Programmable soft actuators show the great potential of soft robotics

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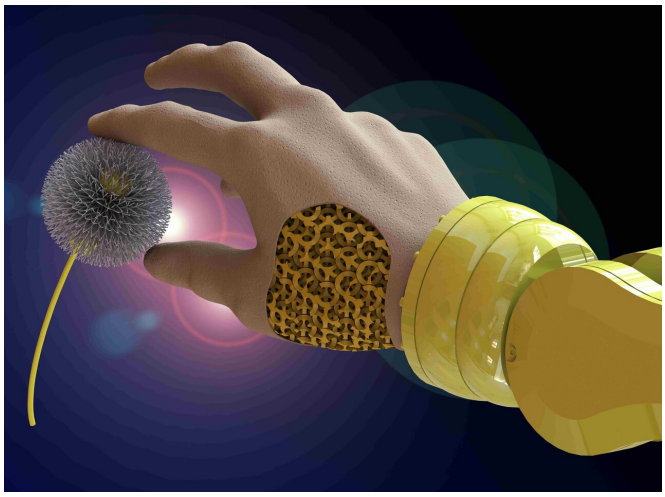


Researchers develop soft actuators that will provide robots with soft touch. Credit: Delft University of Technology

Researchers at TU Delft have developed highly programmable actuators that, similar to the human hand, combine soft and hard materials to perform complex movements. These materials have great potential for soft robots that can safely and effectively interact with humans and other delicate objects. The scientists report on their work in *Materials Horizons* in the issue of July 8th.

Soft

"Robots are usually big and heavy. But you also want robots that can act delicately, for instance when handling soft tissue inside the human body. The field that studies this issue, soft robotics, is now really taking off," says prof. Amir Zadpoor, who supervised the research presented in *Materials Horizons*.

"What you really want, is something resembling the features of the human hand including soft touch, quick yet accurate movements, and power. And that's what our soft 3-D-printed programmable materials strive to achieve.

Tunability

Owing to their soft touch, soft robotics can safely and effectively interact with humans and other delicate objects. Soft programmable mechanisms are required to power this new generation of robots. Flexible mechanical metamaterials working on the basis of mechanical instability, offer unprecedented functionalities programmed into their architected fabric that make them potentially very promising as soft mechanisms. "However, the tunability of the mechanical metamaterials proposed so far have been very limited," says researcher and first author Shahram Janbaz.

Programmable

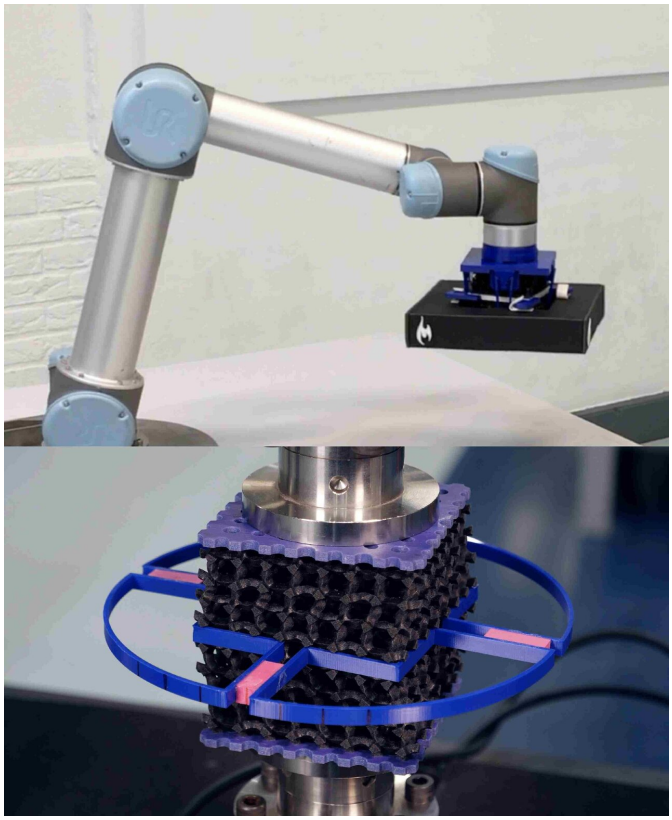
"We now present some new designs of ultra-programmable mechanical metamaterials where not only the actuation force and amplitude but also the actuation mode could be selected and tuned within a very wide range. We also demonstrate some examples of how these soft actuators could be used in robotics, for instance as a force switch, kinematic controllers, and a pick-and-place end-effector," says Janbaz.

Buckling

"The function is already incorporated in the material," Zadpoor explains. "Therefore, we had to look deeper at the phenomenon of buckling. This was once considered the epitome of design failure, but has been harnessed during the last few years to develop mechanical metamaterials with advanced functionalities. Soft robotics in general and soft actuators in particular could greatly benefit from such designer materials. Unlocking the great potential of buckling-driven materials is, however, contingent on resolving the main limitation of the

designs presented to date, namely the limited range and actuation amplitude could be adjusted."

of their programmability. We were able to calculate and predict higher modes of buckling and make the material predisposed to these higher modes."



A conventional robotic arm is modified using the developed soft actuators to provide soft touch during pick-and-place tasks. Credit: Delft University of Technology

More information: S. Janbaz et al. Ultra-programmable buckling-driven soft cellular mechanisms, *Materials Horizons* (2019). DOI: 10.1039/C9MH00125E

Provided by Delft University of Technology

3-D printing

"So, we present multi-material buckling-driven metamaterials with high levels of programmability," says Janbaz. "We combined rational design approaches based on predictive computational models with advanced multi-material additive manufacturing techniques to 3-D print cellular materials with arbitrary distributions of soft and hard materials in the central and corner parts of their unit cells. Using the geometry and spatial distribution of material properties as the main design parameters, we developed soft mechanical metamaterials behaving as mechanisms whose actuation force