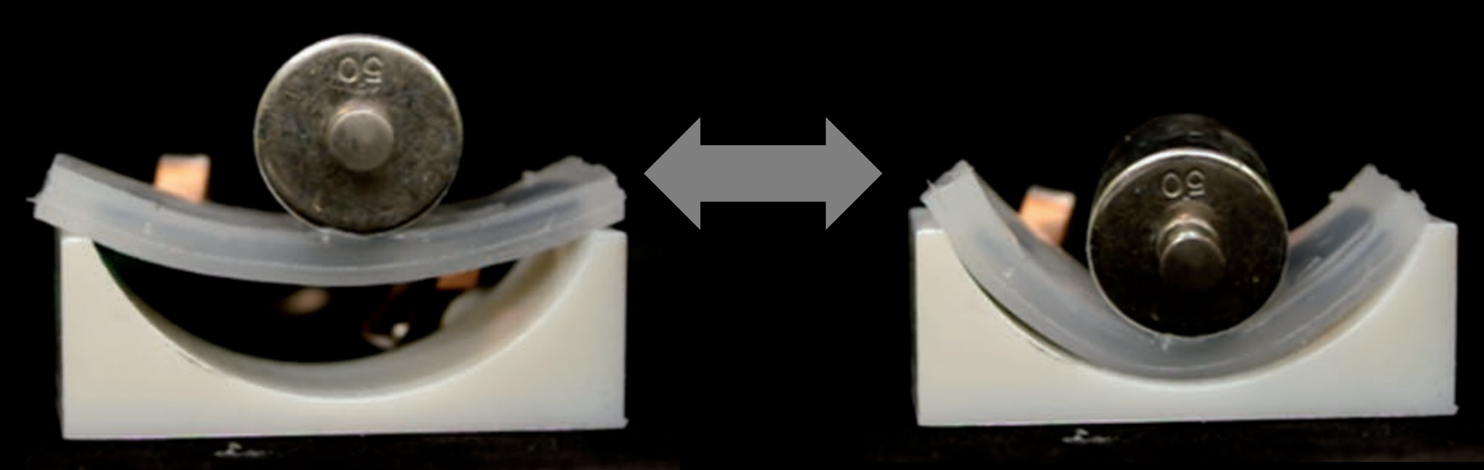
NRI:INT:COLLAB: Soft Active Contact Pads with Tunable Stiffness and Adhesion for Customizable Robotic Grasping

CMMI 1830362, CMMI 1830475, and CMMI1830388.



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Problem Statement & Motivation

Objects from Amazon Picking Challenge 2015 (IEEE Spectrum)

Universal & Customizable Robot Grasping

Conventional robotics typically utilize specialized grasping technologies that can only handle a limited class of objects. In contrast, emerging co-robotics require *universal* gripping systems that can match the versatility of natural grippers in handling a wide variety of objects.

Challenges & Existing Methodologies

Currently, the challenge of robot grasping is being addressed through advancements in system-level hardware and algorithms for sensing, control, and planning. However, progress also depends on **new materials and architectures** that exhibit the mechanical compliance and rigidity-tuning properties of biological systems.

Our Approach: Adhesion & Stiffness Tunable Materials

Rigidity tuning element with shape memory polymer (Wanliang Shan & Carmel Majidi)

In an effort to address this challenge, we will build on the following recent advances by our research labs and others in the fields of solid mechanics, materials engineering, and soft robotics:

- Novel polymer-based materials that can change their elastic modulus in response to electrical stimulation and be integrated into soft robotic systems;
- Mechanisms for tuning the effective dry adhesion strength of soft surfaces by modulating the subsurface stiffness or pressure the mechanical stiffness to alter the stress distribution at the interface.

Together, these advancements will be utilized to realize soft active gripper pads that can be mounted to a robot end-effector (example implementation shown on upper right).

