Development of a Flexible Durometer Sensor for Improving Hardness Tactile Modality Using Piezoelectric Polymers

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Robotic tactile sensing systems have been of interest in electrical engineering due to their application to prosthetics, manufacturing, and medicine in imitating human touch. However, there is a lack of flexible, inexpensive and larger surface area sensors to detect and quantify the durometer (hardness) of a material without damaging the sample. This paper presents a novel durometer sensor that is flexible and simple to wire, allowing for surface attachment, e.g. to a robotic finger, hand, or limb. 16 silver parallel plate capacitor electrodes were deposited on a 5cm by 5cm film of polyvinylidene fluoride, a piezoelectric polymer. Upon fabrication, electrical charge was accumulated by force application against a compliant layer of foam. Amplitude of the voltage output signal by ten various material tips controlled by a force machine was multiplexed and recorded using an Arduino Mega 250 and the serial terminal emulator, CoolTerm. The curvature (second derivative of normalized voltages) of each material was found and categorized. Sensor results showed high resolution with a sensitivity of 0.49V/N. Curvature vs. Shore Durometer A was significant and quantifiable using a logarithmic fit ($p = 3.14e-06$; $a = 0.05$). This research has medical and industrial manufacturing applications to artificial intelligence and electronic skin, since hardness can be determined with 0.05N of contact force applied and minimal compression, allowing robots to perform certain force-dependent organizational and mechanical tasks based on the material handled. This flexible, cost-efficient durometer sensor, with real-time feedback for material discrimination, can be used for embedded silicone prosthetics, as well as multifunctional properties to determine contact geometry, force, and localization.

Awards Won:

Second Award of $1,500

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