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Pushing the Boundaries of Shape Memory Alloy Actuators: record-breaking actuation frequencies and AI-based closed-loop control

Shape memory alloys (SMA) are commonly utilized in compact actuators due to their high energy density, meaning possible work output in relation to their weight and volume. Their application area is limited by their poor dynamic behavior, caused by the thermal activation characteristics of SMA materials. Typical actuation frequencies of SMA-based actuators range from 1 Hz to 10 Hz. In this presentation, we introduce an actuator system architecture, termed bidirectional rotational antagonistic (BIRAN) SMA actuator, which uses bundles of thin SMA wires to generate repeated rotational movement at frequencies up to 200 Hz. The second part of the talk focuses on the so-called self-sensing capability of SMA-based actuators. Through measuring the electrical characteristics voltage and current, the state of the SMA actuator can be predicted. To compensate for non-linear behavior and hysteresis, SMA models are utilized. The presentation introduces a simple data-driven modeling approach and neuronal network architecture, which enables real-time closed-loop control strategies with minimal computational effort and highest prediction accuracies validated in experimental setups. As a result, SMA actuators can be proportionally controlled without additional sensors using the simplest microcontroller platforms like Arduino.

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