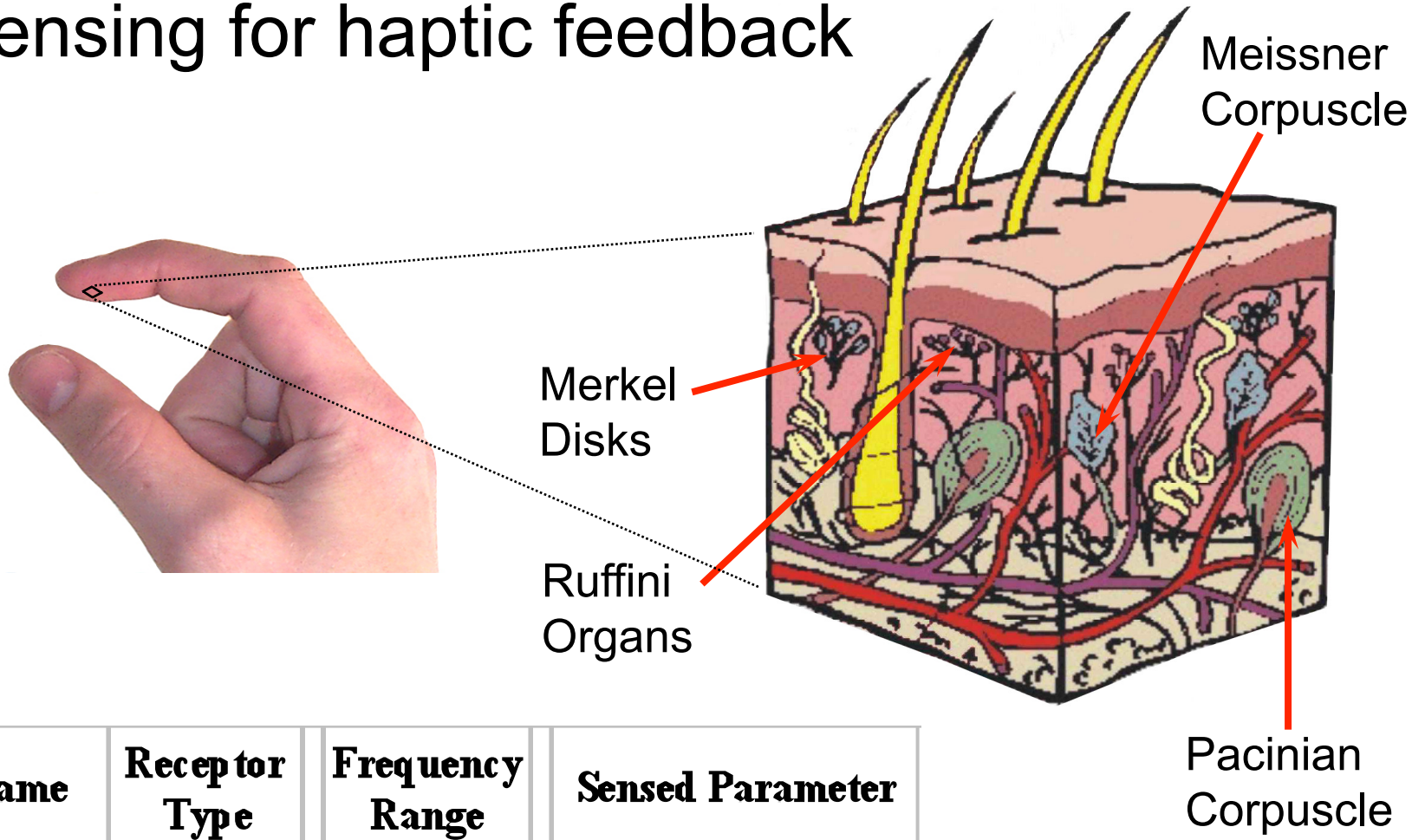
Tactile sensing for haptic feedback



[graphic adapted from http://psych.athabasca.ca/html/Psych402/Biotutorials/27/part1.html]

