

Computational Mechanics in the AI era: from Microscale to Macroscale

Lecture of

May 22, 2025, 4pm

Ing. Renato Zona

Institute of Applied Mechanics
Seminar room (ground floor)

Università della Campania
Vanvitelli, Aversa, Italy

Pockelsstraße 3
38106 Braunschweig

In recent years, artificial intelligence (AI) has started to play an increasingly important role in the field of solid mechanics, opening up new perspectives both in terms of understanding mechanical phenomena and advanced design. In particular, AI has proven to be a powerful tool in the analysis and design of metamaterials, i.e. engineered materials with unconventional mechanical properties, often obtained through complex microstructures. One of the challenges of computational mechanics is the rapid and effective estimation of the properties of metamaterials and their continuum equivalent, and the search for isotropy classes depending on the lattice configuration especially in the case of geometry variation of the element within the same texture. Through machine learning techniques, it is possible to explore extremely vast design spaces, identifying optimal configurations that would be difficult to achieve with traditional approaches, even unpredictable.

AI is also finding increasing applications in structural mechanics, for example in identifying damage, monitoring structural conditions and optimising shapes and loads. Thanks to the ability to analyse large amounts of experimental and numerical data, intelligent algorithms make it possible to build accurate predictive models and support engineering decisions in real time. In this context, the creation of structured databases is of great interest, as they can be used to train algorithms with a view to the conscious use of Artificial Intelligence systems. The integration of data-driven approaches and physical-mathematical models thus paves the way for a new generation of tools for structural design and diagnosis.

In the context of metamaterials, the construction of a structured database is shown in detail, highlighting the critical issues and aspects of greatest interest in the performance-aided design. In the field of civil structures, a concrete application of an AI algorithm based on a structured database and applied to emergency management for buildings is shown.