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BEYOND PERFORMANCE: ADAPTIVE TOPOLOGY OPTIMISATION FOR FUNCTIONAL SYSTEMS

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ABSTRACT

Engineering systems must increasingly combine multiple functions, operate across changing conditions, and maintain or adapt their performance in the presence of uncertainty. Topology optimisation is thus extending beyond conventional performance-driven design towards engineering systems in which geometry and material distribution are tailored to achieve specific functions and tasks. Topology therefore becomes a key determinant of how function is achieved: how energy is harvested, heat is managed, waves are guided, motion or shape change is generated, or interactions with physical and biological environments take place.

These functions often emerge from the interplay of several physical phenomena and may require different, even competing, topological features across operating states. This poses new challenges for topology optimisation, requiring methods that can efficiently address parameter-dependent design problems, coupled multi-physics phenomena, evolving geometries, uncertain operating conditions, and high-dimensional design spaces. Advances in numerical algorithms, adaptivity, error estimation, high-performance computing and data-driven modelling offer new opportunities to improve the accuracy, reliability and computational efficiency of the optimisation process.

This mini-symposium aims to bring together researchers advancing topology optimisation methods and applications, emphasising the interplay between methodological innovation and emerging functional requirements.

Methodological topics of interest include: adaptivity and error estimation; multi-resolution and multi-scale optimisation; parallel and GPU computing; multigrid and preconditioning; surrogate and multi-fidelity modelling; uncertainty quantification and robust optimisation; AI-assisted optimisation and generative models; quantum and hybrid quantum-classical approaches; CAD-compatible and manufacturing-aware formulations.

Applications of interest include: multi-scale and multi-functional metamaterials; energy harvesting; thermal-fluid systems and battery thermal management; programmable and adaptive materials; active, shape-morphing, and reconfigurable devices; soft robotics; coupled actuation-control design; acoustic, photonic, and electromagnetic devices; vibration and noise control; bio-integrated, biohybrid, and tissue-interacting systems.