A novel flexible mechanical actuator serving as an artificial muscle

Wentz Symposium 2021

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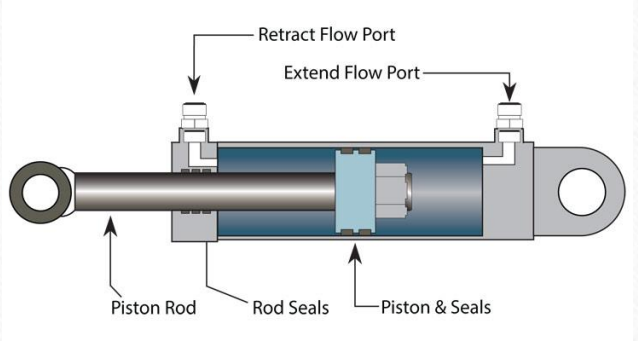
Background and Motivation

https://www.amazon.com/PROGRESSIVE-AUTOMATIONS-Linear-Actuator-PA-14P/dp/B081CW4D1Z

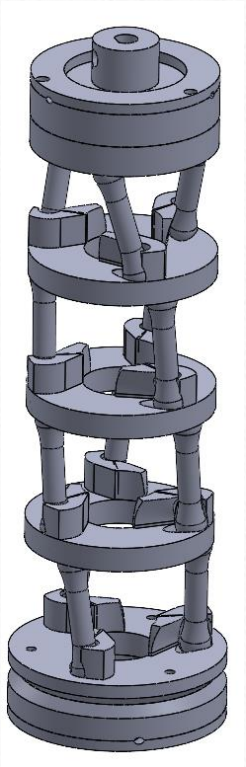
- Current linear actuators are limited in their relative displacement
- Due to their construction they can not extend more than 100% of their original length



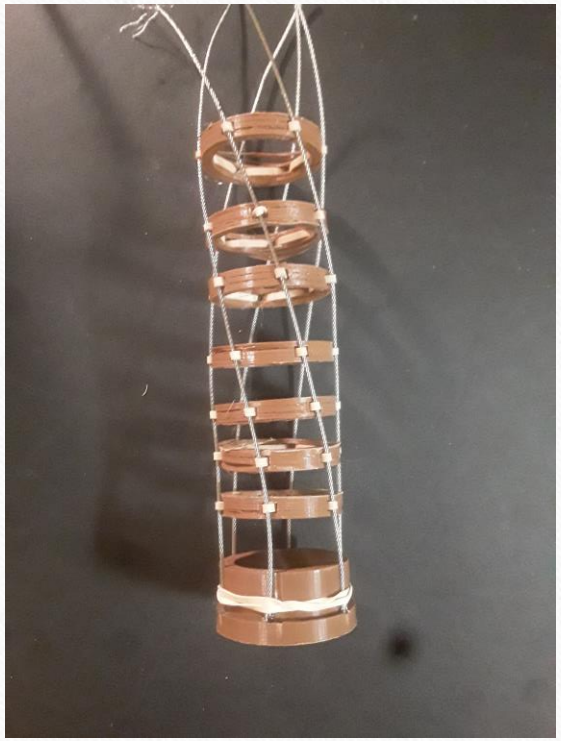
https://www.mobilehydraulictips.com/business-end-hydraulics-cylinder/

