# SEMINAR

## Young Researchers in Mechanical Engineering

# Unraveling The Mechanics of Architected Soft Systems

### SPEAKER

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### ABSTRACT

This talk explores the control and dynamic modeling of soft, slender bodies and their interactions with fluid flow. Specifically, it focuses on developing scalable software and algorithms to model two-way flow-structure interactions between soft, slender structures with viscous flows. Leveraging these tools alongside topological and geometric principles, this work aims to unravel how the complex muscular architecture of octopus arms simplifies control, with potential applications in designing dexterous soft robots. This is achieved by a scalable, user-friendly, open-source software platform called PyElastica. This platform models the dynamics of soft, slender structures using Cosserat rod theory, which efficiently captures the 3D dynamics of slender objects through a one-dimensional Lagrangian framework. Building on this, we introduce algorithms that integrate Cosserat rod theory with the velocity-vorticity formulation of the Navier-Stokes equations, allowing us to model soft, slender structures immersed in viscous flows. The result is a validated, multiphysics framework that accurately simulates the behavior of both rigid and soft, homogeneous and heterogeneous structures in fluid environments, setting the stage for scientific discovery and engineering design. Next, we apply these frameworks to gain insights into the exceptional dexterity and reconfigurability of muscular hydrostats, such as octopus arms, through numerical simulations. To achieve this, we develop a highly detailed model of an octopus arm with over 200 continuous muscles, informed by imaging experiments. We demonstrate that complex 3D arm motions are driven by the storage, transport, and transformation of topological and geometric properties, achieved through simple muscle activation patterns. Building on this understanding of the arm's mechanics and topology, we automate control by designing a 3D feedback controller. The controller's performance is demonstrated through various reaching and tracking benchmarks, including a challenging case where an eight-armed octopus with 1,600 continuous muscle groups is controlled. Overall, this talk presents novel physical discoveries and versatile numerical algorithms packaged into scalable software. These contributions enable the accurate modeling of complex fiber-based structures in fluid environments, with wide-ranging applications in engineering, healthcare, and medicine.

### ABOUT THE SPEAKER

Arman Tekinalp is a Postdoctoral Researcher at the Department of Mechanical Engineering at the University of Maryland College Park working with Eleonora Tubaldi. He earned his Ph.D. in Mechanical Engineering (2024) under the supervision of Mattia Gazzola, and his M.S. in Aerospace Engineering (2019) with Deborah Levin, both from the University of Illinois Urbana-Champaign. He received his B.S. in Aerospace Engineering (2016) from Middle East Technical University. He is a Fulbright Scholarship recipient. His research focuses on understanding the mechanics of soft, slender structures and developing numerical methods to capture their dynamics, whether interacting with frictional surfaces or immersed in fluid flows with potential applications in designing dexterous soft robots. His work has been published in journals such as PNAS and Computer Methods in Applied Mechanics and Engineering, with one of his publications selected as the cover article of PNAS.

### ZOOM DETAILS

https://zoom.us/j/2837443344?pwd=NnZJaEpwQklJdUlxNGZtcFhRY0Rjdz09&omn=99976476223
**Meeting ID**: 283 744 3344. **Passcode**: 2354290

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