Method Evaluation & Device Testing

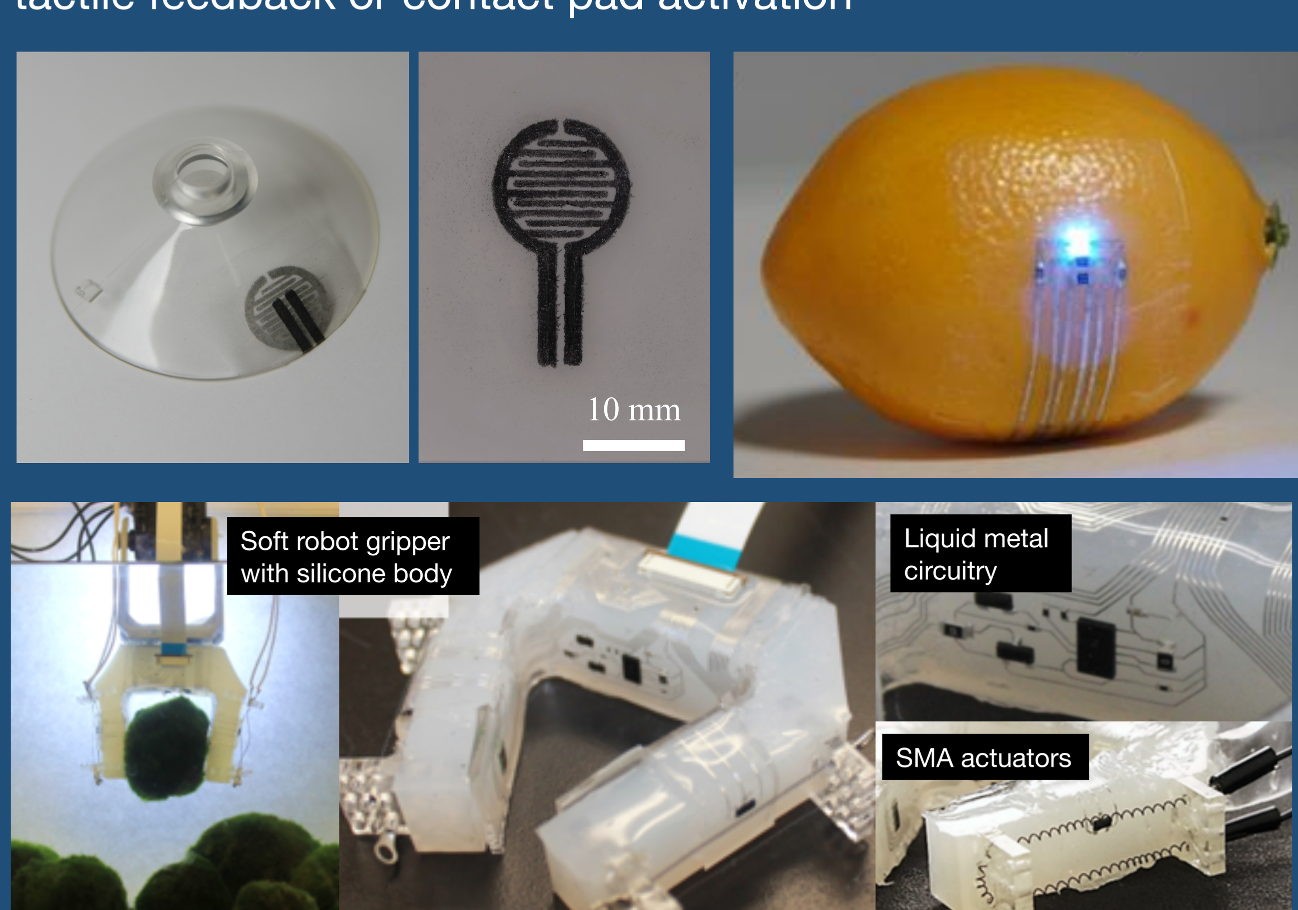
Robotic Gripper Systems

The adhesive structures and materials will be incorporated into the contact pads of a robot end effector. Robot grasping tests will be performed with a conventional wide-face parallel gripper (mounted to a 4 DOF arm or Baxter robot) and vacuum-based suction cup gripper.