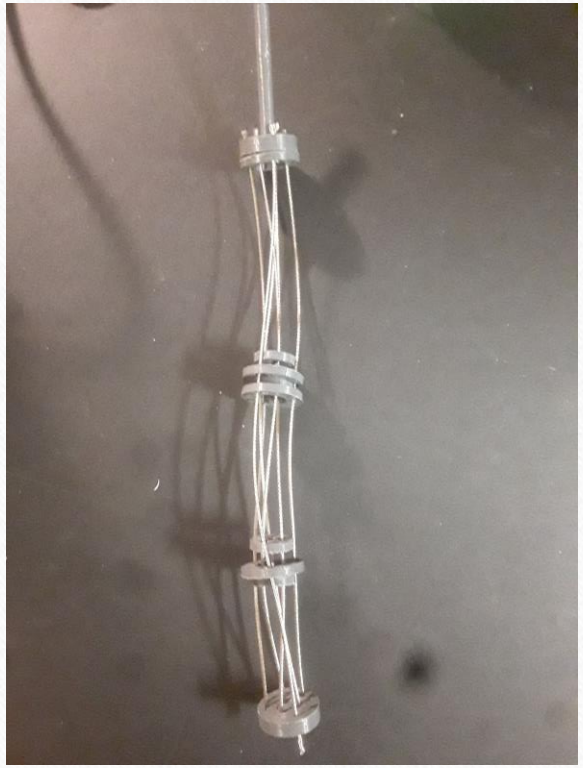
SolidWorks Design

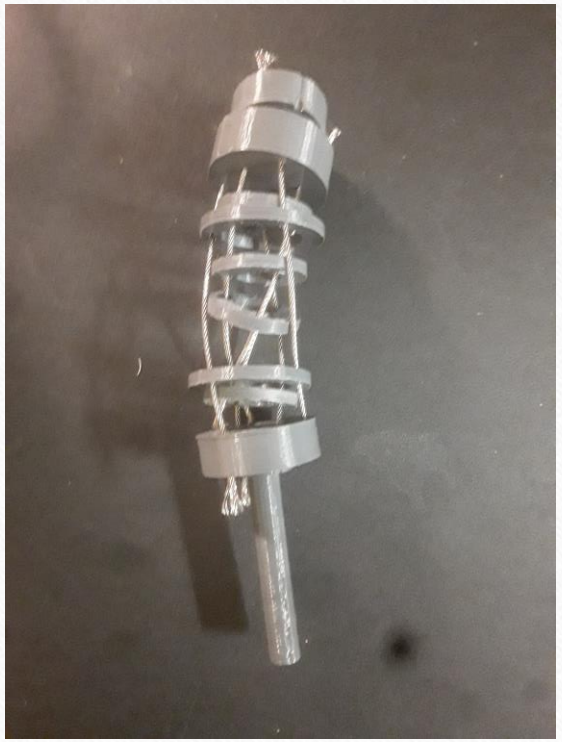
- One end is restricted from rotating
- The other end is rotated
- The supports between the rings coil up and cause contraction



