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Next generation soft wearable robots

Next generation wearable robots will use soft materials such as textiles and elastomers to provide a more conformal, unobtrusive and compliant means to interface to the human body. These robots will augment the capabilities of healthy individuals (e.g. improved walking efficiency, increased grip strength) in addition to assisting patients who suffer from physical or neurological disorders. This talk will focus on two different projects that demonstrate the design, fabrication and control principles required to realize these systems. The first is a soft exosuit that can apply assistive joint torques to synergistically propel the wearer forward and provide support to minimize loading on the musculoskeletal system. Unlike traditional exoskeletons which contain rigid framing elements, the soft exosuit is worn like clothing, yet can generate significant moments at the ankle and hip to assist with walking. Future versions of the exosuit will monitor the 3D kinematics and kinetics of the wearer using soft stretchable sensors that do not interfere with the natural mechanics of motion. Advantages of the suit over traditional exoskeletons are that the wearer's joints are unconstrained by external rigid structures, and the worn part of the suit is extremely light, which minimizes the suit's unintentional interference with the body's natural biomechanics. The second part of the talk will focus on the preliminary development of a soft robotic glove for hand rehabilitation that consists of a wearable textile with attached elastomeric fluid-powered actuators specially designed to match the natural movements of the fingers and thumb. A component of the research is to develop the knowledge and techniques required to design soft multi-material fluid-powered actuators. These actuators, powered by pneumatic or hydraulic means, are of particular interest to the robotics community because they are lightweight, inexpensive, easily fabricated with emerging digital fabrication techniques and capable of producing complex three-dimensional outputs with simple control inputs. This is accomplished via a multi-step molding process where some combination of fillers (e.g. cloth, paper, particles and fibers) is integrated into a soft elastomeric matrix to create anisotropy in the bulk material properties. Upon pressurization, embedded channels or chambers in the soft actuator then expand in directions with the lowest stiffness and give rise to linear, bending, and twisting motions.