Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Mechanics & Materials Laboratory
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Master Thesis/Semester Project

Computational modeling of frictional metamaterials for energy absorption

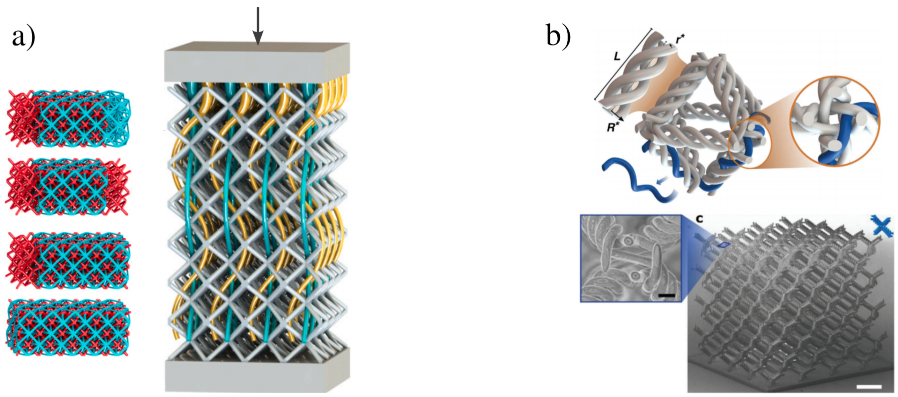

Figure 1: Self-contact in metamaterials: a) Interpenetrating lattices (adapted from [1]). b) Hierachical woven materials (adapted from [2]).

Description:

The development of materials with high energy absorption capabilities is crucial in many engineering applications such as the design of sports equipment. Truss metamaterials have shown great such potential by leveraging processes such as microstructural buckling. However, the conventional design of these materials fails to take advantage of frictional self-contact, which can significantly increase energy absorption. This project deals with an emerging class of architected frictional materials that explicitly leverage contact and friction between their constituents to maximize their potential for energy absorption, while allowing for increased reversibility. Examples of these novel materials are interpenetrating [1] and micro-woven [2] lattices.

The computational modeling of such systems presents many challenges, which is why they have so far mostly been explored experimentally. In particular, the shear amount of persistent contacts in such systems calls for a highly efficient treatment. To tackle this challenge, we plan to extend our high-performance open-source variational FEM framework to account for self-contact. First, we plan to formulate and implement an appropriate contact detection algorithm followed by a regularized contact mechanics model where the contact force is derived from a conservative frictionless penalized energy potential [3]. At a second stage, the model will be extended to account for frictional contact by introducing a dissipation potential [4], capable of capturing hysteresis. Finally, the model will be validated against available experimental data, and will be used to explore the rich design space of this new class of materials. Such a computational tool will hopefully guide subsequent experimental campaigns targeting even more efficient designs.

Tasks:

- Literature review of contact mechanics and familiarization with our open-source FEM code
- Implementation of contact detection algorithm, conservative and nonconservative contact model
- Computational design and parametric analysis of a new frictional metamaterial

Prerequisites:

- Good background in mechanics
- Computer coding skills, experience with high level languages (C, C++)
- Knowledge of high performance coding and parallelisation is an advantage
- Knowledge of commercial design software is an additional advantage

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References

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