Giving Robot Hands a Feeling

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Background: Grasping is a critical function for humanoid robots to automate mechanical labor. Current robotic grasping is limited by the inability to precisely set grasping conditions before touching the object, often resulting in crushing or slipping of the object. The solution is to optimize integrated pre-touch sensors for versatile ranging and material detection. This project will test the capabilities of a set of 5 miniaturized optoacoustic (OA) sensors integrated into the fingertips of a robotic hand to address this fundamental challenge. Methods: Five miniaturized OA sensors are built using a new optical design and low-cost components. A human-size robotic hand is adapted for OA sensor mounting. An apparatus is constructed that transmits laser pulses through 5 optical fibers into the miniaturized sensors that focus light onto the target. Sound signals generated by the incident laser pulses are simultaneously received via microphones built into each the sensors, amplified by a 5-channel PCB amplifier, and acquired by an 8-channel oscilloscope. The sensor-target range is estimated from the sound signal travel time and the target material type is predicted from the frequency spectra via a machine-learning-based classifier. Results: Seamless integration of OA sensors into a robotic hand is demonstrated. Simultaneous and parallel operation of multiple OA sensors is verified. Adequate ranging accuracy and high classification rates in differentiating various materials, thicknesses, inner structures, and mechanical conditions is achieved under actual grasping conditions. Conclusion: The experimental results confirm that OA pre-touch sensors are viable for robotic integration and provide critical information for accurate grasping.

Awards Won: