Putting Materials to Work: Functionalizing Matter in Service of Robotic Solutions

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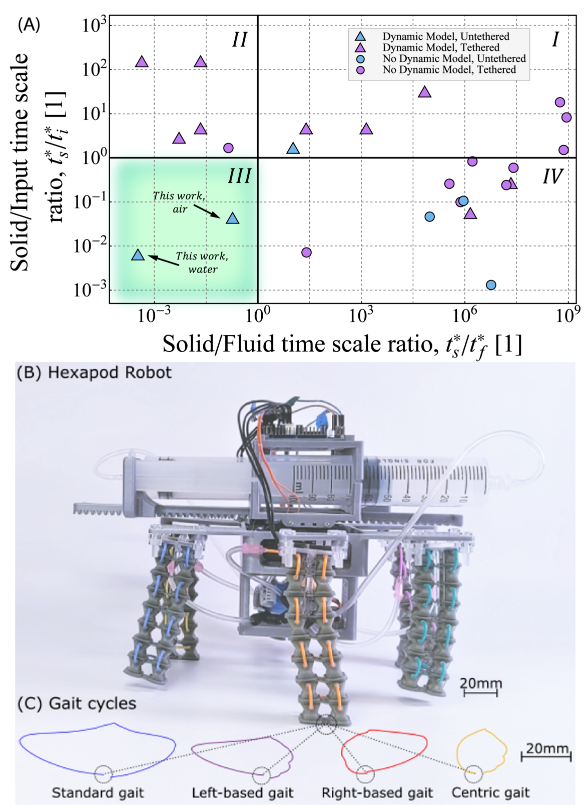
Abstract: The primary goal of this work is to demonstrate how to teach a set of bladders a specific behavior - embodying code into matter. Specifically, we discuss the generation of complex motion in soft, fluid-driven actuators composed of elastomer bladders arranged around a neutral plane and connected by slender tubes. The motion is generated with a single pressure input, leveraging viscous flows within the actuator to produce non-uniform pressure between bladders, rather than relying on complex feedback control or multiple inputs. Using an accurate predictive model coupled with a large deformation Cosserat rod model and low Reynolds-number flow, all dominating dynamic interactions, including extension and curvature, are captured with two governing equations. Given insights from this model, five design elements are described and demonstrated in practice. By choosing the relative timescales between the solid, fluid, and input pressure cycles, the tip of the actuator can obtain almost any desired trajectory and can be placed temporarily anywhere within its 2D workspace. Finally, a six-legged untethered walking robot showcases the benefits of viscous-driven soft actuators. **This work lays the foundation for a new class of morphologically intelligent, soft robotic appendages that are capable of complex deformations and multifunctionality without explicit drivers. By generating non-uniform pressure distributions, their infinite degrees of freedom can be exploited.**



Biography of Presenting Author:

Yoav Matia is an Assistant Professor at Ben-Gurion University. Earlier in his career, he was awarded the distinguished *Zuckerman STEM Leadership Research Fellowship* and *The Royal Society Newton International Research Fellowship*. Yoav holds a Ph.D. from the Technion-IIT, where he received the distinguished honor of the *Pnueli Award* in recognition of the best doctoral research conducted at the Faculty of Mechanical Engineering, Technion-IIT. In his work, **Yoav draws inspiration from the mathematical principles of Artificial Neural Networks (ANN), which serve as the foundation for most machine learning technologies today, and investigates fundamental realizations for embodied analog computation through FSI-enabled morphology.** His research covers the interdisciplinary field of fluid-structure interactions, where the interplay between fluid dynamics and solid mechanics in a host of non-linear transient phenomena governs the physics of the system.

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