Compliant Robotic Sensing Skins

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THIRTY YEARS OF SYSTEMS RESEARCH EXCELLENCE

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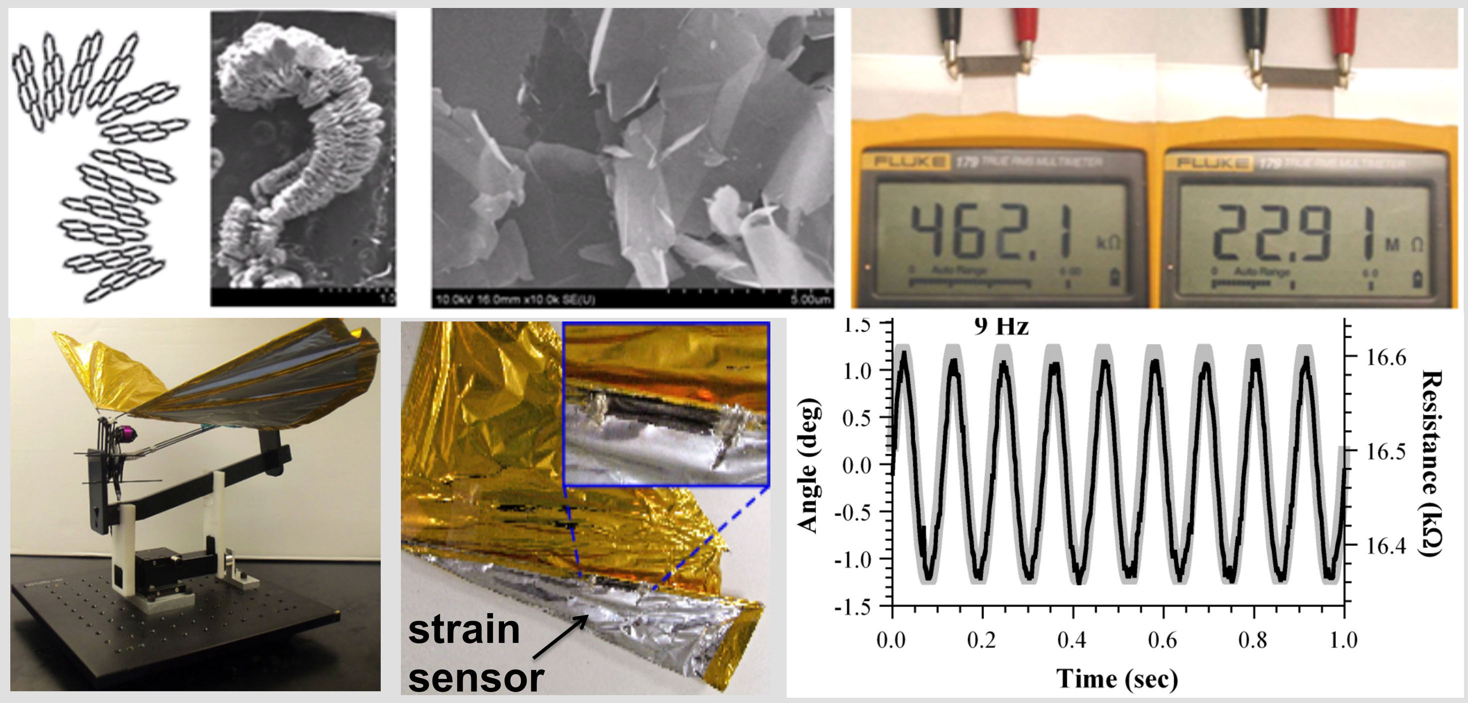
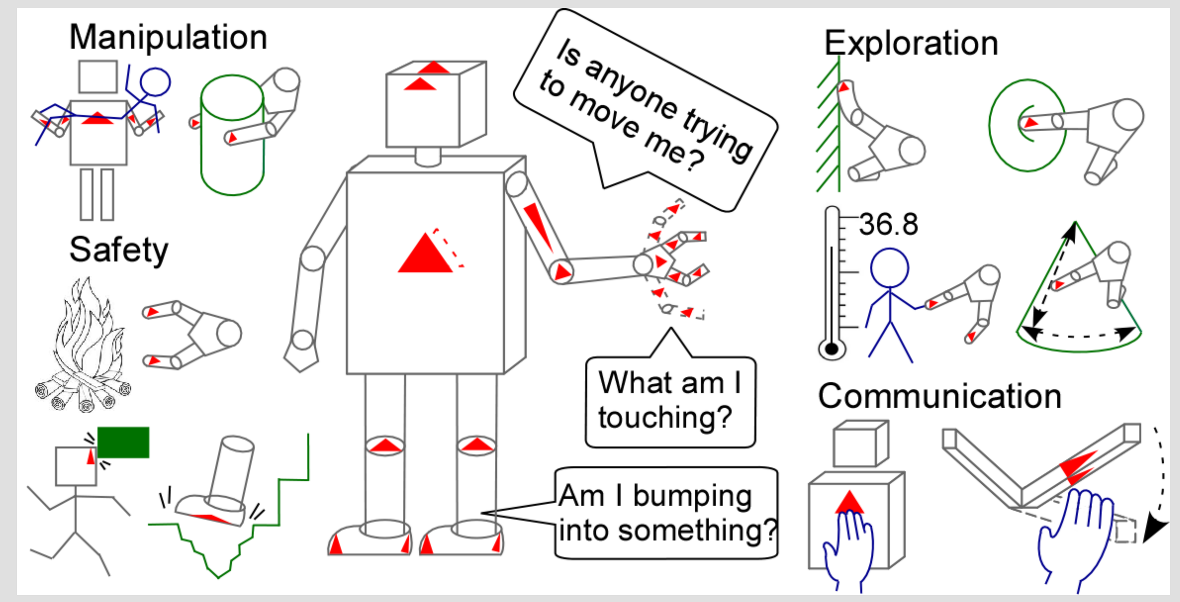
Compliant Strain Sensors

