Modeling Deformation and Load in Periodic Discrete Structures

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Embedding the ability to control deformation and load distribution within a structure has the potential to revolutionize industries ranging from healthcare, to construction, to aerospace. It can be done actively, by integrating actuators into a structure, or passively, by selectively controlling the mechanical properties of individual elements in the structure. To design such structures, it is crucial to understand and model their mechanical response to embedded features. In this seminar, I will describe two approaches to modelling discrete structures, one active and one passive. I will start with the modelling and optimization of macroscopic deformation of lattice structures. The force method allows us to explicitly define the relationship between a lattice's connectivity and its internal and external loads. I will show examples of its implementation in 2D, 2.5D, and 3D structures, in which I optimize the replacement of trusses by actuators to achieve a target shape change. In contrast to lattices, more complex periodic discrete structures, such as knots in a knit textile, cannot be modelled without explicitly defining their shape and the effect of friction on the total energy of the system. In the second part of this seminar, I will describe how to use finite element modelling for homogeneous knits and an implementation of discrete elastic rods for heterogeneous knits to prescribe their deformation and stiffness response. I will examine the most important variables in a knit textile and show the potential of this method through a proof-of-concept wearable haptic device utilizing distributed stiffness.

Cosima du Pasquier is a Postdoc in the Department of Mechanical Engineering at Stanford University. Working with her postdoc sponsor Allison Okamura, as well as academic collaborators from the Massachusetts Institute of Technology (MIT), Georgia Tech, and University of Houston, she focuses on design, modeling, and fabrication of wearable technologies for healthcare. Prior to joining Stanford, Cosima received her BSc, MSc, and PhD in Mechanical Engineering from ETH Zurich in 2014, 2017, and 2022 respectively. Her PhD dissertation was awarded the ETH Medal. Dr. du Pasquier's research combines structural mechanics, materials, and design. During her PhD at the Engineering Design and Computing (EDAC) Lab at ETH Zurich, she focused on modeling and optimizing deformation of morphing structures using soft printed actuators. In her postdoc, she focuses streamlining the design of assistive wearable technologies, such as rehabilitative devices for stroke survivors and wearable haptic platforms. Dr. du Pasquier's work has appeared in a number of peer-reviewed journals, including Soft Robotics, Additive Manufacturing, Smart Materials and Structures, and Structural and Multidisciplinary Optimization. During her MSc and PhD, she collaborated with academic partners from MIT, which culminated in the founding of the startup Rapid Liquid Printing Co., for which she is an advisor. Her current work is funded by the U.S. National Science Foundation through the Convergence Accelerator and Human-Centered Computing programs.

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