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Soft robotics to ensure safe food handling

> The use of soft robotics for food handling could reduce damage during processing stages. This could enhance production efficiency and leads to improved food security in the future.

Soft robotics is a subfield of robotics that concerns the design, control, and fabrication of robots composed of compliant materials, instead of rigid links [1]. Using softer materials similar to those found in living organisms, researchers have developed a variety of actuators that are lightweight, fast acting, and compliant. Soft actuators are trending due to their increased flexibility and adaptability for different tasks like manipulating and grasping fragile objects, agricultural products, and food items.

Harvesting, sorting, and packaging fragile food items like delicate fruits and vegetables have been predominantly done using human labour. Such exhausting and repetitive work leads to increased food wastage due to rough handling and human errors. The use of soft robotics for food handling could reduce damage during processing stages. This could enhance production efficiency and leads to improved food security in the future.

The Computational Sensing and Smart Machines (CSSM) laboratory of the Department of Mechanical Engineering, University of Moratuwa is doing inspiring research applications in soft robotics like soft continuum arms, exosuits, and grippers. The latest development of the CSSM laboratory is the soft gripper which can grasp complex and fragile food items.

Soft Pneumatic Actuators (SPAs) use pressurized gases to create motion. One of the main SPA types is PneuNet actuator which uses arrangements of chambers and channels to deform the actuator with pressurized air. SPAs can be designed to produce a wide range of motions from linear to rotational and therefore have many potential applications.

However, soft actuators often have a lower mechanical efficiency compared to rigid actuators, which increases their energy consumption. The flexible materials used in soft actuators can deform and absorb some of the energy that is supplied to them, leading to energy losses and reduced efficiency. Other factors contributing to low efficiency include the requirement of a continuous supply of pressurized fluid to sustain a particular action. Soft actuators often require sophisticated sensing and control mechanisms to precisely regulate their movement, which can require additional energy inputs and increase the overall energy consumption of the system.

The research team from CSSM laboratory has developed a novel hybrid soft actuator to overcome the limitations of existing SPAs. The actuator combines PneuNet actuation and layer jamming for a soft gripper to handle complex and fragile food items. Layer jamming utilizes the transition of a material from a compliant state to a rigid state due to external stimuli, such as pressure or vacuum to change the stiffness of an actuator.

The developed actuator is 130mm long, 25 mm wide, and fabricated using Sorta-Clear 40 silicone material. It is an assembly of multiple components manufactured using 3D-printed molds. 10 layers of P220 grit sandpapers wrapped in a sealed Polyurethane fabric were used as the jamming section. The

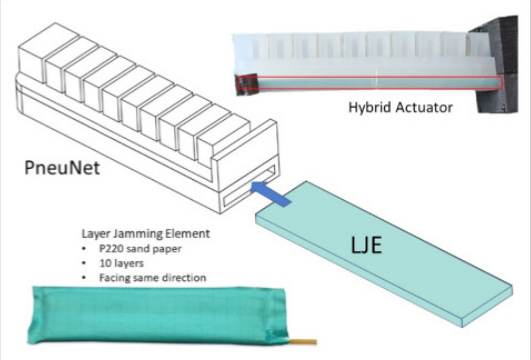

Figure 1: Hybrid actuator assembly

PneuNet section was actuated by SMC-ITV2030 pressure regulator and the jamming section was controlled through a series of flow control valves. Figure 2 illustrates the experimental investigation carried out to characterize the proposed hybrid actuator. Performance evaluation of the actuator showed a maximum 30 degrees bending angle and tip force of 2.3N at 160kPa pressure. The requirement of continuous pressurized fluid supply was averted by the use of the jamming actuator, performing the role of a locking mechanism.

Two-finger and a three-finger gripper have been developed using the actuator to manipulate food items. They have successfully performed grasping of fragile food items with different shapes. The locking feature of the gripper has been implemented to hold the food items for a longer duration while being manipulated.

The researchers at the CSSM laboratory have published a detailed description of the design, development, and assessment of the novel actuator and gripper as a conference paper presented at the 2022 Moratuwa Engineering Research Conference [2]. They are currently investigating other soft actuation techniques and their applicability in food handling.

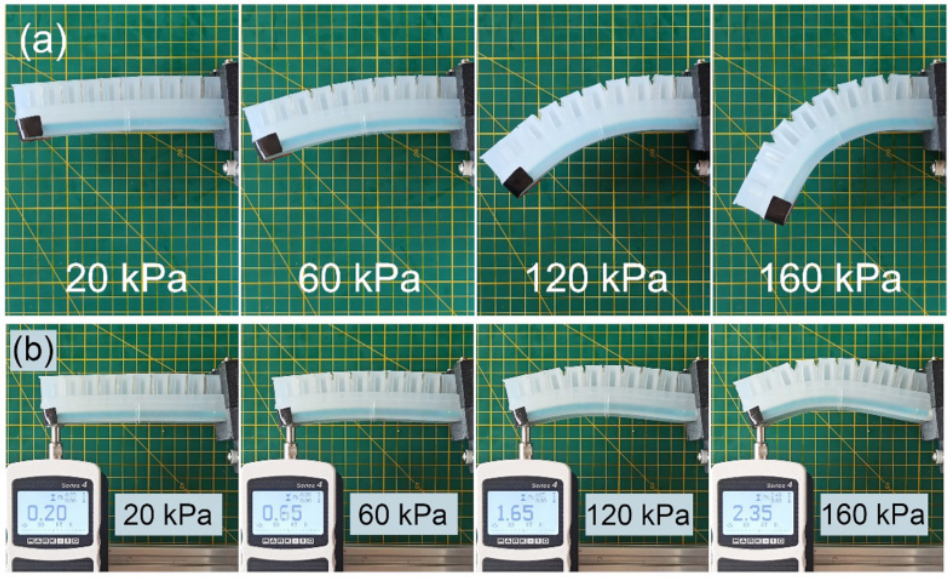

Figure 2: Hybrid actuator experimental evaluation

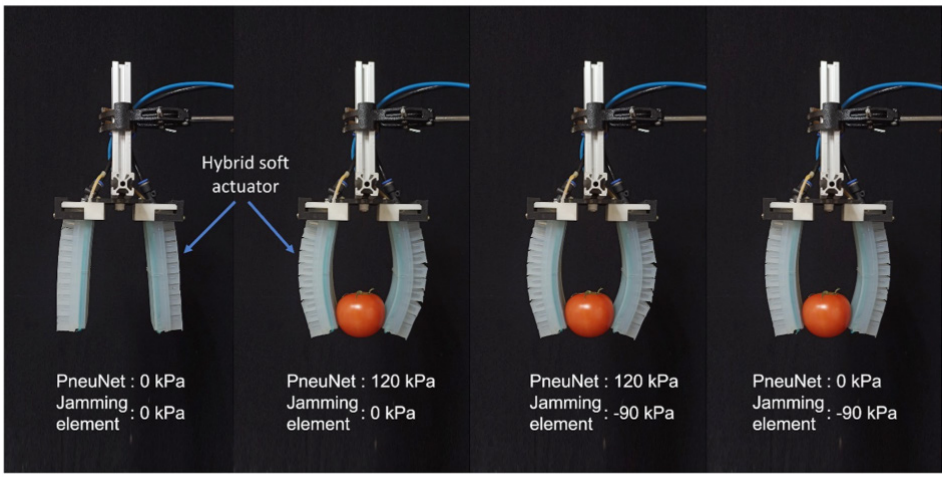

Figure 3: Two-finger soft gripper handling food items

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