- Formed from exfoliated graphite (EG) and elastomers (e.g., latex).
- Strain sensitive (piezoresistive).
- Applied to surfaces using spray coating.
- Can be integrated into existing structures (e.g., robot appendages, gloves, flapping wings) .



Tactile Sensing for Co-Robotics

- Compliant multi-functional skins for robotics can "sense" contact with other structures, as well as temperature.
- Large-area compliant skins can cover padded robots.
- Enables bio-inspired robotic control principles for manipulation, safety, exploration, and communication.
- Enables humans to work alongside robots.
- Provides robots with additional awareness of their environments.

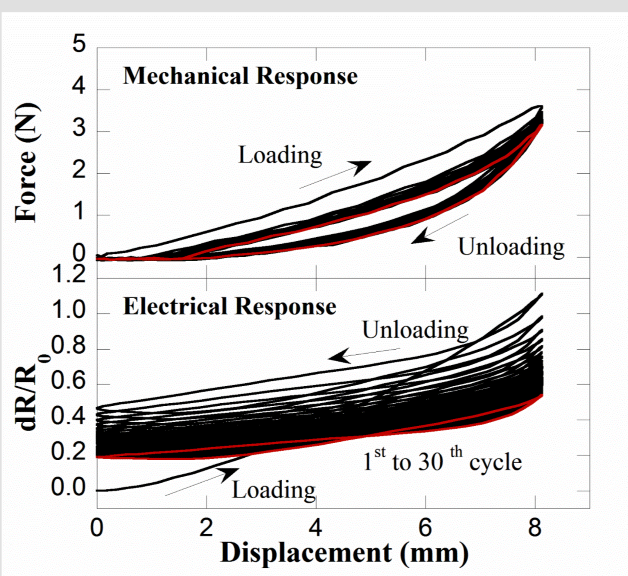


Robot interactions with the environment; red rectangles represent tactile sensors; gray, the robot; green, objects; and blue, humans.

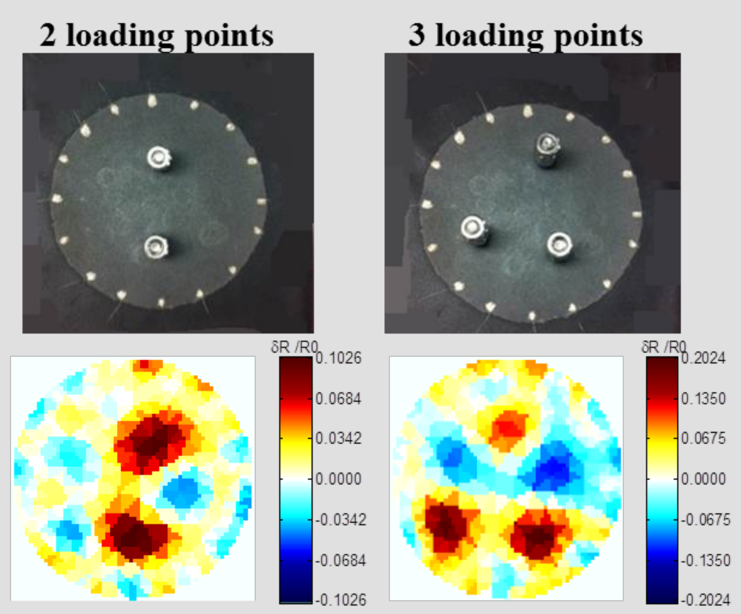
Strain Sensing

- Calibrate for both static and dynamic response under a combination of compression and tension.
- Investigate the performance of the skin with various padding materials .
- Characterize cross-sensitivities to compensate for environmental conditions.

