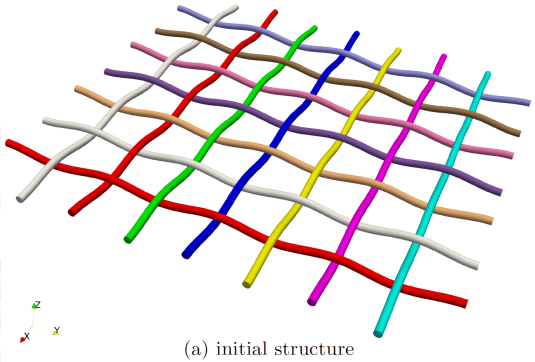
Università degli Studi di Pavia
Computational Mechanics & Advanced Materials Group - DICAr

3D@UniPV
Virtual Modeling and Additive Manufacturing for Advanced Materials

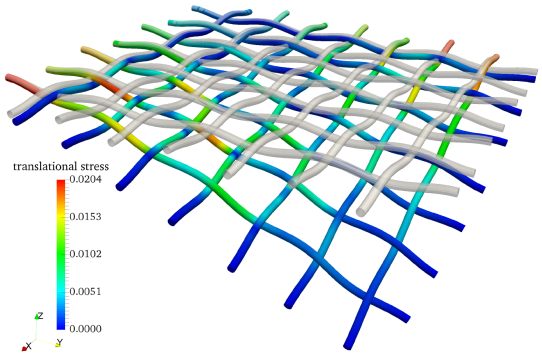
SEMINAR

Isogeometric collocation methods for Cosserat rods and their application in design optimization for additive manufacturing

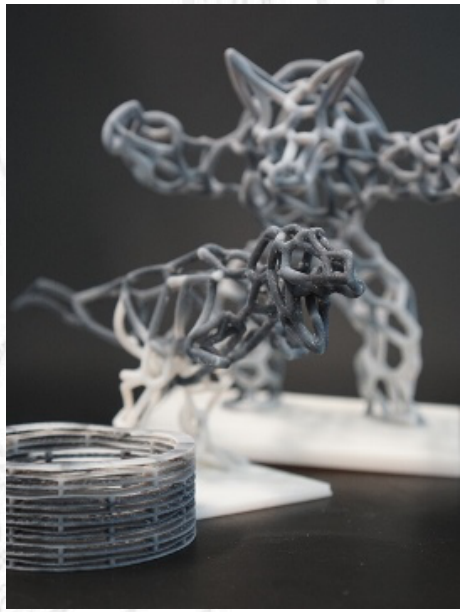
We present a computational design, simulation and optimization framework for 3D rod structures in additive manufacturing applications.
It is based on a novel isogeometric collocation method for the Cosserat rod model, where the rod centerline deformations and orientations are both parameterized as NURBS curves. Within the isogeometric framework, the strong forms of the equilibrium equations are collocated, leading to an efficient higher-order discretization method. We also develop a mixed isogeometric formulation, which alleviates shear locking for thin rods. The methods are verified by numerical convergence studies and further computational applications, including large-scale 3D rod structures.
Furthermore, we develop a frictionless rod-to-rod contact formulation for spatial rods within the isogeometric collocation approach. An important aspect is the application of contact penalty forces as point loads within the collocation scheme, and methods for this purpose are proposed and evaluated. We investigate applications in the direction of textile simulation.
Main application of our computational methods is the design optimization and manufacturing of complex 3D curved rod structures with spatially variable material distributions and exhibiting active deformation behavior. This so-called 4D printing approach is enabled by the shape memory effect of 3D printed photopolymers. Our framework optimizes the cross-sectional properties of a rod structure, in particular the Young's modulus, which is also parameterized as a NURBS curve, for a desired 4D printing deformation. We demonstrate the entire design-fabrication-test approach and illustrate its capabilities with examples including 3D characters, personalized medical applications, and complex structures that exhibit instabilities during their nonlinear deformation.



(a) initial structure



(b) final deformation



Dr. Oliver Weeger
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December 20th, 10:00am
DICAr MS1 Meeting Room
Via Ferrata, 3 – Pavia