Robot Muscles
Super-Coiled Polymer Actuators
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Project Background
Artificial muscles are made by coiling high-strength polymer fibers used for fishing line into a spring-like shape. When stretched, it can strain up to 20% of its natural length, similar to human muscle. However, in response to thermal heating, these actuators will contract back to their unstretched length. Research has discovered an approximately linear relationship between the actuator temperature and displacement from room temperature to 125 degrees Celsius. To aid the heating process, an actuator can be wrapped in copper before it is coiled allowing for electrical heating.

Project Objectives
- Design a method to cool the actuator without constricting its movement
- Implement a robotic device to showcase the power of the actuators

Actuator Background
Super-coiled polymer actuators use both copper and nylon. The process to manufacture these actuators included the following:
- Copper is wound around the polymer (nylon fishing line)
- Two stepper motors were spun in opposite directions to force the nylon to wind into a helical shape.
- Actuators were baked in an oven to assist in shape retention
- Actuators were trained to sustain a specific force

Tube Manufacturing
The available tubing on the market with the desired dimensions and heat resistance required too much force to expand and contract, causing a damping effect on the actuators.

Manufacturing our own tubing was necessary for the cooling system to improve actuator force transmission. Platinum-Catalyzed silicone was used for the tubing material, and a custom mold was machined to meet our design requirements.

Results
- Expansion Time: 5 seconds
- Contraction Time: 4.5 seconds
- System Weight: 18 lbs
- Cost: $495.04

Conclusion
The primary objective of our project was a working cooling system. The manufactured tubing met the design needs, thus enabling us to use water as our working fluid. Even though the system didn't meet the extension and contraction times, a higher rated power supply and different cooling fluid, one with a lower specific heat like propylene glycol, could improve contraction and expansion rates to reach the desired times. Future work could also focus on a system that uses electrical heating and reuses the heated fluid to improve heating rate and efficiency.

Metrics
- Full expansion/contraction time < 3 seconds
- Overall system weight < 25 lbs
- Cost less than $600 for entire system