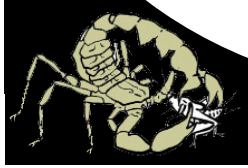
Receptor Name	Receptor Type	Frequency Range	Sensed Parameter
Meissner Corpuscles	FAI	10 - 60 Hz	Skin Stretch
Merkel Discs	SAI	DC - 30 Hz	Local Skin Curvature
Pacinian Corpuscles	FAII	50 - 1000 Hz	Unlocalized Vibration
Ruffini Organs	SAII	DC - 15 Hz	Directional Skin Stretch

* Adapted from Phillips & Johson 1981, Johansson, Lanstrom, & Lundstrom 1982, and Vallbo & Johansson 1984.

Robotic Tactile Sensing Technologies

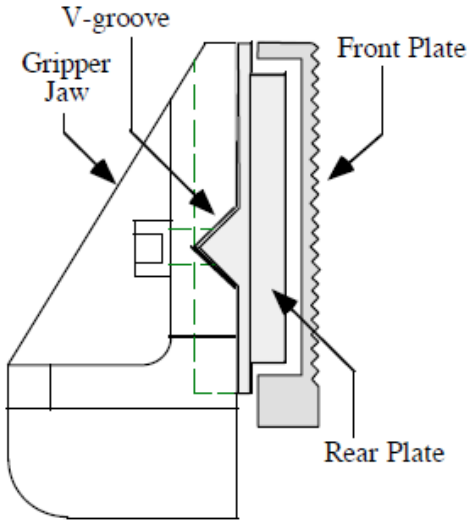
- Capacitive
- Piezoelectric film
- Piezo-resistive
- Optical
- Tunneling effect
- Organic circuits
- …others

- Good for detecting contact events (make/ break contact, slip)
- Easily embedded
- Not affected by depth, pressure
- Relatively simple, noise-robust electronics

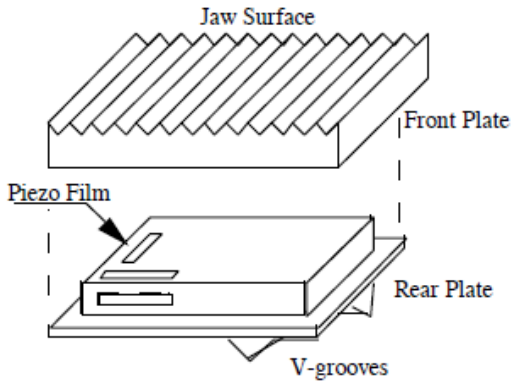


Previous use of PVDF for underwater robotics

[1]



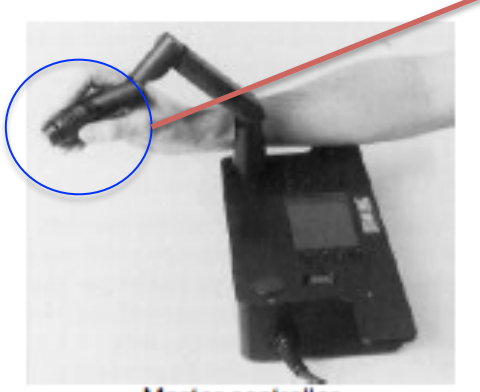
a. Sensor in Gripper Jaw



b. Sensor Plates

[1]

TITAN III remote manipulator



Master controller

[2]

