



Introduction

Robotic artificial muscles are alternatives to electric motors; they have advantages comparable to human skeletal muscle. Artificial muscles made from supercoiled polymers (SCP) can be used as both sensors and actuators. Applied heat causes around 20% contraction [1].

This work: Combining SCPs with another artificial muscle: twisted string actuator (TSA):

- Allows actuator to contract via heat or motor rotations.
- Allows for self-sensing by correlating length with ulletactuator's electrical resistance [2].





Figure 1: A twisted string actuator (TSA) model.

Motivation

Robotic grippers have potential for outer space applications on planetary rovers or as assistive devices on the International Space Station. Current robotic grippers can be too heavy or rigid. This research helps create robots that are:

- **Compliant**: SCPs have low stiffness: safer for human-robot interaction.
- Lightweight: A 20-cm, 8-ply SCP weights only 1.2 g. Typical SCP power density is 27 W/g [1].
- Large-strain: Actuating by both heat and twisting increases overall strain.
- **Self-sensing**: Adjust actuator input based on its electrical resistance.
- **Low-cost:** SCPs are made from inexpensive, readilyavailable conductive sewing thread.

Self-Sensing, Compliant, and Large-Strain Twisted String Actuators **David Bombara, Steven Fowzer, Cianan Brennan, and Jun Zhang.**

Smart Robotics Lab, Department of Mechanical Engineering, University of Nevada, Reno

Open gripper

- 3D-printed components using rigid ABS plastic (grey) and compliant TPU (yellow).
- Rigid "fingernails" for gripping small objects.
- Rigid spine behind each claw to prevent backward bending.
- Cylindrical base to mount it on a robotic arm.

- electrical resistance to motor rotations.
- Limitation: short lifecycle, delicate actuators.
- polymer strings.

References and Acknowledgements

[1] J. Zhang, J. Sheng, C. O'Neill, C. J. Walsh, R. J. Wood, J. H. Ryu, J. P. Desai, and M. C. Yip, "Robotic artificial muscles: Current progress and future perspectives for biomimetic actuators," IEEE Transactions on Robotics, vol. 35, no. 3, pp. 761–781, 2019. [2] D. Bombara, V. Mansurov, R. Konda, S. Fowzer, and J. Zhang, "Self-sensing for twisted string actuators using conductive supercoiled polymers," in Proc. ASME Conf. Smart Materials, Adaptive Structures and Intelligent Systems, Paper SMASIS2019-5587, 2019. [3] J. Zhang, D. Bombara, S. Fowzer, and C. Brennan, "Compliant and large-strain twisted string actuators using supercoiled polymers," in Proc. IEEE Int. Conf. Soft Robot, to appear.

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Figure 8: Robotic gripper with six total TSAs.



Figure 9: Rigid fingernails help the gripper pick up objects like the fishing line.

Conclusion

On-going experiments reveal the transient response of

SCPs reach high temperatures: potentially dangerous in wearable robotics and human-robot interaction.

Self-sensing, compliant, and large-strain twisted string actuators for soft robots are realized with supercoiled