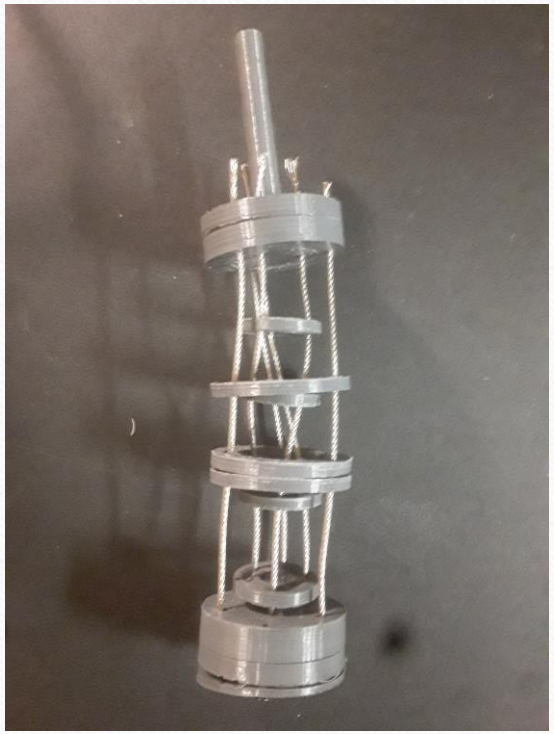
Prototypes 1-3

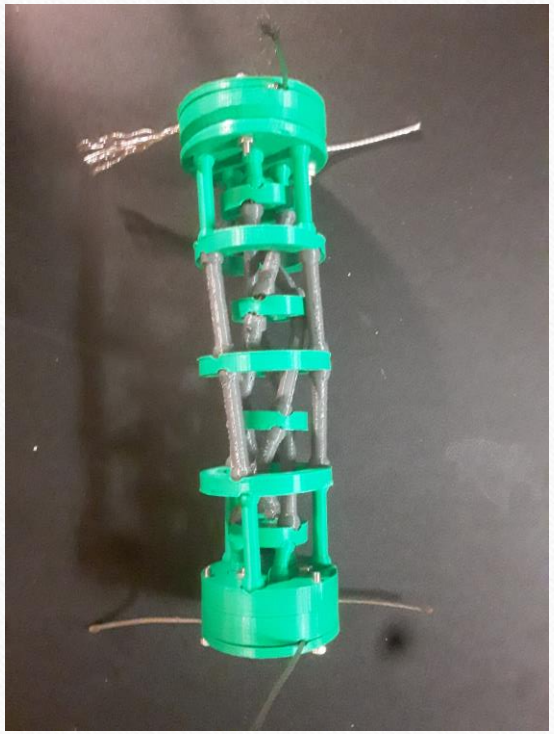


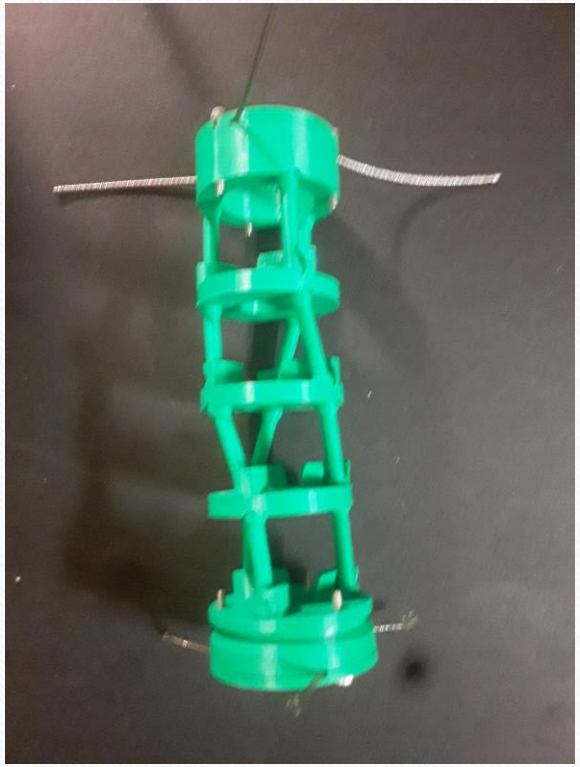




Prototypes 4-6







Prototype 7

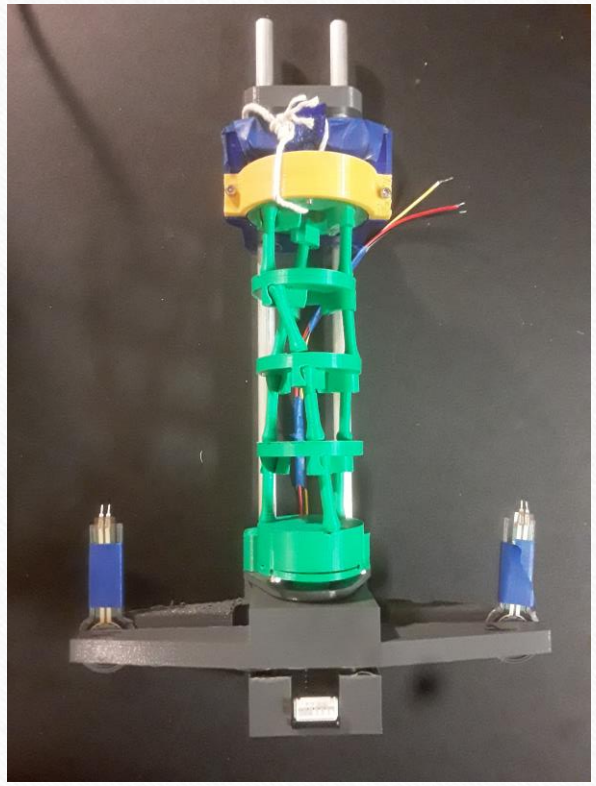
- Kept the wires and supports from twisting backward
- Single set of wires
- Strong wire clamping system

