A SUCSHM (सूक्ष्म) Soft Robotic Gripper

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As Shakuntala Devi (Indian mental calculator) said, “Everything around you is mathematics.” Therefore, at SUCSHM (Searching Unique Class of Small-scale High-performance Materials) Lab in the Department of Mechanical and Aerospace Engineering at IITH, we emphasize the development of mathematical models to understand the fundamental physics that governs various physical problems involving actuation techniques of multiphysics-based slender, rod-like soft robotic grippers, plant growth, innovative and energy-efficient metamaterials.

In this article, we will limit our discussion to the growing field of soft robotics. Soft robotics is a booming field that focuses on designing and developing robots made from flexible and highly deformable materials. These robots can mimic the adaptability and dexterity of biological organisms.

Unlike traditional rigid robots, soft robots are built from highly compliant materials, such as silicone, elastomers, and shape-memory alloys, allowing them to interact safely with humans and delicate objects without causing harm or damage. These soft robots can undergo large deformations, thus making them capable of being used in medical applications such as minimally invasive surgery (MIS), targeted drug delivery, and many more.

We primarily model these soft robots as slender multiphysical bodies that can either bend, twist, translate, or undergo a combination of these mentioned deformations to perform the desired task.

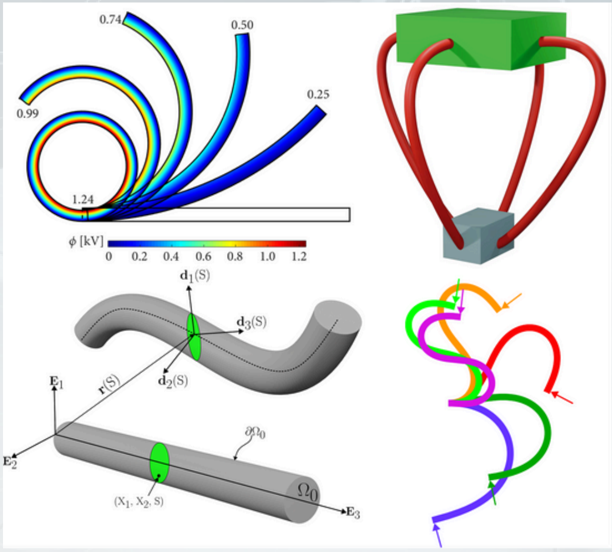

Figure 1. A Glimpse of our work at the SUCSHM (सूक्ष्म) Lab

Unlike conventional (rigid) robots, soft robots can grasp objects without causing damage and are safer for human interaction.

Additionally, they do not require precise control or complicated algorithms to operate effectively. This approach utilizes hydraulic or pneumatic, thermal, or electric actuators that can undergo large deformation rather than traditional motors or rigid linkages.

As a result, soft robots can effectively mimic natural movements, which reduces mechanical complexity and allows for safe operation in environments designed for human interaction.

Furthermore, the absence of bulky motors makes soft robots lighter, quieter, and more energy-efficient. For these soft grippers to securely grasp and hold objects, friction plays a critical role in its performance. When the soft gripper interacts with the surface of the object, the friction between the gripper's surface and the object prevents the slipping of the object and provides secure grasping. The friction is directly influenced by factors such as surface texture, material properties, and the normal force exerted by the gripper.

In our work, we control the normal force that the gripper acts upon the object via different designs and voltage actuation. By carefully adjusting frictional forces, engineers can design more reliable and efficient grippers capable of handling delicate objects without causing damage.

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