- Employ electrical impedance tomography (EIT) for distributed sensing.
- Reduce wiring complexity through reconstruction of the internal resistance change from measurements at the periphery.
- Improve the algorithm for the inverse problem to enhance image quality of the reconstruction.

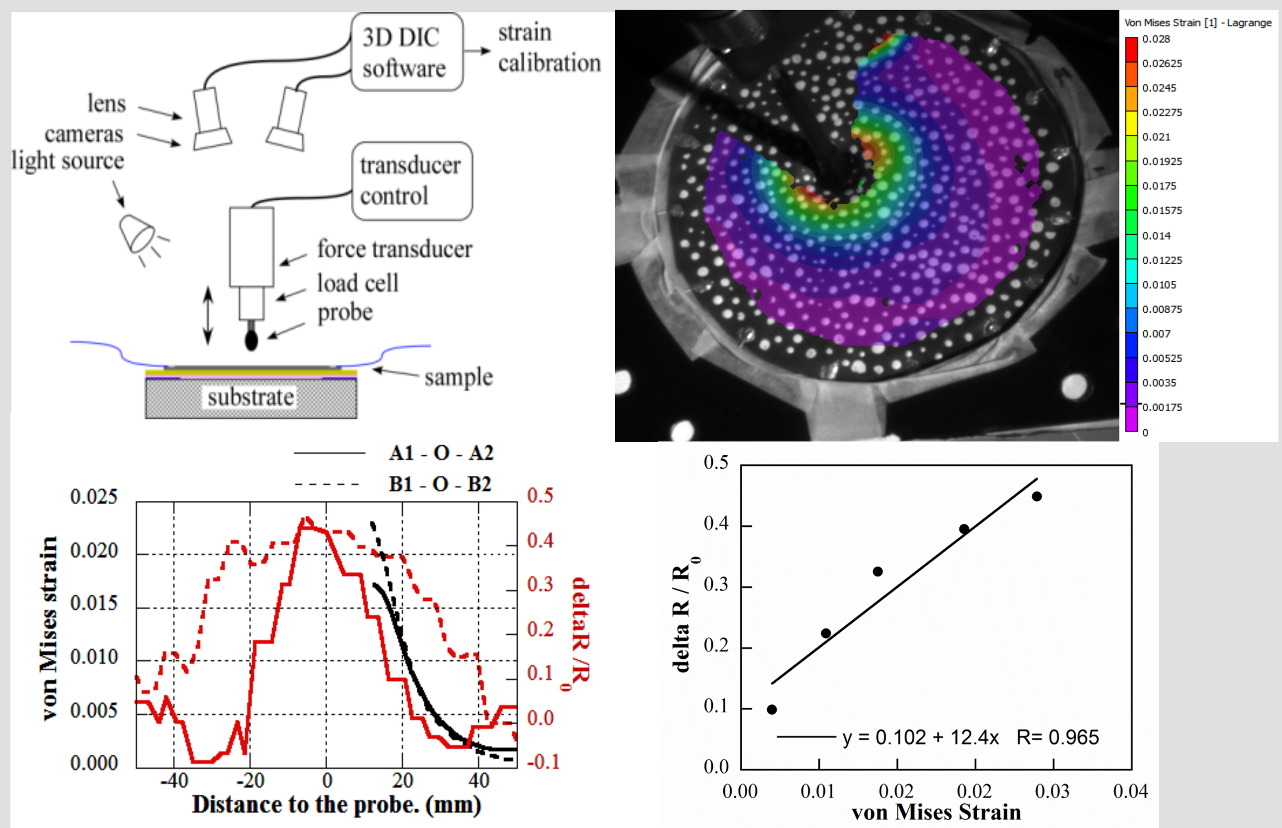


Stabilization of the Sensing Skin



Distributed Sensing Skin

Validation



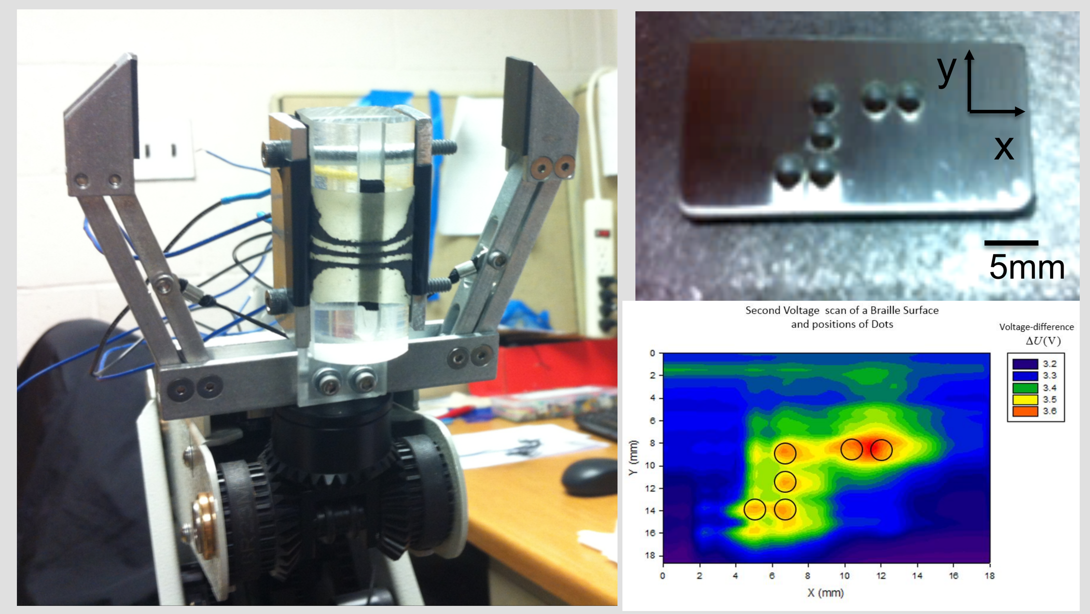
DIC Strain Characterization of Sensing Skins for Robotics

- Use digital image correlation (DIC) to characterize deformations of compliant robotic structures.
- Provide high resolution full-field deformation measurements.
- Enable direct quantification of interactions.
- Develop fundamental relationship between sensor configuration and distributed pressures and geometries from human contact .