Prototype Construction

- 3D printed
- Wires inserted into supports and held by each end
- Errors in each prototype were noted and changed in future versions

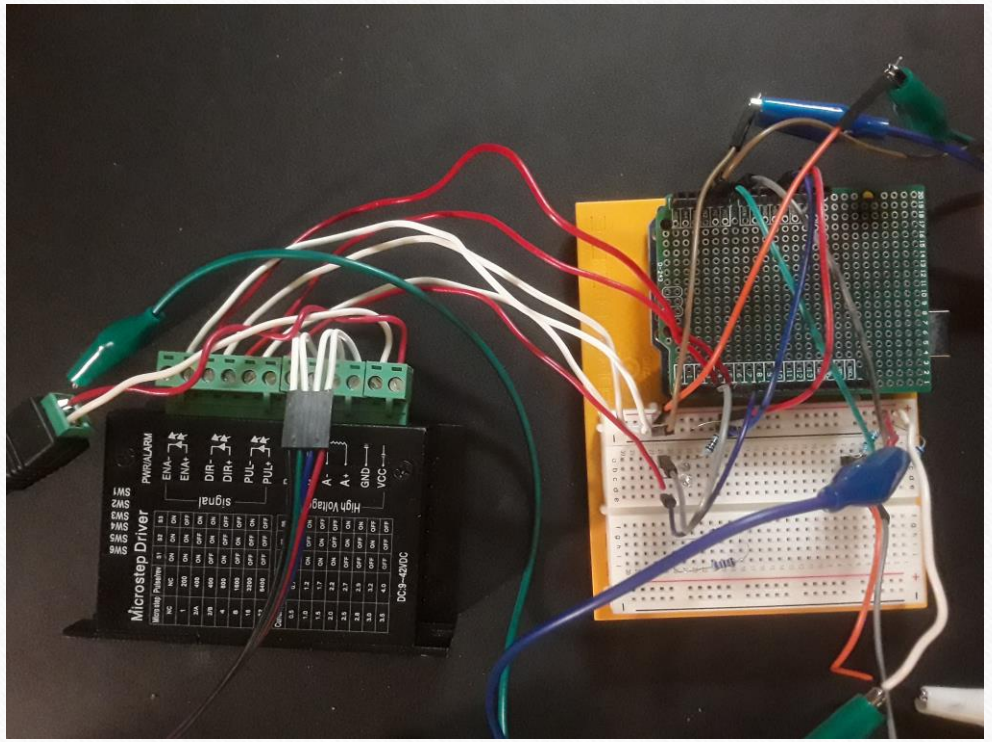
Test Rig

- Motor rotates actuator
- Distance sensor measures displacement of actuator end
- Force sensor measures applied torque of motor



Control System

- An Arduino Uno is controlled using MatLab
- The Arduino outputs control signals to the stepper motor driver
- It collects input signals from the sensors

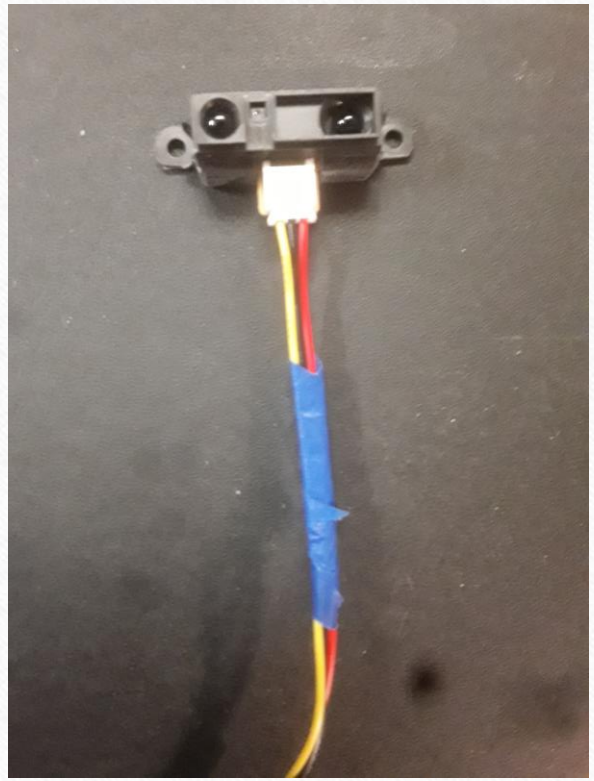


Force Sensitive Resistor Calibration

- Support column and sensor were placed on a scale
- Sensor was incrementally loaded with weights
- Scale value was correlated with sensor output voltage

