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Sense of Touch in Robots Using Optoelectronic Prosthesis

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Abstract: Even though autonomous robots mainly rely on some form of visual perception to interact with the surrounding environment, there are tasks that would be impossible or too complicated without the sense of touch. Tactile sensing can be used for this purpose. A tactile sensor is a device that measures information arising from physical interaction with its environment. The sense of touch is of utmost importance in the field of robotics since a well-performing robot must be able to interact with objects in its environments. It is also important as it supports, and sometimes substitutes, the visual modality during recognition of objects. Like humans, robots need to perceive properties like shape, size, texture, and hardness and discriminate between individual objects by the sense of touch. This paper presents the activation of a sense of touch in robots using optoelectronic prosthesis and all sensors that are integrated within the body of the robots, so they can actually detect forces being transmitted through the thickness of the robot.

Keywords: Tactile Sensing, Robot, Optoelectronic Prosthesis.

INTRODUCTION

Touch sensors called tactile sensors, by engineers, are part of many devices that we use every day. Tactile sensors are sensitive to touch, force or pressure, and are made using light (optical), electricity or magnetism. The stimulus-to-response pathways seen in electronic touch sensor operation mimic the human body process that involves our skin, signal transmission via the nervous system, and brain. For instance, computer keys are touch sensors that inform the computer which keys are being pressed. All keypads have touch sensors. Similarly, you can open a car door using a touch sensor that generates an infrared signal that goes to the car's computer informing it to unlock the door. Touch screens on phones and computer tablets enable even more exquisite communication between people and machines. The use of sensors has exploded into the design of uncountable everyday tools, equipment, appliances, and devices. Current robots usually use external sensors to sense their surroundings. The technology by Cornell University engineers relies on stretchable optical waveguides instead that send the impulses towards sensors, which are inside the robot, thus mimicking the human experience.

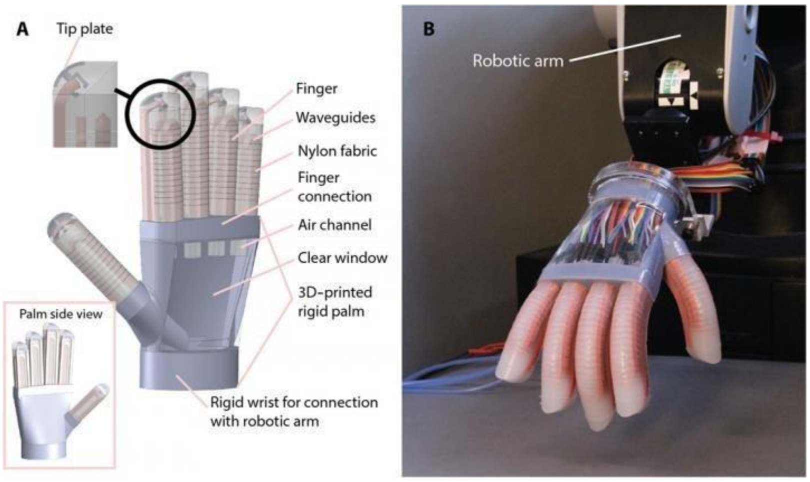
OPTOELECTRONIC PROSTHESIS

Optical waveguides have been in use since the early 1970s for numerous sensing functions, including tactile, positioning and acoustics. Fabrication was complicated originally, but the development of lithography 20 years ago and 3D-printing in the last decade has allowed the creation of elastomeric sensors that are easily produced and incorporated into a soft robotic application. The optical waveguides flex and elongate when touched and pressed, modifying the way light propagates through them to a sensing photodiode at the heart of the system. A four-step soft lithography process was used to produce the core (through which light propagates), and the cladding (outer surface of the waveguide), which also houses the LED (light-emitting diode) and the photodiode.

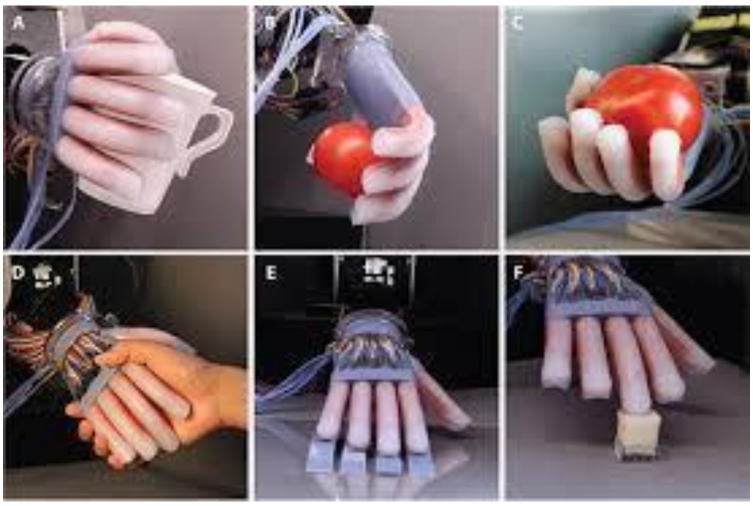
The more the prosthetic hand deforms, the lighter is lost through the core. That variable loss of light, as detected by the photodiode, is what allows the prosthesis to "sense" its surroundings. If no light was lost when we bend the prosthesis, we wouldn't get any information about the state of the sensor. The amount of loss is dependent on how it's bent. The optoelectronic prosthesis is used to perform a variety of tasks, including grasping and probing for shape and texture. The hand was able to scan three tomatoes and determine, by softness, which was the ripest. The

team foresees the technology could have many potential uses including in prosthetics, bio-inspired robotics and space exploration.
Robots using these actuators require stretchable sensors that can be embedded in their bodies for sophisticated functions.

Presently, stretchable sensors usually rely on the electrical properties of materials and composites for measuring a signal; many of these sensors suffer from hysteresis, fabrication complexity, chemical safety and environmental instability, and material incompatibility with soft actuators. Many of these issues are solved if the optical properties of materials are used for signal transduction. We report the use of stretchable optical waveguides for strain sensing in a prosthetic hand. These optoelectronic strain sensors are easy to fabricate, are chemically inert, and demonstrate low hysteresis and high precision in their output signals. As a demonstration of their potential, the photonic strain sensors were used as curvature, elongation, and force sensors integrated into a fiber-reinforced soft prosthetic hand.



Optoelectronically innervated prosthetic hand was used to conduct various active sensation experiments inspired by the capabilities of a real hand. Our final demonstration used the prosthesis to feel the shape and softness of three tomatoes and select the ripe one



The researchers hope to increase the sensory capabilities of the optical waveguides by 3D-printing more complex sensor shapes. They also intend to incorporate machine learning into the system to decouple signals from an increased number of sensors.