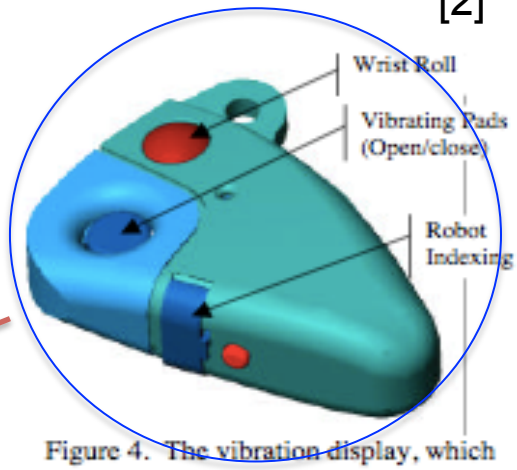
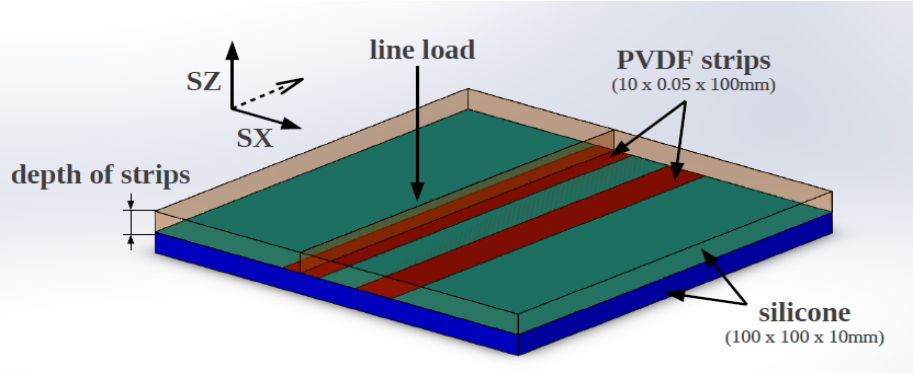


Figure 4. The vibration display, which mounts onto the existing master.

[1] J. Dennerlein, P. Millman, R. Howe. Vibrotactile Feedback for Industrial Telemanipulators. ASME IMECE, Nov 15-21, 1997.

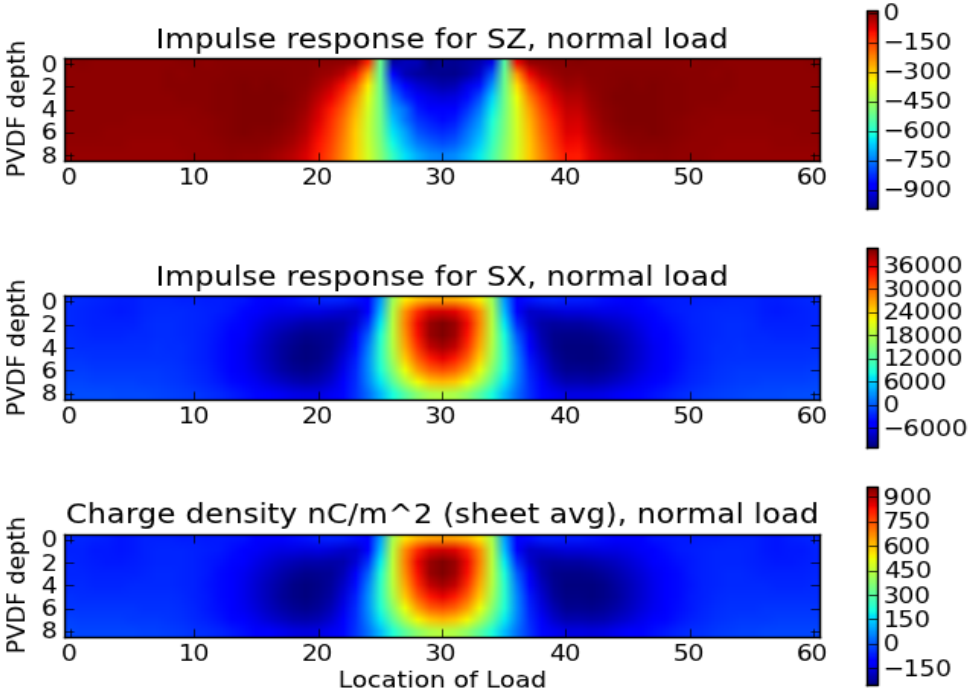
[2] J. Dennerlein, R. D. Howe, E. Shahoian, and C. Olroyd. Vibrotactile feedback for an underwater telerobot. In World Automation Congress, Maui, HI, USA, June 2000.