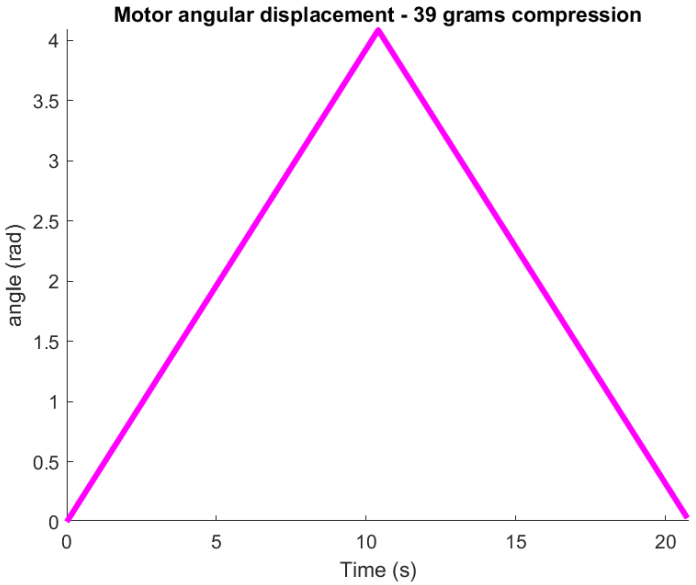
IR Displacement Sensor Calibration

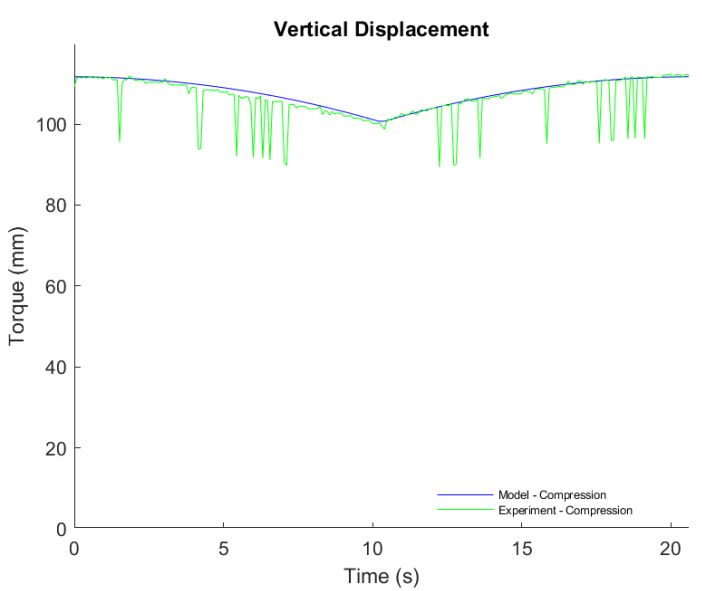
- Sensor was exposed to incremental distances
- The voltage was correlated with each distance