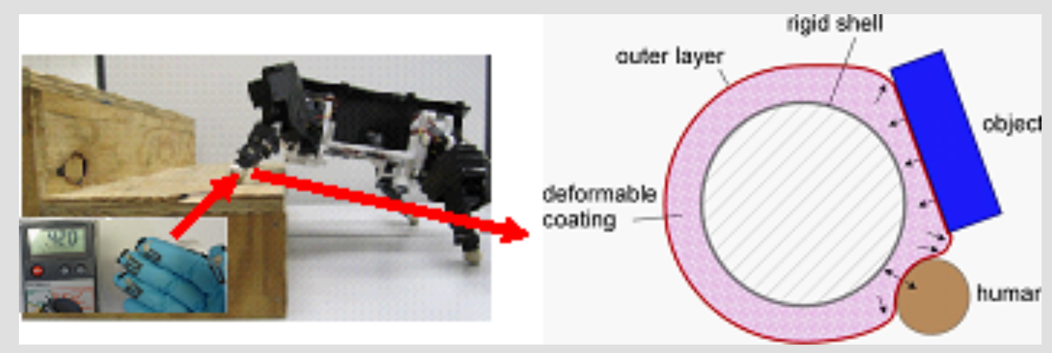
References:
[1] J. Wissman, et al., Smart Materials and Structures, vol. 22, p. 085031, 2013.
[2] M. Kujawski, et al., Carbon, vol. 48, pp. 2409-2417, 2010.
[3] M. Kujawski, Thesis: Polymer Composites for Sensing and Actuation, 2011.

Integration

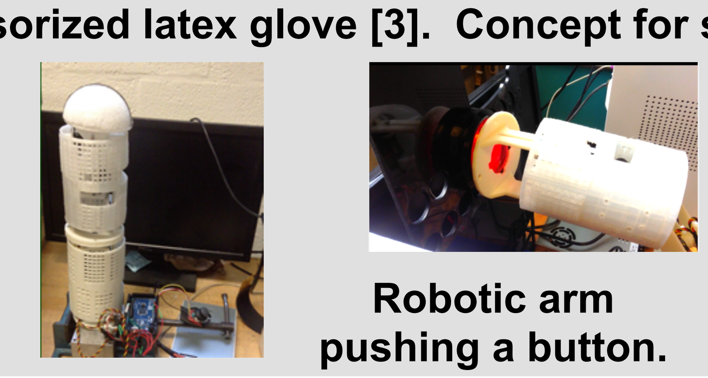
- Readily integrate sensing materials or retrofit onto any robotic platform.
- Create multifunctional robotic structures with integrated sensing materials at many length scales (nanoscale to macro-scale).



Sensing Braille dots with sensor on robot finger.



Sensorized latex glove [3]. Concept for skin.



Robotic arm pushing a button.

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