Translational AI Center (TrAC) Seminar Fall 2025

Ryan Truby

September 30th at 1:00 PM (US Central Time)

Location and zoom link: https://trac-ai.iastate.edu/event/trac-seminar-series-ryan-truby/

Design and Additive Manufacturing of Autonomous and Soft Robotic Material Systems

Abstract

Living organisms continuously adapt their bodies to changing environments to enhance their performance, resilience, and efficiency. These capabilities, found throughout the natural world, inspire the development of multifunctional materials for bioinspired engineered systems, with applications ranging from autonomous materials to robotics. However, unlocking the full potential of morphing, responsive material systems demands new approaches to materials design and advanced manufacturing. In this talk, I will present three recent advances from our research group at Northwestern University, the Robotic Matter Lab, in the development of material systems that morph, move, and mimic muscles. First, I will introduce an integrated computational co-design and additive manufacturing framework for the rapid development and fabrication of liquid crystal elastomer (LCE) composites that change shape in response to heat and light. Our framework simultaneously optimizes target deformation, material selection, and manufacturing parameters, enabling programmable actuation in response to both heat and light. Second, I will share how architected elastomers fabricated using desktop fused deposition modeling can drive untethered, fast soft robotic locomotion. We use a handed shearing auxetic (HSA) structure 3D printed from thermoplastic polyurethane (TPU). Soft robotic legs are constructed from four HSAs that extend when rotated by a servo motor. By tuning the mechanical compliance of HSA legs, we show that walking speed and efficiency can be significantly improved. Finally, we present our efforts toward artificial musculoskeletal systems composed of soft architected actuators that extend and contract in response to servo-driven inputs. These actuators combine TPU HSAs and Yoshimura origami structures to achieve motions inspired by biological musculoskeletal systems and open new avenues for integrating soft actuators and bioinspired mechanics in electrically-driven, battery-powered soft robots. The last two efforts open opportunities for developing new strategies integrating advancements in artificial intelligence, computational materials design methods, and digital manufacturing to achieve end to-end optimized design of heterogeneous material systems for deployable, untethered soft robot bodies. Altogether, our efforts strive to highlight the promise of digital manufacturing in encoding physical intelligence into morphing, multifunctional material systems. They point toward a future of deployable, robotic materials and soft robots capable of performing practical tasks in unstructured environments with the adaptability and responsiveness of living organisms.

Short Bio

Ryan Truby is the June and Donald Brewer Junior Professor of Materials Science and Engineering and Mechanical Engineering at Northwestern University. His research broadly aims to advance machine intelligence by material design. He and his team in the Robotic Matter Lab are currently developing novel soft actuators and sensors, rapid multimaterial 3D printing methods, and machine learning-based control strategies for soft sensorized robots. Ryan's research also includes work in 3D printing vascularized tissue constructs, soft electronics, artificial muscles, and architected materials. Prior to Northwestern, Ryan was a Postdoctoral Associate at MIT's Computer Science and Artificial Intelligence Lab, and he received his Ph.D. in Applied Physics from Harvard University. Ryan is the recipient of a DARPA Director's Fellowship, DARPA Young Faculty Award, Office of Naval Research Young Investigator Award, Air Force Office of Scientific Research Young Investigator Award, the Outstanding Paper Award at the 2019 IEEE International Conference on Soft Robotics, an Inaugural 2018 Schmidt Science Fellowship, and the Gold Award for Graduate Students from the Materials Research Society. He was named a 2025 ASME Rising Star of Mechanical Engineering and a 2023 Searle Fellow at Northwestern University.

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