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Perspective

Soft Robotics: An Overview

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PERSPECTIVE

Soft robotics is a subject of robotics that deals with making robots out of highly flexible materials that are comparable to those found in live organisms. The way living organisms move and adapt to their surroundings is greatly influenced by soft robotics. Soft robots, as opposed to rigid robots, provide for greater flexibility and agility when doing tasks, as well as higher safety when working with humans. Because of these qualities, it has the potential to be used in medical and industry. Soft robotics aims to design and build robots with physically flexible bodies and electronic components. Softness is sometimes restricted to a certain area of the machine. Soft end effectors, for example, can be used by rigid-bodied robotic arms to gently grasp and manipulate delicate or irregularly shaped objects. Soft components, such as shock-absorbing foot pads or springy joints that store and release elastic energy, are strategically used in most rigid-bodied mobile robots. Soft robotics, on the other hand, tends to favour robots that are mostly or fully made of soft materials. Robots with completely soft bodies have a lot of promise. For one thing, their flexibility allows them to fit into spaces where hard bodies cannot, which could be beneficial in disaster relief situations. Soft robots are also more suitable for human interaction and deployment within the human body. Given that animals are largely formed of soft components and appear to use their softness for efficient mobility in complex surroundings practically everywhere on Earth, nature is typically a source of inspiration for soft robot design. As a result, soft robots are frequently made to resemble known species, particularly fully soft invertebrates such as octopuses.

Soft robots, on the other hand, are incredibly difficult to construct and control manually due to their low mechanical impedance. Soft robots' flexibility and compliance, which makes them valuable, also makes them difficult to regulate. The equations that have been developed over centuries for creating rigid bodies do not always apply to soft robots. As a result, soft robots are frequently built using automated design methods such as evolutionary algorithms, which allow a soft robot's shape, material characteristics, and controller to all be designed and optimised simultaneously and automatically for a specific task. Because of a solute concentration difference between the cytoplasm and the external environment, plant cells can naturally produce hydrostatic pressure (osmotic potential). Plants can also control their concentration by moving ions across their cell membrane. As a result, the plant's shape and volume change as a result of the change in hydrostatic pressure. Because soft robots have complicated shapes and deformable bodies, traditional manufacturing processes such as subtractive techniques like drilling and milling are ineffective in their construction. As a result, more sophisticated production methods have been created. Shape Deposition Manufacturing (SDM), Smart Composite Microstructure (SCM) and 3D multimaterial printing are among them.

SDM is a method of fast prototyping that involves cyclical deposition and machining. In essence, one deposits a material, machines it, embeds a desired structure, deposits a support for said structure, and finally machines the result to a final shape that incorporates both the deposited material and the embedded portion. Circuits, sensors, and actuators are examples of embedded hardware, and scientists have successfully integrated controls inside polymeric materials to build soft robots like the Stickybot and the iSprawl. SCM is a method of combining carbon fibre reinforced polymer (CFRP) hard structures with flexible polymer ligaments. The skeleton's joints are made of flexible polymer. Through the use of laser machining and subsequent lamination, an integrated structure of CFRP and polymer ligaments is formed. The polymer connections used in this SCM process serve as low-friction alternatives to pin joints in the fabrication of mesoscale robots. Robocasting, also known as direct ink writing, may now be utilised to create a wide spectrum of silicone inks utilising 3D printing (DIW). This method enables for the fabrication of fluidic elastomer actuators with locally determined mechanical properties in a seamless manner. It also permits the creation of pneumatic silicone actuators with programmable bioinspired structures and motions via digital manufacturing. This technology has been used to print a variety of completely functional softrobots, including those that bend, twist, grip, and contract. Some of the disadvantages of traditional manufacturing methods, such as delamination between glued parts, are avoided using this process.

Another additive manufacturing approach for producing photosensitive, thermally triggered, or water responsive shape morphing materials. When these polymers come into contact with water, light, or heat, they can alter shape autonomously. Using light reactive ink-jet printing on a polystyrene target, one example of a shape morphing material was generated. Additionally, shape memory polymers with two different components: a skeleton and a hinge material have been quick prototyped. The material is heated

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to a temperature greater than the hinge material's glass transition temperature after printing. This permits the hinge material to deform without influencing the skeleton material. Furthermore, this polymer may be reformed repeatedly by heating. To move and interact with its surroundings, all soft robots require an actuation mechanism to generate response forces. Soft actuation systems must be able to move without the usage of stiff materials that act as the bones in organisms, or the metal frame that is typical in rigid robots, due to the compliant nature of these robots. Nonetheless, various control solutions for the soft actuation problem exist and have been implemented, each with its own set of benefits and drawbacks. The following are some examples of control methods and the materials required.