Baxter Robot at CMU Robotics Institute

Sensing Skin for Monitoring Interfacial Tractions

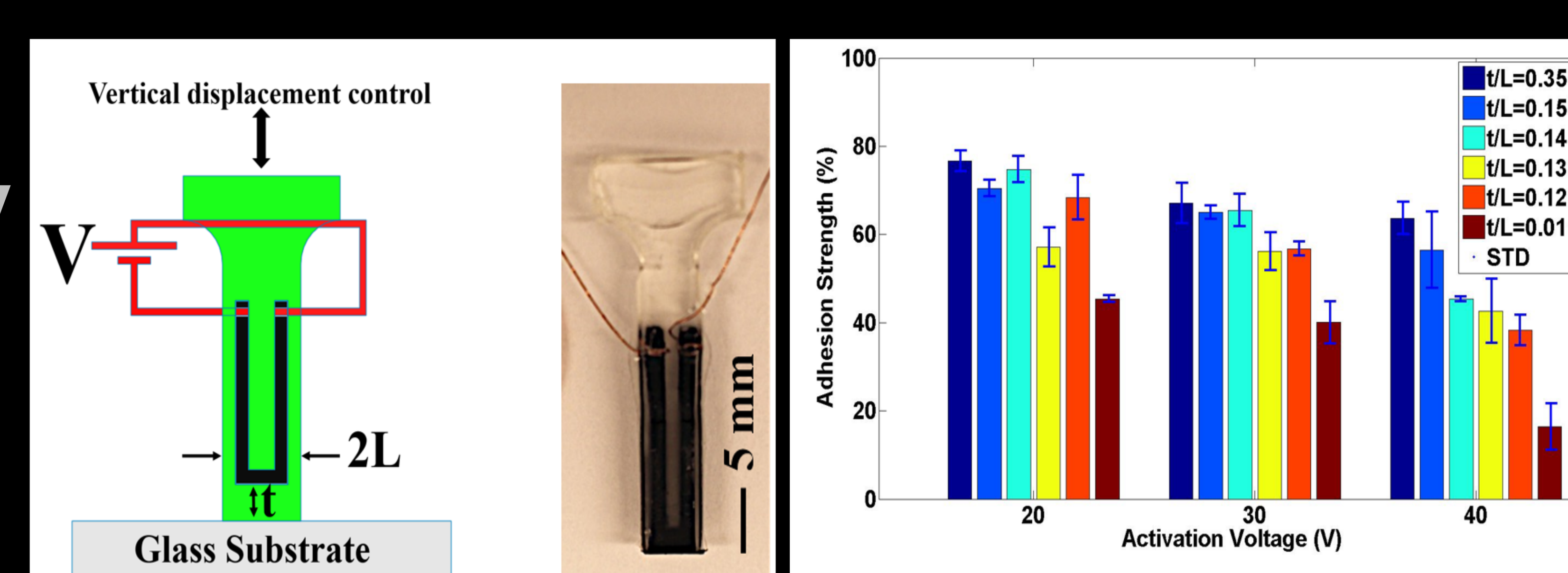
To examine the influence of contact pads on interfacial pressure distributions, we will cover the objects with a tactile skin that will map surface tractions. Depending on the shape and stiffness of the object, the skin will either be a soft elastomeric sheet or a tattoo-like ultrathin film. These same electronics could also be incorporated into the gripper for tactile feedback or contact pad activation



Soft electronic skin using liquid metal circuitry (Carmel Majidi)

Materials Technology

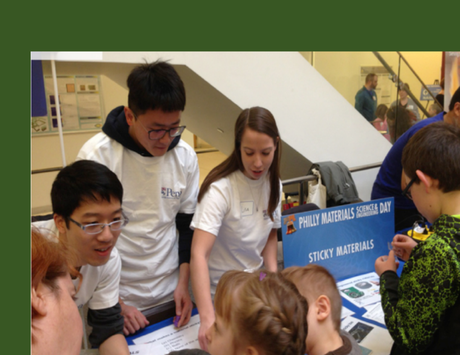
We will fabricate soft active contact pads that implement adhesion-tuning concepts via Subsurface Stiffness Modulation (SSM) and Subsurface Pressure Modulation (SPM)



SSM with core-shell composite posts with dynamically tunable dry adhesion (Kevin Turner & Wanliang Shan)

Education and Outreach

Shan group member Amir Mohamamdi Nasab presenting a research demo at Engineer's Day at UNR



Turner group members presenting demos of "Sticky Materials" at Philly Materials Science and Engineering Day

Majidi group members James Wissman and Tong Lu hosting a hands-on demo at the 2014 SciTech Festival for Pittsburgh-area middle school students