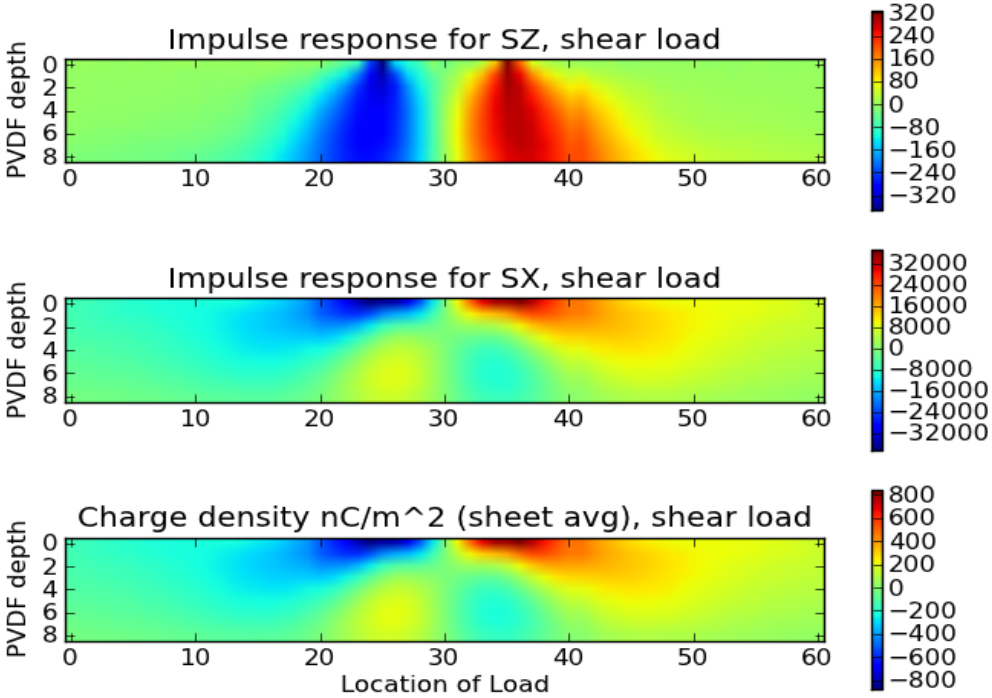
PVDF Sensor Simulation



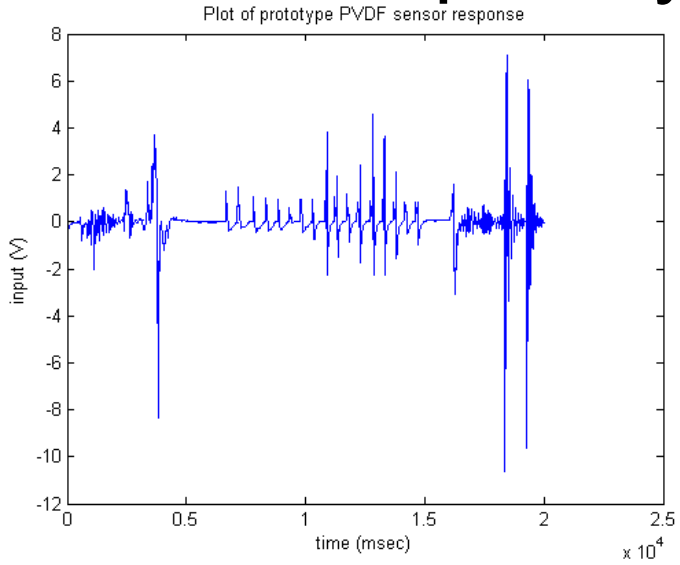
Implications:

