

Machine learning for shape and topology optimisation: from metamaterials to engineering structures

Dr. Federico Bosi

Abstract: Machine learning (ML) is transforming the way engineers design, optimise, and discover new structures and materials. This seminar will explore how the combination of ML, computational mechanics, and advanced optimisation techniques is enabling a new paradigm of data-driven engineering design. The first part will present a machine-learning-assisted framework for the shape optimisation of metamaterials, revealing how deformation mechanisms govern the achievable gains in stiffness, strength, and structural efficiency. The second part will introduce a meta-learning approach to topology optimisation, in which prior design experience is distilled into reusable knowledge that accelerates the discovery of optimal solutions. Its recent extension to fracture-resistant structures will also be discussed. The seminar will conclude with a brief overview of related research activities in computational mechanics, ranging from the thermo-viscoelastoplastic characterisation and modelling of structural membranes to the design and control of large-scale elastic robotic structures

Biography: Dr Federico Bosi is an Associate Professor in the Department of Mechanical Engineering at University College London (UCL) and a Professor and Head of Research in the Department of Innovative Technologies at the University of Applied Sciences and Arts of Southern Switzerland (SUPSI). Prior to joining SUPSI in 2023 and UCL in 2017, he was a postdoctoral scholar (2015-2016) and a senior postdoctoral scholar (2017) in the Space Structure Laboratory at the California Institute of Technology, USA. He earned his PhD degree (2014) in Engineering of Civil and Mechanical Structural Systems from the University of Trento, where he was a Marie Curie Early Stage Researcher in the Solid and Structural Mechanics Group, and received the award for outstanding PhD thesis. Before this, he received a Bachelor (2009) and a full-honors Master degree (2011) in Civil Structural Engineering from the University of Trento.

His research activity is devoted to studying the mechanics of solids and structures, with a particular interest in the nonlinear, time-dependent, and thermo-mechanical response of ultralightweight materials and mechanical systems. Currently, the group's main research activities combine analytical, numerical and experimental techniques to (i) characterise and model the thermo-visco-elasto-plastic response of membrane materials and structures, and (ii) design and optimise additively manufactured architected materials. The work of his research group (<https://federicobosi.com/>) is supported by EU H2020, EPSRC, and the Royal Society.