Karlsruhe Institute of Technology

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Health Robotics and Automation

Variable Stiffness for Exoskeletons

Design and Fabrication of an Actuator-Unit with Shape-Memory-Alloys for Tendon-Driven Applications.

— 10th October 2021 —

Master's Thesis

Context

Exoskeletons can support rehabilitation and handling of daily tasks for disabled and elderly people. To facilitate body movement, e.g. of the limbs, tendon-driven mechanisms can be used that are controlled by a central control unit. These mechanisms however require complex tendon routing and cannot provide a mechanical decoupling of the central control unit and the manipulated limb where high force impacts occasionally occur that might damage or destroy the control unit. "Smart materials" such as **Shape Memory Alloys** (SMA) could be useful to face this challenge due to their shape memory. SMA could be used 1) as non-destructive **overload protection** due to their high repeatable strains and 2) to form a **variable stiffness actuator unit** featuring a bias-spring and SMA-actuators in a parallel configuration.

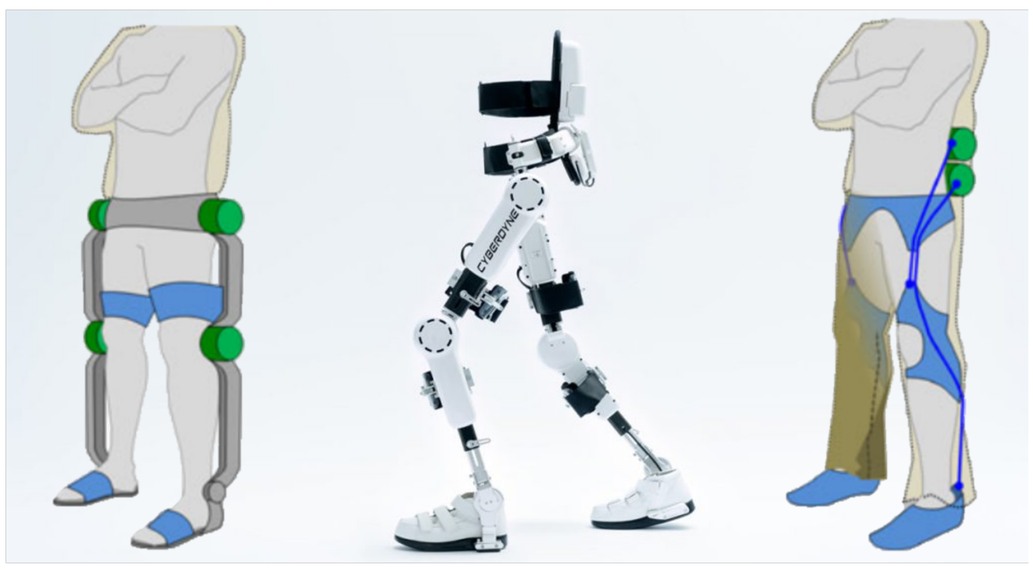

Figure 1: Lower-limb exoskeleton configurations. Sources: 10.1109/TMECH.2017.2718999, www.cyberdyne.jp (modified).

Objective

Investigate the utilization of SMAs for overload protection and variable stiffness in tendon-driven lower-limb exoskeletons.

Task Summary

- **Study** relevant literature about exoskeletons, SMA actuation and variable stiffness.
- **Design** a modular actuator unit to allow for variable stiffness with SMAs.
- **Create** a mathematical model to investigate design parameters.
- **Fabricate** the actuator unit.
- **Evaluate** the controllable stiffness of the designs in a stand-alone scenario and integrated in the kinematic chain of an exoskeleton.

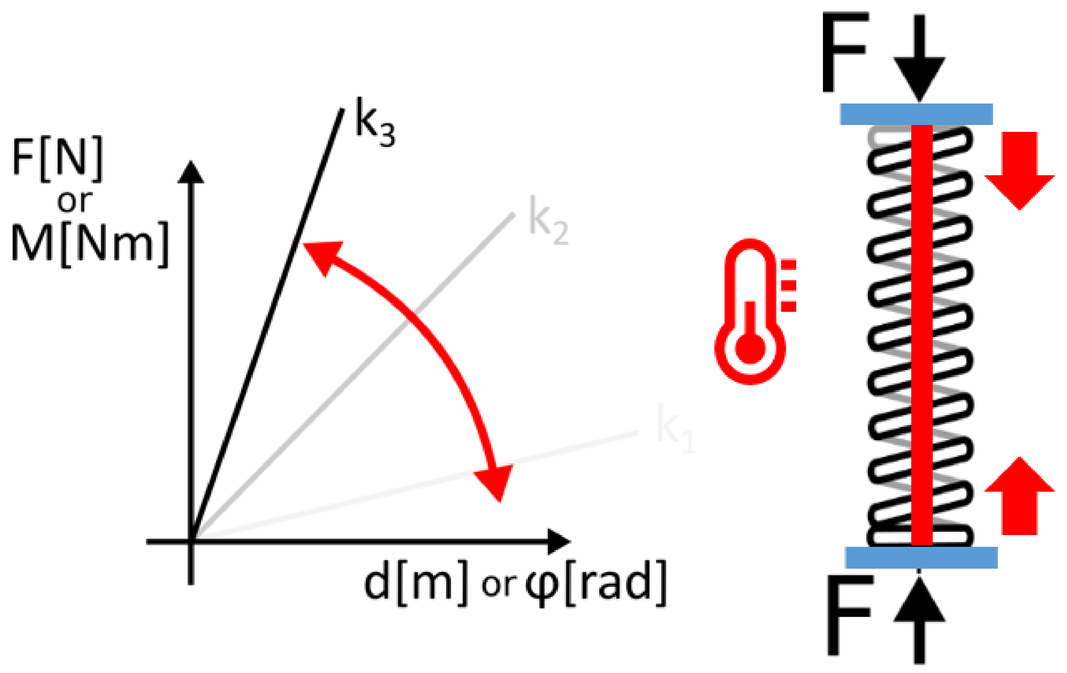

Figure 2: Continuous stiffness variation of a bias-spring using heated SMA wires (red).

Requirements

Qualified candidates (computer science, engineering, physics, material science) shall be interested in:

- Mechanics
- Design, engineering
- Experimentation

Contact

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