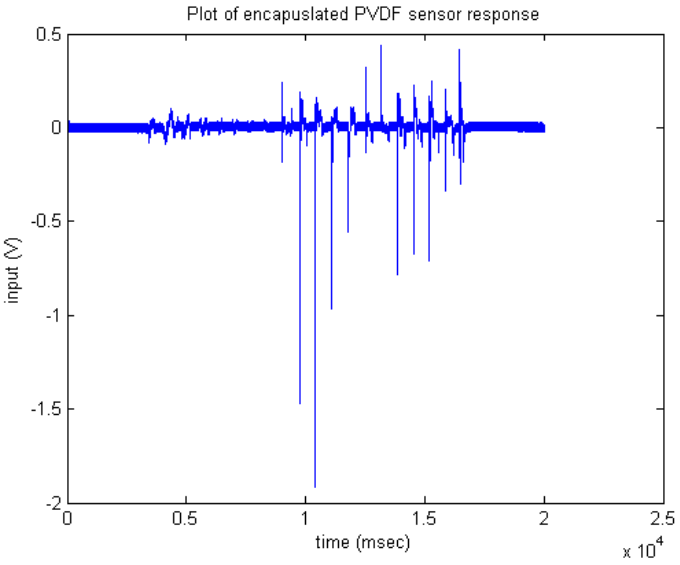
- Increased sensitivity through multi-axial stress summation
- Keep sensors near the surface
- Add surface textures (if small only local effects)