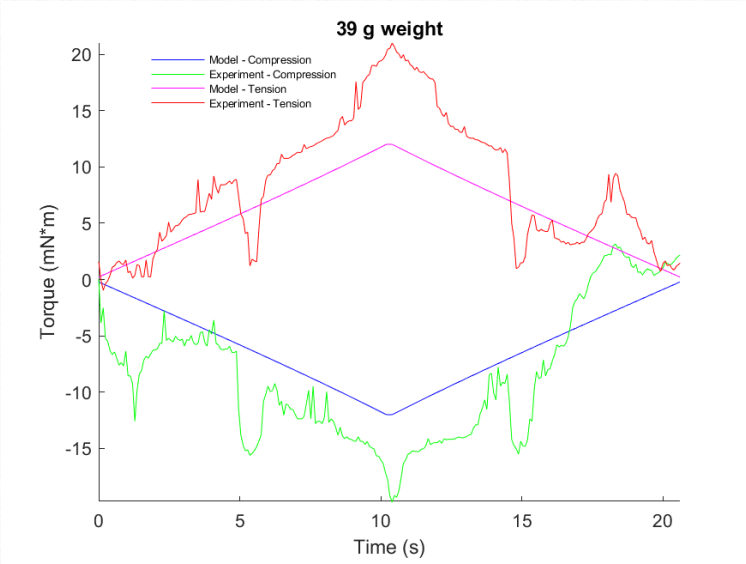
Testing

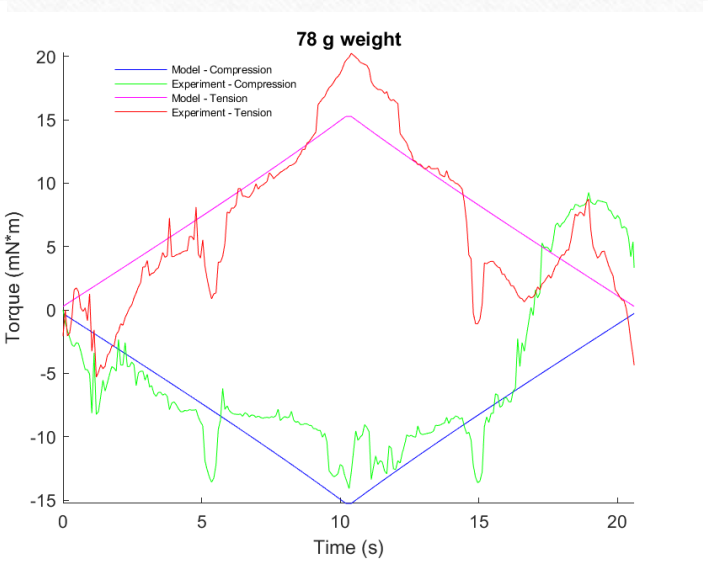
- Each test had the same motor movement
- The motor rotated about a full turn and then rotated back
- The sensors recorded data over this interval

