Harnessing Instability in Soft Actuators

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ABSTRACT

To increase the capabilities of mechanical devices, soft materials are emerging in the field of engineering. The stiffness of these soft materials makes them ideally suited for application in devices that deal with delicate and diverse tasks. As such, they find an interesting application in soft actuators and robots that are for example able to jump, squeeze through small openings or even play the piano. However, to enable the necessary large deformation and actuation, these soft actuators and robots typically rely on large external input. In our research we aim to limit external input by exploiting instabilities in the design, therewith paving the way for fully autonomous soft robots.

When soft actuators are designed properly, instabilities can trigger large deformation, which can be effectively used to generate motion. Since these new soft devices are characterized by a highly non-linear behavior that makes their design difficult, we use a modular approach. By combining well-understood non-linear mechanical systems, we drastically simplify the design of soft devices showing complex behavior. As an example, we show that upon inflation a system containing two or more spherical membranes undergoes an instability at constant volume. This instability redistributes the internal fluid therewith drastically changing the shape of the system. Such a system could function as the basis for an autonomous robot with controlled motion.