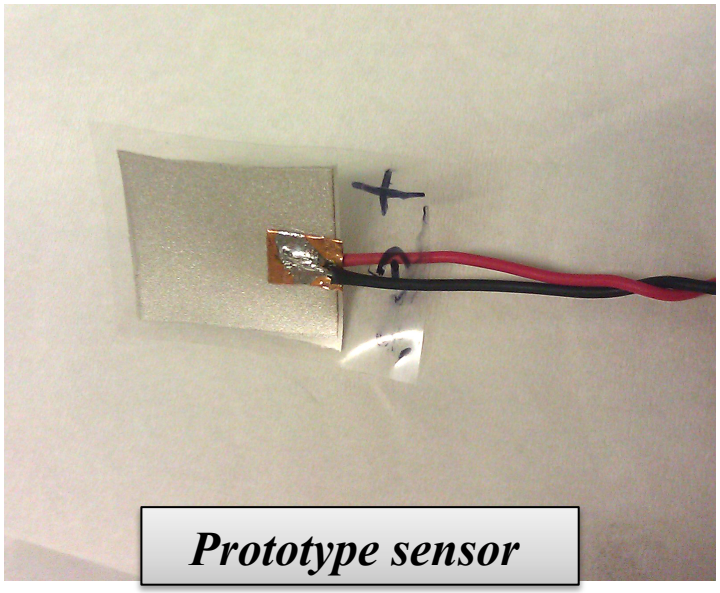


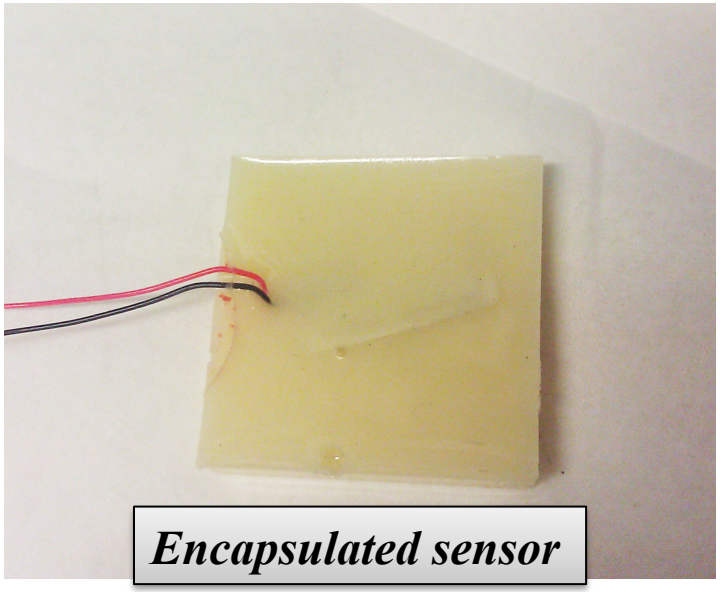


PVDF current prototype

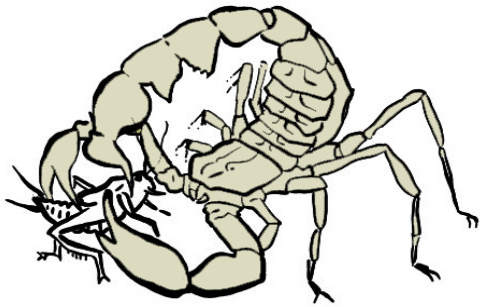


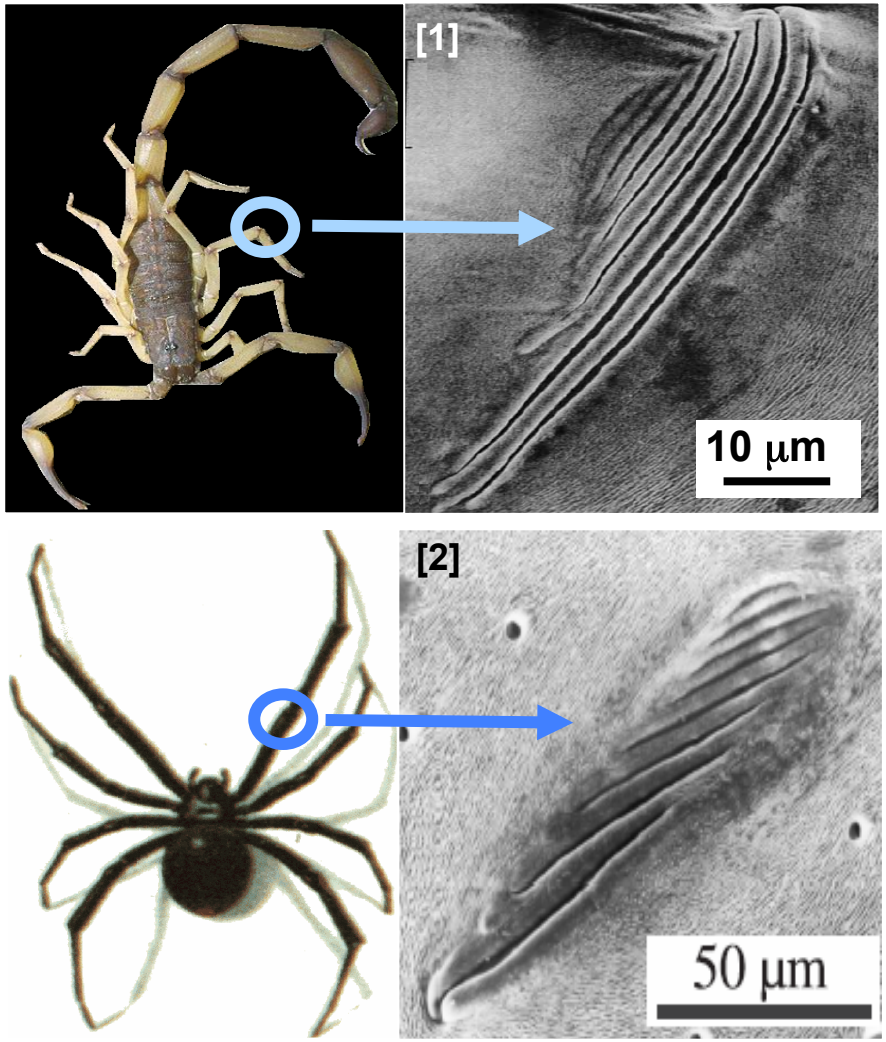






Other biological exemplars





- Slit sense organs
  - Scorpion: ***76*** / leg
  - Spider: ***224*** / leg
- Senses strains on the leg
- Exoskeleton structures make the sensors possible
- Able to sense forces applied to areas elsewhere on the leg
- Additional hair sensors give contact locations

[1] F. G. Barth and M. Wadepuhl. Slit Sense Organs on the Scorpion Leg. *Journal of Morphology*, 145 (2): 209-227, 1975
[2] F. G. Barth and J. Stagl. The Slit Sense Organs Arachids. *Zoomorphologie,* 86:1-23, 1976