SEMINAR

CMDiscovery - Discovering three-dimensional constitutive models

ABSTRACT

Mechanical constitutive models serve as the foundation for the design of engineering structures and components. However, as traditional constitutive models are empirically derived for specific materials based on experimental observations, their calibration or extension to new materials, especially those characterized by pronounced heterogeneity, anisotropy, and nonlinearity is challenging. CMDiscovery proposes a transformative, end-to-end framework for discovering mechanical constitutive models directly from raw grayscale images, boundary displacements, and sparse force measurements, without requiring precomputed displacement fields or stress–strain labels. By embedding fundamental physical principles, brightness conservation, mechanical equilibrium, and thermodynamic consistency, into a unified physics-informed neural network (PINN), CMDiscovery simultaneously infers the nodal displacement field and identifies a parsimonious, interpretable constitutive model. Implemented using raw grayscale images from 2D stereo-camera setups and 3D X-ray CT scans, CMDiscovery will be applied on silicone rubber elastomers and 3D-printed foam concrete, yielding thermodynamically consistent UMAT subroutines ready for finite-element integration and real-time Digital Twin deployment. By collapsing traditional multi-step testing into a one-shot, unsupervised discovery protocol, CMDiscovery delivers robust model identification in noisy or incomplete data regimes, accelerates qualification workflows, and opens new horizons for in-situ characterization of complex, anisotropic materials.

Dr. **Gregorio Mariggiò** has been a fixed-term Assistant Professor (RTD-a) of Structural Mechanics at Politecnico di Torino since March 2025. He earned his Ph.D. in Civil and Environmental Engineering from the same institution in 2022. His research interests include computational mechanics, experimental mechanics, and numerical methods. His studies focused on optimizing the design methodology for load-bearing glass components, addressing significant challenges in integrating discontinuous functions within the extended finite element method (XFEM), and developing innovative hybrid systems that combine glass, 3D printing, and advanced coatings. He currently leads the MUR-funded CMDiscovery project, awarded under the Young Researchers 2024 call, where he is developing a novel physics-informed neural framework to discover and calibrate constitutive models directly from imaging data. By combining high-resolution grayscale scan data with fundamental mechanical principles in a single, unified optimization, this approach promises more accurate and reliable mechanical characterization of materials under realistic loading conditions.

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