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Soft, Curved, Reconfigurable Buckling Beams for Underwater and Terrestrial Autonomous Vehicles

-Background

Tape springs (or tape measures) exhibit nonlinear stiffness and asymmetric behavior when bent in one direction compared to the opposite direction. This behavior can be utilized, tuned and actively reconfigured to achieve locomotion on land and in fluids. Even in the presence of symmetric flapping, a swimming gait similar to “breaststroke” can be achieved. If the tape spring is stiffened, its motion can resemble that of the tail fin of a fish. There has been some research conducted in the area of using buckling or bistable elements to rapidly change the state of a robot or mechanical system using stored energy, but no research has yet been conducted for use in cyclic, flapping systems to generate asymmetric work loops that can produce positive average thrust for locomotion.

Tunability of these tape springs can be achieved through control of length, curvature, material properties, or other geometric parameters. However, this has not been extensively researched, and there remains a need for tuning of the buckling effect both during the design process as well as in use.

Invention Description

Researchers at Arizona State University have developed a novel method for asymmetric buckling of curved thin beams to achieve locomotion by robots or autonomous vehicles in a fluid or on land. This method allows for the design of simple locomotive systems that use fewer moving parts to achieve high degree-of-freedom motion on land and in water, while maintaining tunability and reconfigurability. Swimming gaits such as rowing, paddling, and flapping can be generated by controlling the effects of stiffness and buckling in swimming robots. This method allows the active switching of gaits on demand by reconfiguring the system, which permits autonomous vehicles to change their behavior without the added cost or complexity of multiple, high power drive motors. On land, the same phenomenon can be controlled to create forward motion in simple walking systems with fewer motors.

Potential Applications

- Swimming robots for applications listed below:
  - Remote sensing applications
  - Medical robotics
  - Low-cost robotic platforms
  - Sensing water quality in waterways

- Swarm applications

Benefits & Advantages

- Easy to embed into simple mechanical systems
- Reduces complexity of control signals needed to make robots move
- Reduces the number of high-power motors needed to locomote
- Can change the behavior of mechanical systems on demand

Related Publication: Reconfigurable Curved Beams for Selectable Swimming Gaits in an Underwater Robot

Related Publication: Curvature-Induced Buckling for Flapping-Wing Vehicles