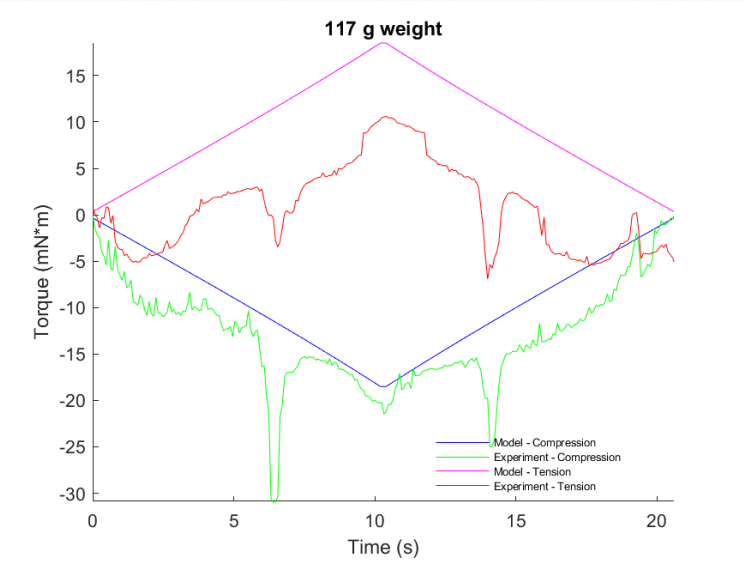


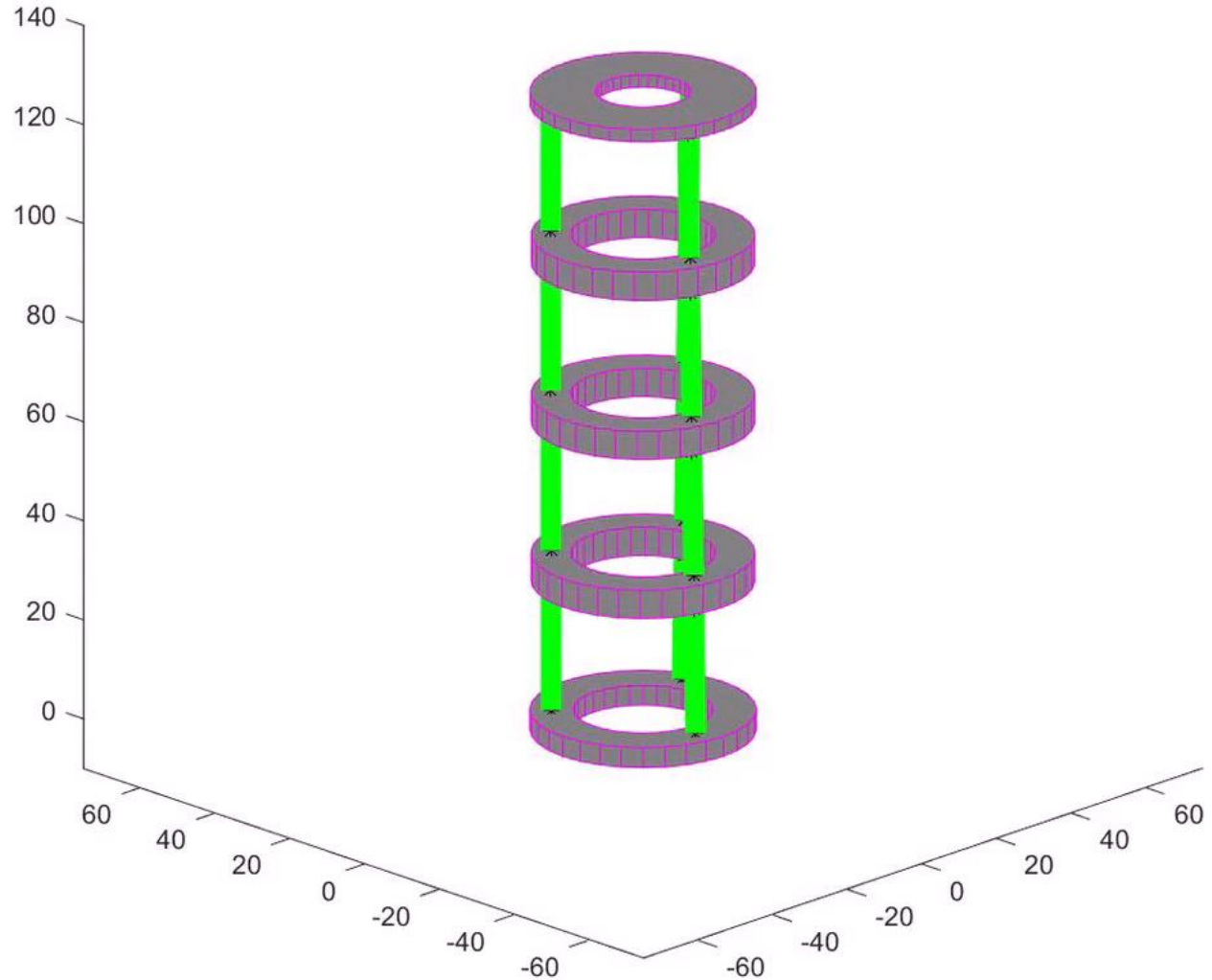


Torque Data


39 g weight
Model - Compression
Experiment - Compression
Model - Tension
Experiment - Tension
Torque (mN*m)
Time (s)


78 g weight
Model - Compression
Experiment - Compression
Model - Tension
Experiment - Tension
Torque (mN*m)
Time (s)


117 g weight
Model - Compression
Experiment - Compression
Model - Tension
Experiment - Tension
Torque (mN*m)
Time (s)


140
120
100
80
60
40
20
0
60
40
20
0
-20
-40
-60
-60
-40
-20
0
20
40
60

Analysis

- The system has the potential to compress to a smaller relative displacement
- The required torque is highest when actuator is fully compressed
- Linear displacement is roughly inversely proportional to input angular displacement

Acknowledgements

- Dr. Yujiang Xiang