeling remains a scientific challenge, in the heart of the present project.

Candidate: A solid background from the fields of applied mathematics (Linear Algebra) and/or computational mechanics (linear/nonlinear, static/dynamic finite element simulation techniques) is required as well as a passion for software development (fluence in Matlab is a minimum requirement). Candidates with a documented experience in finite element modeling/TO/Matlab programming are strongly encouraged. A high profile candidate will possess a record of publications in international scientific journals, published during her/his MSc. Fluent English is a pre-requisite, along with a strong motivation to learn French.

References

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