Efficient Stiffness Modulation of Springs

VANDERBILT UNIVERSITY
CTTC Center for Technology Transfer & Commercialization

Summary

Vanderbilt researchers have developed a novel variable stiffness spring mechanism that affords low energy cost stiffness adaptation. Essentially, the energy cost of changing the stiffness of the spring is rendered independent of the energy stored in the spring.

Addressed Need

Compared to constant stiffness springs, variable stiffness springs offer a range of new capabilities such as stable robot-environment interaction, safer human-robot interaction, efficient resonance-based robot actuation, as well as human performance augmentation. Due to the inherent coupling between the stiffness and the energy stored by the spring, current variable stiffness spring actuators suffer from the limitation of high energy cost when changing spring stiffness. The technology and mechanism developed at Vanderbilt overcomes this limitation and renders the energy cost of stiffness modulation independent of the energy stored by the spring.

Unique Features

- Enabling stiffness change with negligible energy cost when the spring is deflected.
- Providing an energy reservoir during repeated motion (steps, jumps, squats) when used in parallel with human limbs, to store and return greater amounts of energy compared to the limb alone.
- Placing the mechanism in parallel with a direct-drive motor can create a parallel variable stiffness actuator (PVSA) capable of high-fidelity force control and controllable energy storage
- PVSAs enable resonant energy accumulation despite the limited deformation of the spring and the constrained motion of the load attached to the actuator.

Technology Development Status

An initial lab-scale prototype has been developed. The theoretically predicted energy accumulation have been experimentally confirmed. Work remains to be done on "productizing" the mechanism.

Intellectual Property Status

A provisional patent application has been filed.

Future vision for Mechanically Adaptive Energetically Passive Robotics.

CTTC CONTACT:
Ashok Choudhury, PhD
(615) 322-2503
ashok.choudhury@vanderbilt.edu

INVENTORS:
David Braun, PhD; Kim Sung; Chase Matthews
Advanced Robotics & Control Laboratory

VU REFERENCE: VU 21035

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