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Bistable Elastomeric Actuator

-Soft robotics is a growing field of study encompassing biology, chemistry, materials science, and engineering. Soft robots can be used for safe and adaptive interaction with humans and harsh environments, manipulation of delicate objects, navigation through a confined space, and actuation with multiple degrees of freedom. One key element in soft robotics is soft actuators that drive deformation and motion of the soft (robotic) body. Soft actuators can conform to objects with different shapes and sizes, and are safe for interacting with humans, thanks to their compliant nature. Among different types of soft actuators, fluid-driven soft actuators have shown advantages such as being low-cost, compact, and customizable. These actuators have been widely adopted in manipulators, wearable robots, and grippers. However, one critical challenge in fluid-driven soft actuators is their slow actuation speed, which reduces the task efficiency and greatly limits their applications.

Current approaches to improve actuation speed include using fast-switching valves with high airflow rates and reducing chamber volume. However, the reaction time of pneumatic actuators utilizing these approaches is still limited by slow dynamics. An alternative approach, bistable and elastic energy storage structures can improve actuation speed. Bistable structures have been used to generate periodic motion such as crawling, jumping, and grasping, to name a few. Although bistable structures improve the actuation speed, the actuators cannot deform continuously and are not capable of generating sophisticated motion profiles. There is a need for a bistable actuator that can not only have fast snap-through (i.e., fast actuation speeds), but also have controllable, continuous elongation.

Researchers at Arizona State University (ASU) have developed novel bistable elastomeric actuators for swift tasks that reacts quickly through a bistable structure while preserving compliance, tunable stiffness with pressure, and continuous elongation capability. Given a pressure input, these actuators can snap-through quickly to a point close to the desired location. Afterward, it can still make fine adjustments with a continuous motion for precise and compliant manipulation. The pressure to trigger the snapping motion and the continuous motion range is tunable by changing the design parameters. By combining multiple actuators in different configurations, more sophisticated motion patterns could be achieved such as bidirectional bending.

Related publication: Design, Characterization, and Dynamic Modeling of BEAST: a Bistable Elastomeric Actuator for Swift Tasks

Video of ASU Actuator: Bistable Elastomeric Actuator for Swift Tasks

Potential Applications:

- Soft robotics
- Fluid-driven soft robotics
- Elastomeric actuators
- Bistable elastomeric actuators

Benefits and Advantages:

- Capable of both fast snap-through and controllable continuous elongation
- Experiments have shown a maximum snapping speed of 1.5m/s, a maximum extension ratio at 0.58, and an output force up to 48N
- Actuator’s triggering pressure and deformation range can be tuned through varying its bistable material (e.g., PET sheet) and soft material (e.g., silicone rubber)
- Can perform both power push and a gentle push on an object
- Large extension ratio and fast reduction time were demonstrated in an object push application scenario