Robotics and Autonomous Systems Thesis Defense

Design and Manufacturing of a Shape Memory-Based Actuator

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Abstract

Shape memory alloys (SMAs) are a class of smart materials that can recover their predetermined shape when subjected to an appropriate thermal cycle. This unique property makes SMAs attractive for actuator applications, where the material's phase transformation can be used to generate controlled motion or force. The actuator design leverages the one-way shape memory effect of NiTi (Nickel-Titanium) alloy wire, which contracts upon heating and recovers its original length when cooled. A bias spring opposes the SMA wire contraction, enabling a cyclical actuation motion. Thermal actuation is achieved through joule heating by passing an electric current through the SMA wire.

This thesis presents the design of a compact, lightweight SMA-based actuator, providing controlled and precise motion in various engineering applications. A design of a soft actuator is presented exploiting the responses of the shape memory alloy (SMA) combined with elastic instabilities to trigger intrinsically multistable shape reconfiguration. The proposed class of soft actuators can switch between six stable states (three bending and three twists) by selectively activating the SMA. The transition sequences were optimized by geometric parameterizations and energy-based criteria. The reconfigured structure is capable of arbitrary bending as well as twisting angles, which is reported here. The proposed class of robots has shown promise as a fast actuator or shape reconfigurable structure, which will bring new capabilities in future long-duration missions in space or undersea, as well as in bio-inspired robotics.

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